STUDY ON CDIO COMPETENCY MODEL FOR ENGINEERING STUDENTS WITH UNIVERSITY-ENTERPRISE COOPERATION IN SHANTOU UNIVERSITY

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ABSTRACT

One key goal of CDIO Initiative is to solve the problem of the lack of the ability for students. Shantou University cooperated with both local and international companies to draw up the model of Intended Learning Outcomes (ILOs) for undergraduates, and built the engineering undergraduate competency model. This model includes three parts. The first is to design attributes in our graduates. The second is to design Engineering Undergraduate Competency Model in Shantou University, and give detail Intended Learning Outcomes for each competency. The competencies in this model are classified into two categories, including the General and the Career-related. The General includes all the essential and necessary competencies for students. The Career-related is about the competencies related to students' hobbies and career positions. The third is to construct the evaluation criteria and corresponding performance levels. It includes 5 levels (from 1 to 5) with detailed descriptions as reference for evaluation of learning outcomes.

KEYWORDS

Engineering Student Competency Model, Behavior Level Description, Intended Learning Outcomes, University-Enterprise Cooperation

INTRODUCTION

Higher education should be based on comprehensive development, social needs and international background, which develops the graduates with all-round competencies explicit and implicit in developing a successful career(Chinese Academy of Engineering Education Committee, 2007). It means that students do not just acquire the skills of learning, but also learn to live and survive. Therefore, one priority in higher education is to explore approaches to improve education quality through education research, student competency model and investigation of problems at home and abroad, which also intends to improve students to exercise self-management, self-service and core competencies in interpersonal communication. By the survey of stakeholders of teachers, students and employers through behavior event interview, questionnaire and statistical analysis, this paper introduces the

construction of engineering undergraduate competency model in Shantou University and its comprehensive assessment system with examples.

CDIO represents Conceive, Design, Implement and Operate. It sets operating life cycle of products, processes and systems as engineering educational context and builds an integrated system of training standards and curriculum for active and practical engineering learning(Edward Crawley, 2009,2011). CDIO composes the knowledge, skills and qualities that a qualified engineer needs, then organizes them, and refines them to be observable and measurable in learning outcome, and ultimately constitutes the CDIO Syllabus and 12 Standards. CDIO Syllabus and Standards are two key guidance documents. The CDIO Initiative has been implemented in China in 2005. Now, CDIO is becoming one of the effective ways for China to promote the reform of engineering education (Gu Peihua, 2008).

Then how to design and implement an effective approach for developing these capabilities has become the core of the higher education. Decades of experience in engineering education in China has told us that University-Enterprise Cooperation might be one useful approach. In June 2010, the Chinese Ministry of Education come up with the Excellent Engineer Education Plan which recommended the"3+1" training mode for the Plan's implementation in colleges and enterprises. "3+1" means 3 years' knowledge-majored study in colleges and 1 year's product design-oriented practice in enterprises. College of Engineering, Shantou University, is part of the Plan.

Centering on engineers education improvement, in this paper, part of the research and practical work in cooperation with enterprise is studied. Based on the graduates attributes and social requirements, it introduces the construction of Intended Learning Outcomes Model. Accordingly, an evaluation model is designed and expected to make an effective assessment on students during enterprise education.

STUDENT ATTRIBUTES AND ILOs IN STU

It is the designated role of STU to develop all-round students with professional competence. Both all-roundedness and professional competence are important outcomes, and essentially both outcomes should be achieved upon all students' graduation.

The attributes for all-roundedness and professional competencies outcomes are complementary in Shantou University. Both must be addressed and are not in conflict with each other. Many generic capacities are important for professional development, e.g., critical and creative thinking, lifelong and active learning abilities, etc. Furthermore，there are few, if any, professions nowadays that do not require at least some generic capacities from their recruits that would allow them to work flexibly and learn new capacities effectively.

Attributes for all-roundedness are the more generic and transferable aspects of learning. The list of attributes for all-roundedness varies from place to place. For STU, the following attributes in our graduates are presented: (1) professional competencies in a chosen discipline，(2) creativity and innovation, (3) critical thinking and problem solving abilities，(4) language and communication skill, (5) capability for lifelong and active learning，(6) leadership, teamwork and interpersonal skills, (7) entrepreneurship, (8) global outlook and multi-cultural vision, (9) cultural appreciation, and (10) social and national responsibility. A general outcome definition for each undergraduate attribute is given in the table below:

Table 1.General Outcome Definition for Each Undergraduate Attribute in STU

Attributes	Intended learning outcomes STU undergraduates should be able to:
1. Professional competencies in a chosen discipline	Demonstrate a mastery of the fundamental knowledge and skills required for functioning effectively as an entry-level professional in the field, and an ability to integrate and apply them effectively to practice in the workplace
2. Creativity and innovation	Experiment with new approaches, challenge existing knowledge boundaries and design novel solutions to problems
3. Critical thinking and problem solving abilities	Identify, define, and deal with problems pertinent to their future professional practice or daily life through logical, analytical and critical thinking
4. Language and communication skills	Communicate effectively (both orally and in writing) with a wide range of audiences, across a range of professional and personal contexts
5. Capability for lifelong and active learning	Identify own learning needs for professional or personal development; demonstrate an eagerness to take up opportunities for learning new things as well as the ability to learn effectively and actively on their own
6. Leadership, teamwork and interpersonal skills	Function effectively both as a leader and as a member of a team; motivate and lead a team to work towards a goal; work collaboratively with other team members; as well as connect and interact effectively with other people
7. Entrepreneurship	Demonstrate interests and abilities in discovering and exploiting opportunities, taking prudent risks, and trying out novel ideas or methods
8. Global outlook and multi-cultural vision	Demonstrate an awareness and understanding of global issues and other cultural characteristics and happenings outside China，a willingness to take part in international experiences, as well as an ability to work/interact effectively with people from different parts of the world
9. Cultural appreciation	Demonstrate interests, and participate in, cultural activities, and show a sensitivity to cultural diversity
10. Social and national responsibility	Demonstrate an awareness of their social and national responsibility; engage in activities that contribute to the betterment of the society; and behave ethically and responsibly in social, professional and work environments

ENGINEERING STUDENT COMPETENCY MODEL

 Competency model defines the underlying sets of skills, knowledge, personal characteristics and abilities needed to perform in a role and helps achieve the organization's goals(Anne F. Marrelli, 2005). The competencies and corresponding level assessment are defined and described in a model(Bradley, 2008). Competency model enables the identification, evaluation and development of the behaviors in individual employees. It helps build a strategic HR foundation for subsequent staffing, development, succession planning, and performance

management. It has many types like position competency models for technical, managerial and marketing positions(Glenn M, 2005).

The model is designed to be concise and focused with key competency factors (but not too much) working together. It is supposed to be a display of the positive effects for employees, that middle managers know how to apply it for work efficiency and senior managers learn its benefits for the sustainable development.

There are a few ways for competency model, including behavior event interview, critical incident technique, panel discussion, questionnaire, position analysis questionnaire, functional job analysis and so on(Mark A Albanese, 2008). All these approaches have advantages and disadvantages. The number and type of competencies in a model will depend upon the nature and complexity of work along with the culture and values of the organization in which the work takes place.

Based on competency model construction method above, College of Engineering of Shantou University and cooperative enterprises, construct undergraduate competency model suitable for our college orientation and professional cultivation objectives. The model is composed of two parts: the core competency model of operational excellence department and competency model related to the composition, described in detail in Table 2 and Table 3.

Table2 .The core competency model of operational excellence department

Competencies	Descriptions
Features	Low cost, high quality products and service to provide value for customers
Core abilities	Team Cooperation
Quality of staff	Mental health and behavior, teamwork, leadership, execution
1. Mental health and behavior	
Definition	Health status; Oneself and interpersonal relationship; Life adaptation and psychological adjustment; Ethical behavior and individual morality
Key concepts	Pleasant personality, emotional stability, Optimistic, interpersonal harmony, good conduct
Main behaviors	•Good health and physical strength; •Pleasant personality, emotional stability, optimistic, interpersonal harmony ; •Own a strong ability to adapt to life and psychological adjustment ability, be able to correctly deal with difficulties and setbacks •Keep the faith, resolute in the idea and ability; • Be able to handle interpersonal relationships and moral behavior in the interpersonal communication, and personal moral cultivation
2. Teamwork	
Definition	Clear team goals, lead the team, pay attention to internal team and team's relationship with other institutions or organizations, to achieve common goals
Key concepts	Fully inclusive and equitable, act with united strength, external cooperation, to establish cooperative network, respect for others

Main behaviors	•Clarify the roles and tasks of team members, take personal responsibility in the team; •Play fair, concerned about team members and coordinate relationships, provide timely support and assistance, encourage team towards common goals; •Coordinate the relationship between the team and the other team, clarify the cooperation mechanism among teams;

3. Execution

Definition	In strict accordance with the definition of business process, driving the operation of a business process instance
Key concepts	Specification, process control, pay attention to the process
Main behaviors	•Pay attention to the regulations, to do things organized •implement and follow up tasks according to regulations •Consider repeatability and sustainability, focus on every step in the process •Take the initiative to find and willing to accept new ideas, experience and ways of doing things, improve the current process and system, etc

4. Leadership

Definition	Drive oneself and team members to achieve stated goals energetically in as short a time period as possible, .
Key concepts	Set goals, focus on the target deadline,, overcome obstacles, reach the goal
Main behaviors	• Attention to the deadline of reaching the goal, driving the team put in more effort, to accomplish the goal in the shortest possible time; • To put the time and effort required for the work, have the courage to try, try to overcome obstacles to complete the task; • Maintain focus, tough, dedication; mobilize the required resources, to ensure to reach the objective. •The final results for action guiding, attach importance to practical action •Not satisfied with the status quo, refine on request

Table 3. Competency model related to the position

Capacities	Descriptions
5. Critical thinking and effective problem solving	
Definition	Doubt routine, the innovation idea, change; Timely and effectively solve the difficult problem; Follow up until the obstacle is ruled out.
Key concepts	Recognize problems, feasibility analysis, determine the solution plan, carry out and follow up project
Main behaviors	•To grasp the essentials, have genius for discrimination, based on rigorous inference, witty aura, daily clear thinking agility. •In the face of difficulties, timely put forward or to perform a feasible solution; •Provide the resources to solve the problem, or offered to resource requirements and follow up to ensure that resources are in place; •Implement and track solution, ensure the effective solution to the problem

6. Innovation and Application	
Definition	Have the ability to think from multiple angles, facing the challenge to come up with a new and effective solution.
Key concepts	Overall innovation, good at invention and creation, continuous improvement, good at learning
Main behaviors	• Not satisfied with the commonly accepted views, look for new opportunities for improvement • Create a better solution to meet customers' needs and expectations •Looking for internal and external resources, using the views and ideas that have been confirmed, create new solutions

7. Communication and interpersonal communication	
Definition	Enthusiasm, clearly, correctly listening and communication, to create an atmosphere of open communication
Key concepts	Listening, expression, conflict processing
Main behaviors	• Clearly, clarify, logically express personal thoughts and opinions; emphasis; • Using the appropriate speed, volume, language, body language, etc, performing proper enthusiasm； • Pay attention to others' message; correctly interpret the information and respond appropriately

8. Active learning and independent thinking	
Definition	Find out their own strengths and weaknesses, maintain their own advantages, improve the shortcomings; to determine their own development needs, and change the environment to improve individual and organizational performance
Key concepts	Predict the gap, continuous learning, and apply it in the work
Main behaviors	• According to the needs of the work, actively participate in learning new knowledge and skills； •Actively learning relevant knowledge of different disciplines under different cultural backgrounds and new ideas and new knowledge generated from the intersection of knowledge. • Through formal and informal learning activities, integrate and absorb new information and knowledge； • Actively participate in learning activities, in order to achieve the best learning effect； • To put the new knowledge or skills in practical application in the work, through repeated practice to increase proficiency. • Without outside help, ability to solve problems by exploring and thinking though one's own

BEHAVIOR LEVEL DESCRIPTION OF THE MODEL

Above competency model only gives the overall expectation of the employers, but did not give the desired degree or degree of the assessment. This section will be based on the above student competency model made by University-Enterprise Cooperation, meanwhile, according to the intended development outcomes of students, the enterprise development

needs and all kinds of enterprises and all types of professional post requirements, formulate the behavior level defining the performance merits of all kinds of posts. Behavior level is mainly used for standard criteria for the assessment of the student competencies, and generally divided into 1-5 grades(Rubin Nancy, 2007). Review the five behavior level description as follows:

• Level 1 is the general competency requirements. It generally refers to the students can know and master basic concepts and terms, organization process or relevant tool use, also can carry on the simple analysis;

• Level 2 is for intermediate demand of ability quality, generally require students to fluently, independently carry out tool operation or to use knowledge of all aspects, and at the same time to carry on the simple education and management for other students or group members.

• Level 3 are sub-high level requirements for the ability quality. It generally requires students to master certain knowledge, processes or a particular aspect of tool use. It also can travel more complicated management functions.

• Level 4 are senior requirements for ability quality. It generally asks students to put forward strategic suggestions or make adjustments to the knowledge, processes or tools they grasped.

• Level 5 are the most senior requirements for the ability quality. It generally requires students to have enough foresight and insight to the development trend of things and the connotative problem.

Because of the limitation of paper length, table 4 only presents behavior level description of cooperative ability in the teamwork from the core competency model of operational excellence department.

Table 4. Behavior level description of the core competency model

2. Teamwork	
Grade	Description
5	• Themselves have the courage to bear and help team members to assume their respective responsibilities, to work together • Adjust the priority of the task to achieve the team goal, self initiatively innovate style, timely adopt new methods • Suggestions or development of new methods, to maximize the participation and pay of team members • To promote cooperation within the organization and between different groups, to achieve common goals • Remove the barriers between teams (such as the organizational structure / function / culture etc.), promote the professional skills and resources sharing • Lead the related team to establish mutually beneficial win-win long-term relations of cooperation, through regular exchanges, strengthen and ascend partnership
4	• Able to undertake and help the team members to assume their respective responsibilities, and to establish effective cooperative relationship • To change the style and method with the help of the external force, can effectively drive team members to participate in and pay

	• Can help cooperation within the organization and between different groups, to achieve common goals • Help related teams to establish mutually beneficial win-win long-term cooperative relationship
3	• Take personal responsibility in a team, have a clear understanding of the team's goals and the roles and tasks of each member • Cooperate with others sincerely, justice, caring, respect • Take the initiative to provide support for colleagues, actively cooperate with colleagues rather than distorting competition • make good use of colleague's participation and pay, can listen to their views on the basis of independent analysis • Communicate with the various aspects, balance interests, persuade the parties to reach a consensus, work towards the common goal specified
2	• Can only assume personal responsibility in the team • Can cooperate with people, treat each other sincerely, balance interests • Able to provide support for colleagues, active cooperation between each other • Respect participation and dedication of colleagues, can listen to and adopt their point of view
1	• Prefer to work alone • Cooperate with people not humbly, not easy to establish and maintain relationships with others • Do not understand the important value of the differences between team members in the process of constructing the team • Be Insensitive to the needs and feelings of others

COMPREHENSIVE ASSESSMENT OF STUDENT COMPETENCY

After establishing the student's competency model and its behavior grade, the most fundamental purpose is to apply this model to the students' comprehensive ability quality assessment process, and need to be combined with relatively complete evaluation system in order to achieve the effect of the model, otherwise the establishment of the model will become meaningless. In addition, the most fundamental way to detect the competency model is performance management, and thus a set of objective, impartial, fair performance management system is critical to the establishment and perfection of the competency model.

Table 5 is based on the research conclusion of the previous sections, presenting a reference to student's interview assessment content and asking questions, which is very conducive to the application in the concrete operation of student assessment.

Table 5. Reference to student's interview assessment content and asking questions

Assessment content	Problems of reference (Details please ask)
1. Core Competency	
①Mental and behaviours	• Your mood is bad? For example, often pessimistic, depression, anxiety, irritability or irritable, like attacking etc. • Whether your work, study and attention are significantly decreased? • Whether there is abnormal and behavior you yourself can't control? For example, repeated washing, closing the door, making a face,

	etc.
	• See the elderly, children, beggars and other vulnerable groups, what would you do? Think what?
	• What do you think of the beautiful countryside teachers program?
②Teamwork	• Take a collective activity you have participated in for example, what is each team member's responsibility? And what kind of role did you play?
	• In this activity, whether there is any crew you don't like (him / way)? How did you handle it? And what's the result?
	• In the activities you experience, which one has the most intense time / task quantity, and how to collaboratively finish on time with team members?
③Executive force	• The most accomplished/the most proud of/ the most successful thing.
	• In the activities, if there is a situation where anyone has different opinions?
	• Tell a matter which cost less than expected, and the results were better than expected?
	• How did you prepare for the final exam? CET Four / CET Six?
④Leadership	• As a project leader, if you have any experience that do not reach the expected target? Then how did you deal with it?
	• Please tell about a project you have recently led to complete? What procedures are you in to ensure the completion of the project on time and accurately?
	• In the activities you have experienced, which has the most limited resources? How did you work? ?
2. Competency model related to the composition	
⑤Critical thinking & solve problem effectively	• Will you often use subversive ideas to think about a problem?
	• What is the most challenging / the most complex / the most difficult thing you encountered?
	• What solutions have you proposed? Choose which program? The result?
	• If you have such experience that your behavior or ideas avoid a potential problem?
⑥Innovation and Application	• If you have such experience that you put forward a new viewpoint or ideas or methods in an activity making the activity very successful?
	• What aspects do you think the novelty of the idea is reflected?
	• When you told the new idea to the players, whether you ever encountered opposition and how did you deal with it?
⑦ Communication & interpersonal communication	Through the process of asking questions, at the same time, inspect the candidates' communication ability.
⑧ Learning and independent thinking	• In your recent study, are there no any special achievements?
	• If you have any experience that you were not satisfied with your grades? How did you change?
	• If ever found a classmate do hard on something, you helped him to complete? What was the situation? What did you say? Do?

CONCLUSION

Based on the work of CDIO engineering education reform of Shantou University in recent years, uniting Chinese local enterprises, international Multi-National Corporation and other industry enterprises, together constitute Engineering Student Intended Learning Outcomes, construct two students competency models of the core competency and career-related competency，developed a standardized competency assessment standard--behavior level, gives a description of each behavior level as a reference, and ultimately used it for the evaluation of students development outcomes.

All the work of this paper is only a part of the job. In the following work, the research group will be based on the students' competence model of the previous stage, focuses on the following work:

(1). Construct the training methods schools and enterprises should provide, in order to complete the objectives required by the students' engineering practical competency model, including the curriculum system during the school semester, training and research and development system of the project during the period of enterprise engineering practice education.

(2). Establish the student's competency evaluation weights from perspective of students, teachers and employers view angle triangle, and get a comprehensive perspective of students' comprehensive competency evaluation model.

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