

PRELIMINARY STUDY ON ESTABLISHMENT NEW CULTIVATION MODE CDIO OF BIOLOGICAL ENGINEERING EXCELLENCE ENGINEER

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ABSTRACT

CDIO is regarded as a brand-new concept to reform engineering teaching in higher education. CDIO teaching methodology is highly valued by universities at home and abroad. However, the current status of Excellent Engineers Program for biological engineering cultivating is to mechanically implant CDIO idea into the traditional undergraduate education model; the CDIO are implanted into almost every course> Even the difference between the culture of excellent engineers and training of undergraduate are distinguished by simply reducing the basic courses and increasing specialized courses or decreasing hours of the theoretical teaching and increasing hours of practice design; they do not inspect professional characteristics, industry trends and demand for talents on current bio-engineering in China. This paper analyzes bio-engineering industry characteristics, industry trends and their impact on demand for talents from a unique perspective, and it systematically describes responsibilities, mission and qualifications between biological engineering undergraduate and excellent engineers in the current industry trend. The cultivating mode in this paper is based on the Chinese people-oriented education spirit to impart knowledge and cultivate people. It critically assimilates CDIO concept and cultivating mode, which cultivates innovative talents for the needs of different industries in biological engineering. The article systematically describes and analyzes new educational ideas and cultivating models, meanwhile, it draws the outline of the professional curriculum, and it drafts the students' professional learning model and establishes preliminary assessment system of learning outcomes. Additionally, it estimates and elaborates the employment patterns and situations. Featuring part of this cultivating model concept is to enhance students' market awareness, to learn the idea of connecting innovation with markets and to integrate learning direction into employment and career.

KEYWORDS: Biological Engineering; New Cultivation Mode; CDIO; Excellence Engineers

INTRODUCTION

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The most significant characteristics of biological engineering is extensive range of employment than other than other professional, such as Modern Agriculture, Industry, Medicine, Pharmacy, Energy, Environmental Protection, Metallurgy, Chemical Raw Materials, Animal Products, Plants Products, Food, Brewing and other fields, and each field is divided into a more extensive and more detailed field. Colleges or Universities could usually offer more courses in order to meet the employment needs of students. In fact, Finishing all the professional knowledge and skill of these fields is an impossibility in a limited four years. Therefore, the actual situation is that the professional courses in a given area only are offered in some colleges or universities. When the graduates could work at the field of biological engineering where they are not familiar with in order to seek jobs, their education and occupation is the actual separation. Although some Universities have introduced engineer cultivating an idea of CDIO (Conceive Design Implement Operate, CDIO), emphasize ability training and strengthen the practice teaching (Michael F. A., 2016, Bai Jianfeng et al. 2013), these are not out of the current predicament of cultivating biological engineers. On the contrary, teaching effect is more worse, the reason is that increase practice training time and compression theory course learning time within finite time could result in that the cultivating talent has weak theory foundation and the low practice ability, which is conflicting with current talents standards of theory solid and skilled required by the enterprise. Therefore, biological engineering employment rate has been ranked at the end of any big industry in recent years, employment rate didn't increase due to the introduction of the concept of CDIO. Some people think that the lower employment rate attributed to the domestic biotechnology industry is not mature. But in fact it embodies a structural contradiction between the talents cultivating and the social demand. The specific performance is the one hand a lot of students graduates cannot find a job. On the other hand, many enterprises cannot find their need talent. The current way of teaching reform in Colleges and Universities makes the contradiction increasingly acute, and gradually developed into a vicious spiral. How to resolve the structural contradictions of talent in biological engineering field has been the focus of this paper.

In order to solve this problem, a questionnaire survey was conducted on 185 graduates for 2004 -2013 years and 95 students of the Yanshan University biological engineering, in order that it is better to understand the state of students learning and the working state. Based on these, this paper combined with features of biological engineering and the idea of CDIO, and puts forward the new cultivating mode of excellent engineer of biological engineering. It expects that this can give cultivating biological engineer in china enlightenment and reference.

1 Cultivating situation of biological engineer in China

Biological engineering is a new comprehensive application disciplines beginning to rise in twentieth Century 70. After 90 years, it gradually formed a relatively complete professional system, which is based on theory and the technology of Biochemistry, Genetics, Cell biology, Microbiology. Through the orientation transformation of biological genetic material or traits function, it created a new species, a new bioreactor and new products, and combined with the chemical, mechanical, electronic and other modern engineering technology, and realize product output, profits gain and society repay by using the biological natural force and scale effect. Biological engineering scope covers all areas between life science and engineering.

Thus there is a relatively uniform cultivating mode of undergraduate biological engineering: general knowledge module (Mathematics, Physics, Chemistry, Language, Politics, Computer), biological foundation knowledge module (Biochemistry, Genetics, Cell Biology, Microbiology and related disciplines), biological engineering module (Cell Engineering, Genetic Engineering, Biochemical Engineering, Fermentation Engineering And Enzyme Engineering), modern engineering module (Chemical, Mechanical, Electronic) and professional characteristics module (Agricultural, Industrial, Medical, Pharmaceutical, Energy, Environmental Protection, Metallurgy, Chemical Raw Materials, Animal, Plant, Food And Brewing Industry) of curriculum integrated group. There is very relevant knowledge background between professional characteristics module and the oneself University.

1.1 Investigation and Analysis on the learning situation of biological engineering students

The questionnaire is conducted on 185 graduates for 2004-2013 years and 95 students of Yanshan University biological engineering. Students are full of expectation to enter oneself for an examination of biological engineering major from the statistical results (Table 1-1). However, the unreasonableness of the current cultivating mode and curriculum design has brought about that the enthusiasm of students is more and more attenuation and learning motivation gradually lose. Learning motivation survey results show:(1) 31.6% of students could pass the exam as their learning motivation; (2)19.6% of the students will get a occupation as their learning motivation;(3) Only 8.8% and 5.4% of students respectively will do a career and love biological engineering as their learning motivation; (4)27.2% of students will be admitted to graduate as their learning motivation. The contrast between survey results of learning motivation and survey results of applying for motivation can find a strong correlation. For example, there are very close data between the percentage (8.8%+5.4%=15.2%) of students doing a career and loving biological engineering as their learning motivation and the percentage (15.4%) of students applying for biological engineering because they like biological engineering. In addition to, there are also very close data between the percentage (100%-15.2%=84.8%) of other reasons as the their learning

Table 1-1 The investigation of learning state from Yanshan University biological engineering 2004-2013 alumnus and undergraduate

The reason of enter yourself for an examination biological engineering	Biological engineering is a sunrise industry	80.4%
	Like biology	15.4%
	Other reasons	4.2%
What prompted you learning	The future career	5.4%
	Seek a occupation in future	19.6%
	To obtain the scholarship	7.4%
	Apply for graduate students	27.2%
	Love learning biological knowledge	8.8%
	No learning power and no make-up learning	31.6%
Why not study power	Don't know oneself will be able to do what, for the employment range is too wide	85.3%
	Not interested in professional	4.6%
	Love to play	7.3%
	Boring of the teacher	2.4%
	There have been the employment post	0.4%

Note: survey data source in 2004-2013 year 185 alumni and 93 students

motivation and the percentage (80.4%) of students applying for biological engineering because biological engineering is a sunrise industry. Students who apply for biological engineering as a sunrise industry are no real understanding of biological engineering, and

they apply for biological engineering by a passion or utilitarian purpose. With the development of study, learning enthusiasm of these students will increasingly weaken, and further differentiate into getting a diploma, postgraduate and seek occupational groups. Such a large proportion (more than 80%) graduates is unlikely to become outstanding talents in the field of bio-engineering. How to turn them into outstanding talent is our topic worthy of study. In addition, a no learning motivation questionnaire shows 85.3% of students do not know their future what be able to do, which reflects the students have no clear goals, expectations and ideals of life. In short, most students are passive learning state due to lack of sufficient understanding of biological engineering, and they temporary lost their learning goals. How to change current state in their learning is a major problem to be solved in this paper.

1.2 Investigation and analysis of the relationship between employment and University learning professional knowledge and skills

The questionnaire is conducted on 185 graduates for 2004-2013 years (Figure 1). 41.5% of

the students think that their learned professional knowledge and skills are only use 10% in the current occupation, and the proportion of students is the highest; In addition, only 17.7% (1.4%+2.7%+13.6%) of the students think that knowledge and skills of their studying in the University can be applied to 40-80% in the current position, and they generally have master or doctor degree; Students who think that 10-20% Of their learned professional knowledge and skills in the University can be applied in the current position reach up to 66.7%

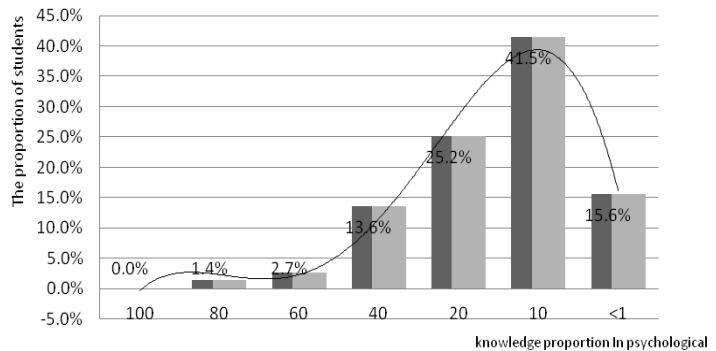
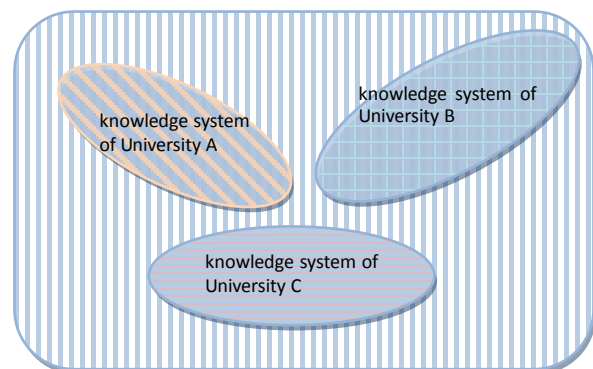


Figure 1 the psychological evaluation between learning knowledge skills in University and currently working

Even 15.6% of the students think that knowledge and skills of their studying in the University is used less than 1% in the practical work. The survey data show that it is serious deviation between students learning knowledge and skills and employment requiring

knowledge and skills. Although these survey questionnaire data only derive from graduates psychological assessment which they learn knowledge and skills in the University applied on the job, such disparity data have to arouse our thinking. The complete departure between cultivating mode and industry requiring is not a case of biological engineering of a University but is universal. Because the scope of employment of biological engineering covers the intersection various industries between life science and engineering discipline, while the students majoring is only the engineering knowledge and skills in a certain field that based on the knowledge of biology; in any



Note: the rectangle represents all biological engineering specialty knowledge system; ellipse represents a different university set up professional knowledge system. University courses cannot cover all biological engineering professional knowledge system.

Figure 2 Schematic diagram of the relationship between knowledge system opened by University and professional knowledge system of biological engineering

case, adjusting curriculum can not solve the problem of reality dislocation between University courses and jobs requiring the knowledge and skills (Figure 2). In addition, a deep-seated reason is that the student in the school learning effort and learning time is limited. Even if the University offers all the courses they may not learn all areas of knowledge and skills. Therefore, students always think the knowledge and skills that they have learned is not consistent with the post needed. Even the introduction of the idea of the CDIO model does not still fundamentally solve the problem, also cannot change the current predicament of education, and it can make teaching more and more worse. Therefore, the above problem is another important issue discussed in this paper.

2. Construction and theoretical analysis of the NCM of biological engineering

The contradiction between the broad employment scope and limited learning time and energy constitutes the main characteristics of biological engineering learning and employment, which extends the deviation between knowledge skills and jobs. The questionnaire reflects that most students' studying state is no pursuit goals, no interest, no power and no confidence in school. To change the current biological engineering facing difficulties must be re construct the New Cultivation Mode (NCM) which will be in line with development characteristics and learning characteristics of biological engineering. The simple thoughts as follows, First is the reconstructing of student occupation target, the digging of students interest point, the establishing of confidence and the finding of the learning motivation; Secondly, learning target closely is integrated with their occupation and the training process is simultaneously carried out with engineering practice; Finally, graduation design become a design of after graduation but graduation design is not only for the graduation. So I put forward a NCM of biological engineering in order to change the predicament of the current biological engineering.

2.1 New Cultivation Mode of biological engineering

According to characteristics of the biological engineering and state of students learning, the

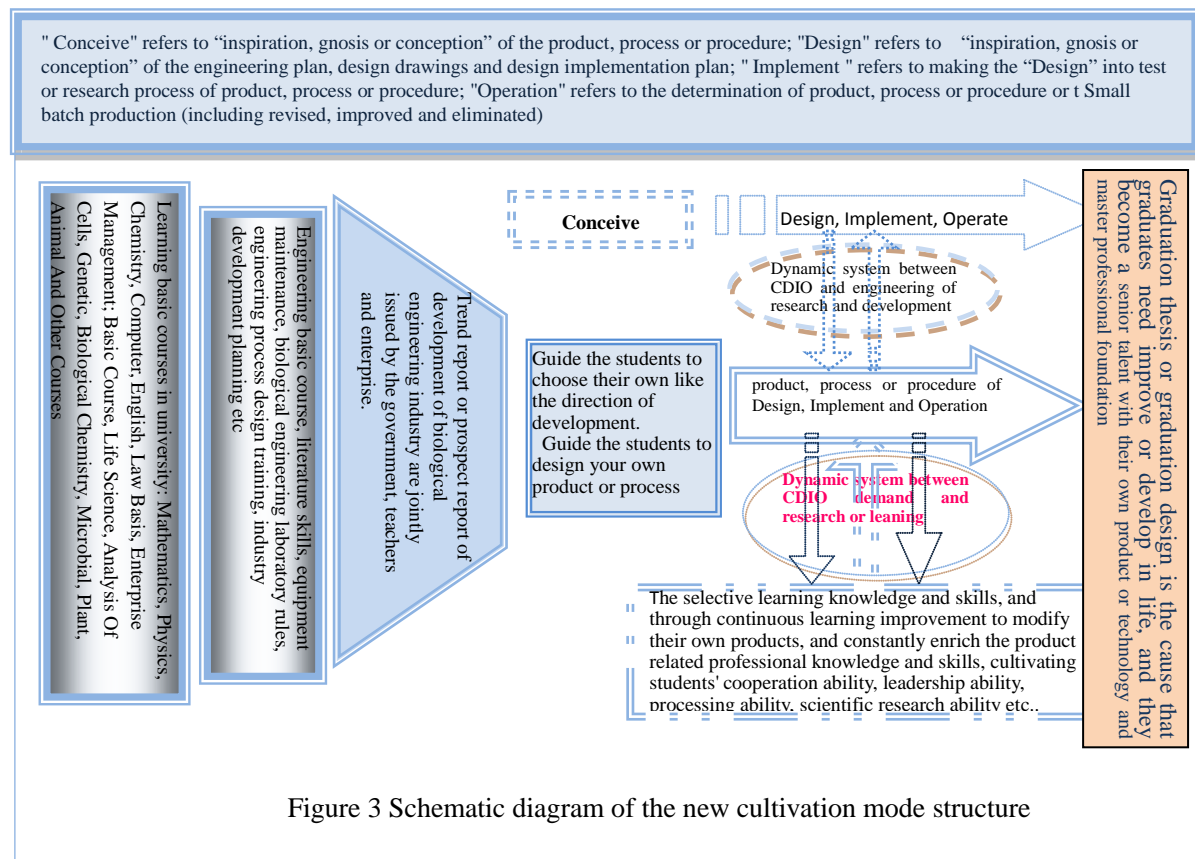


Figure 3 Schematic diagram of the new cultivation mode structure

NCM is reconstructed being based on the CDIO idea (Figure 3). Due to limited space, the points are described as follows: (1) Curriculum system reconstructed covering basic courses, professional foundation courses, career planning and professional development courses, which are completed the 1-2 grade in a university. (2) Some students form a learning or research team in accordance with their own career interests, and the team choose and design their own favorite career development according to reports of the development trends of bio engineering industry, which the government, enterprises, scientific research institutions and universities teachers jointly issued; they develop new biological engineering products, design new technology, or research and learning under an team of teachers guide. At the same time, the document of product or process is their graduation thesis (Design), which become the foundation of the student career development after graduation, and academic combines together closely with career or industry. (3) the students selectively learn professional courses or test skills according to the needs of their product or process development or learning, and they can learn these courses at any college of the University, but also can learn these courses at any University by way of credit trust. (4) After four or more than four years of study and research, each student will probably become a senior talent in engineering field or a product engineering, and has profound knowledge system and their own engineering production or engineering production process. (5) Upon graduation, each student applies for a job or start their own business with their own engineering research results or the production process belong to their owner.

2.2 The basis of biological engineering and the principle of Educational Psychology of NCM

2.2.1 Interest role in talent Cultivating

That interest is the best teacher of learning or career struggle is an acknowledged classic. From the angle of educational psychology, the interest is the psychological characteristics of actively exploring something or getting some knowledge, and is a kind of inner force to promote knowledge and realize the ideal of the people (Michael F. A., 2016). NCM will perfectly integrate the interest, learning, ideal and career of students together. Students choose study direction based on their interest, and the engineering product or process develops into student learning goals, which will finally evolve into the their career and ideal. All successful people have a keen interest in their business, to promote their interests to diligently pursue and achieve success. The survey questionnaire of 185 students showed that 98.1% of the students do not know their own future in what kind of occupation, while 97.7% of the students don't know their knowledge in the future have what use, these data indicated that the students dazed and boring bioengineering, which make students weariness on learning.

2.2.2 The ideal role in talent cultivating.

Ideal is the desire and pursuit which people formed in practice about the future development of the society and their owner, and embodied the people's weltanschauung, philosophy and values in the goal. And it is the product of human social practice. Practice is the soul of engineering education, biological engineering education must provide opportunities and conditions for the reconstruction of students ideal, rather than students and

teachers are confined in the constantly training and assessment. Ideal is the largest source of interest, and interest is the best teacher of learning. NCM will be the ideal and the interest combined together to form a benign learning psychology, which can promote the benign development of biological engineering education. In addition, NCM is able to guide students to the starting point of struggle, the career is the ideal target unremittingly struggle in a person's life and work hard, it is to achieve the highest level of human needs, social recognition and self value.

2.2.3 Limited learning effort and learning time

Anyone learning effort and learning time is limited. No one can finish the human accumulating knowledge and civilization achievement, also no one learns only for learning, the ultimate goal of learning was to do something. The professional characteristics of biological engineering makes the contradiction become more prominent, when students finish mathematics, physical, chemical and biological basis, they also learn the professional knowledge and skills of Agriculture, Industry, Medicine, Medicine, Energy, Environmental Protection, Metallurgy, Chemical Raw Materials, Animal, Plant, Microorganism, Food, Brewing and more field. Therefore, bio-engineering students can't finish all the contents in the limited time, how to improve their learning efficiency has been the focus of teaching research. The knowledge that students learn become more compact in NCM, and NCM makes professional knowledge fine but complex. In other words, rather than spend a lot time learning knowledge and skill regardless of their cause, it is better to learn knowledge and skills related to their career and make them more profound. Therefore, we survey found that 97.4% of students are trained at least six months to a year before induction, which confirmed the existence of the problem.

2.2.4 Relationship between CDIO idea and NCM idea

CDIO is based on the life cycle of the product development, operation, maintenance and waste as the carrier, to establish a set of mutually support each other and organic links course system, to let the students actively and practically learn engineering (Michael F. A., 2016, Guo Lingling et al. 2012). However, NCM is different from CDIO in a concrete engineering product or system as the carrier, to dynamically construct a personalized support each other and organic links course system, to sensitively reflect biological engineering talent market demand at any time, but also it is innovating, leading product updates, creating products market and the talent market. The core of CDIO is students learning engineering and creating the engineering in the engineering scene, to enable students to grow into new talents with proficiency in a particular line (Michael F. A., 2016, Guo Lingling et al. 2012). But NCM pay more attention to students' human factors, highlighting the role of human emotion, ideal, interest in engineering teaching, while CDIO shows even more Talent Engineering Training, highlights the "student product" factor in the talent market. So NCM is more in line with the principles of education than CDIO. It more embodies the educational people-oriented concept. Therefore, the concept of NCM is sublimation and progressive base on the concept of CDIO.

3 Difference and analysis of NCM and current CDIO

3.1 Difference of idea and form between NCM and current CDIO

NCM is based on theory of biology with the operation cycle of engineering products as the guidance, dynamically to help students build their own personalized engineering knowledge system. Engineering products are firstly contacted with students' interests, ideals and feelings together. However, the current reforms form of the biological engineering curriculum base of CDIO has deviated from the idea of CDIO (Guo Lingling et al. 2012). Almost every curriculum is implemented by the same model that is compression of theory and increase of the design or the experiment (Yu Feng et al.2012, Guo Lingling et al. 2012). So, its form is CDIO but the idea is still passive education, and there is no making students actively learn the engineering scenario. Therefore, creativity and wisdom of the teachers and students are not released, but it was imprisoned in cages of the assessment of each other. However, NCM is completely open to the cultivation mode, to greatly liberate wisdom of teachers and students base on engineering background, it can let them learn in creation, creation in learning. The general goal of CDIO develops an engineer who has the technique of basic knowledge, who can lead team innovation, development and operation the better products and who has social and historical responsibility. But after reform of current CDIO, the students busy with all kinds of certification and examination. In fact, graduates are without a good command of basic knowledge, and they do not have a new product, new technology and new skills. NCM can make students independently research their own engineering product or engineering technology, which can establish the confidence, interest, ideal, career and occupation of the students, and students' interest arouse them learning motivation and innovation ability.

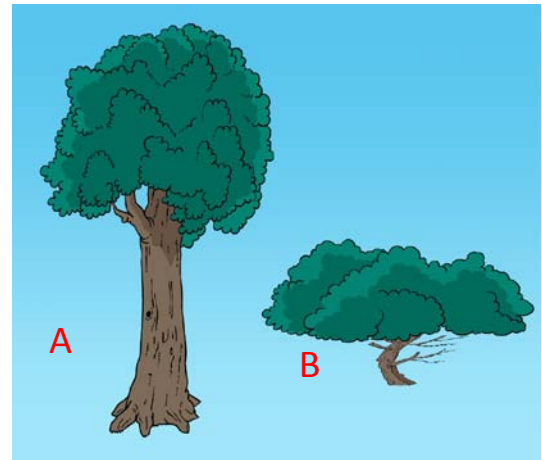
3.2 Difference of thought and evaluation between NCM and the current CDIO

The design of CDIO engineering education inspired by the life cycle of engineering products (system), and the engineering situation are implanted into the education process, where a new generation engineers team are cultivated and they have a high level, a solid professional basis, and noble professional ethics. This advanced idea is worthy of recognition and promotion (Michael F. A., 2016, Guo Lingling et al. 2012). But the education process is equivalent to the engineering product process. It will violate the educational principle of people-oriented. Although the cultivating mode added capacity evaluation, sentimental evaluation, responsibility evaluation, education of engineering is not equal to the engineering of education. Educational engineering logic is as long as the students with the CDIO course the listed system assessment standards they can become an excellent engineer. So much so that they can lead to developing and run new product, new process or a new system. Such logic is worth discussing. Chinese type CDIO engineer cultivating mode is hybridism with " thinking of the student be the product", " thinking of exam oriented ", " thinking of quantitative assessment " and the idea of CDIO. Therefore, they need to build a quality certification system which can regard students as products for certification. Unfortunately, this kind of system does not exist, because the person is not a product. The basic idea of NCM is that students are evaluated through their creating a new product or process or a new system because human evaluation is evaluated through what he had done but not to various indicators of persons. In other words, the excellent engineer trained by the current CDIO mode may create a product but not be able to create a product in the future; however, the

engineers trained by NCM have created new products, so the engineer is not excellent engineers?

3.3 The difference of talent quality between NCM and the current CDIO

There is the obvious difference of talents in quality between NCM and the current CDIO. Talents cultivated by NCM have not only a solid foundation of knowledge but also a set to knowledge system which be able to create at least one engineering product. Thus, this talent is similar to a tree with a developed root system, clear main trunk and the peripheral branches (Figure 3). Talents trained by the current CDIO also have a knowledge system and many indexes of certification examination, but they did not highlight the skills and knowledge of one engineering product. So this talent is similar to the bush with a developed root system and luxuriant foliage, without clear main trunk (Figure 4). That the tree is different from the shrub is the main trunk which can become a man of tremendous promise. But any branch of shrubs can only be used as ingredients. Biological engineering is a sunrise industry, but it still does not have too big improvement for many years in China. The main reason is that the majority of engineering talent are similar shrub but not similar tree. Therefore, there is a hand enterprises lack the high fine talent. On the other hand, a large number of college graduates cannot find a job. University must open up a soil of the root and an innovative space of growth for biological excellent engineer. Therefore, with the help of interest, the NCM could find a development potential branch of students, the branch will be developed into a trunk through the knowledge of nutrition and selected, the trunk will develop into a capable pillar of outstanding engineer. The most typical example is Bill Gates who was interested in computer software engineering, which makes him to achieve as the world's most outstanding engineers. As everyone knows he didn't finish the curriculum weaved by his university while his whole life learning all around his engineering products. This thing enlighten that a good engineering product is not only the achievements of one's career but also likely to change the world.



Note: Instruction of the letter A is that the talents cultivated by NCM is similar to a tree with developed root system, clear main trunk and the peripheral branches. Instruction of the letter B is that the talents cultivated by current CDIO is similar to a bush with luxuriant foliage without clear main trunk.

Figure 4 the schematic diagram of talents quality between NCM and the current CDIO

4 Questionnaire of NCM

The basic idea of NCM was sent to 300 graduates of 2004-2013 10 years by E-mail, 185 of graduates reply to me (see table 2). Students with their own projects, product and process are very popular when they obtain employment, because many enterprises do not have a good investment projects and worry, which is the student said in reply to a message. The questionnaire showed that NCM is more close to the actual needs of students and social demand than other cultivating model. Then, I pay a return visit some graduates who have a

suspicious and negative attitude of NCM by email or phone, and they think that learning may be more difficult or not easy to get a diploma. Furthermore, the questionnaire of 93 students show that have 88.6% of the students are willing to accept the NCM, and students not willing to accept NCM are worried about their self-study ability and not be able to get a diploma, because they just want to graduate and employment as soon as possible. 97.7% of the students thought that NCM would let them have the motivation to learn, because they are doing something of their interest, and more important are that it is their future career.

Table 2 the investigation of feasibility of NCM from Yanshan University biological engineering 2004-2013 alumnus

IF you again go to University, would you choose a new cultivation model?	Yes	89.3%
	No	10.7%
You think that can be the new cultivation mode help employment?	Yes	95.3%
	No	4.7%
You think that would students be accepted when they take their own product or process for a job under the new cultivation mode?	Willing to accept	64.2%
	May accept	18.3%
	Not to say	14.4%
	Refuse	3.1%
If you graduate in the new cultivation mode, you can choose their own business or the company?	My own business	44.7%
	Company employment	39.6%
	Not to say	15.7%
In the new cultivation mode, do you think you would have the learning power?	Yes	95.8%
	Not to say	3.3%
	No	0.9%
Do you think the new cultivation mode and the current cultivating mode which are more connected with the students' learning state and social needs?	New cultivation mode	67.8%
	Current cultivation mode	14.6%
	The two are not good	8.5%
	The two are good	9.1%

Note: survey data source in 2004-2013 year 185 alumni

5 Summary

In conclusion, with the rapid development of science, technology and the social economy, the talents of social demand is also constantly changing, which requires higher education must be synchronized to the science and technology and the social economy demand, in order to achieve the talent cultivating objective. NCM can fundamentally solve requirements for talent cultivating which must closely follow the development of science, technology and social and economic. However, there are many issues need further study in NCM, and there are many questions need to be answered, but they will be discussed in other articles due to space limitations.

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