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Case Report

Teaching Reform in Biochemistry - Facing the Washington Accord and Engineering Accreditation

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Abstract: China was accepted as provisional status of the Washington Accord with full voting rights in 2013. After that, the major of "Pharmaceutical Engineering" in Beijing University of Chemical Technology applied for the engineering accreditation first as an example in China. The graduate attribute (GA) is the most important to judge whether a major can pass the accreditation. Biochemistry plays an important role on helping students reaching the standards mentioned in GA. In order to reach this goal, some reforms in teaching have been conducted based on GA. Reforms include expended learning, heuristic teaching, student-centered teaching, database construction, outside class education, etc. After reforms, classroom was more active, students got more training and improvements outside classroom, and their satisfaction to this course increased. The results could provide some references and offer a model to other universities or majors to make adjustments for engineering accreditation, and thus to comprehensively improve the quality of engineering education in China.

Keywords: Biochemistry Teaching, Washington Accord, Engineering Education, Reform

1. Introduction

The Washington Accord was first sponsored and signed by the civil societies of 6 countries—US, UK, Canada, Ireland, Australia, New Zealand—in 1989. The accord is mainly for the international qualification recognition of undergraduate engineering degree (generally four years). Accreditation decisions made by one signatory are acceptable to the other signatories. The person who has graduated from any signatory should be regarded as having the academic qualification to engage in the primary engineering work by other signatories [1]. On 19th, June, 2013, China Association for Science and Technology (CAST) was accepted as provisional status of the Washington Accord with full voting rights [2]. After that, the major of "Pharmaceutical Engineering" in Beijing University of Chemical Technology (BUCT) applied for the engineering accreditation first as an example in China. And the major of "Bioengineering" will apply for the accreditation this year. Biochemistry, as a fundamental specialized core course which takes the most credit hours in these two majors, plays an important role and faces a lot of new challenges and tasks in terms of engineering accreditation. Since there exists problems in traditional education of China, let alone the education of biochemistry, a tough course which has complex content [3-4]. In order to adapt to the new period and to cope with the requirements of engineering education, reforms are urgently needed.

2. Theoretical Background

2.1. Curriculum in BUCT

BUCT set up the Department of Biochemical Engineering 28 years ago. College of Life Science and Technology, which consists of 3 undergraduate majors (Bioengineering, Pharmaceutical Engineering, and Biotechnology) and 2 postgraduate majors (Biochemical Engineering and Pharmaceutical Engineering), was established in 2003 based

on the Department of Biochemical Engineering. Biochemistry has been being one of the core courses since the very beginning. Its main tasks are to make students master the basic theory, knowledge, techniques of life science, and the recent research progresses, through which students will be able to lay the foundation of their further study and research. Now, biochemistry is also set as an elective course for the students from other colleges and majors. The course is mainly specialized into 72 class hours, 48 class hours, and 32 class hours, with Biochemistry Experiment as a supplementary course (Table 1).

Table 1. *Information of all biochemistry courses in BUCT.*

Course name	Course type	Crs.	Hrs.	Student Major	Class No.[A]	Term	Course code
Biochemistry	Required	4.5	72	Bioengineering	3	5	BIO31700T
Biochemistry	Required	4.5	72	Biotechnology	1	5	BIO31700T
Biochemistry	Required	4.5	72	Pharmaceutical Engineering	4	5	BIO31700T
Biochemistry	Required	4	62	Biomaterial[B]	2	7	BIO31600T
Biochemistry	Required	3	48	Reform Experimental Class	5	2	BIO21400T
Biochemistry Experiment	Required	2.5	40	Bioengineering	3	7	BIO31300L
Biochemistry Experiment	Required	2.5	40	Biotechnology	1	7	BIO31300L
Biochemistry Experiment	Required	2.5	40	Pharmaceutical Engineering	4	7	BIO31300L
Basic Biochemistry	Elective	2	32	Environmental Engineering[C]	3	7	BIO11200T
Basic Biochemistry	Elective	2	32	Chemical Engineering[C]	12	7	BIO11200T
Basic Biochemistry	Elective	2	32	Energy[C]	3	7	BIO11200T
Basic Biochemistry	Elective	2	32	Applied Chemistry[D]	10	8	BIO11200T

A, each class contains 30 students; class No. indicates the total number of students in that major; for the elective course, elective rate has been higher than 50% for recent 5 years. *B*, major in College of Material Science and Engineering. *C*, majors in College of Chemical Engineering. *D*, major in College of Science.

Course settings of College of Life Science are shown in Table 2. It's clear that biochemistry course possesses the most credits and hours among all specialized required courses.

Table 2. *Curriculum of specialized required courses in College of Life Science and Technology.*

Course name	Course code	Crs.	Hours.	Term	Major
General Chemistry	CHM10700T	4.5	72	1	
Chemistry Experiment (I)	CHM11200L	2.0	38	1	
Organic Chemistry	CHM13700T	4.5	72	2	
Chemistry Experiment (II)	CHM11100L	1.5	32	2	
Physical Chemistry (I)	CHM34400T	3.0	48	4	
Chemistry Experiment (III)	CHM33301L	2.5	48	4	
Physical Chemistry (II)	CHM34402T	3.0	48	5	ABC
Biochemistry	BIO31700T	4.5	72	5	
Chemistry Experiment (IV)	CHM33100L	1.5	32	5	
Microbiology	BIO33500T	3.5	56	7	
Biochemistry Experiment	BIO31300L	2.5	40	7	
Microbiology Experiment	BIO33300L	2.5	40	8	
Biotechnology	BIO44301T	2.5	40	8	
Principles of Chemical Engineering (I)	CHE21600E	4.0	64	7	AB
Principles of Chemical Engineering (II)	CHE24400E	3.0	48	8	
Biochemical Reaction Engineering and Equipment	BIO44302T	2.5	40	7	A
Bioseparation Engineering	BIO44300T	2.5	40	8	
Pharmaceutical Chemistry and Drug Design	PME31300T	2.5	40	7	
Pharmaceutics	PME42300T	2.5	40	7	B
Pharmaceutical Engineering and Technology	PME47200T	2.0	32	8	
Cell Biology	BIO33202T	2.0	32	4	
Molecular Biology	BIO32401T	3.0	48	7	C
Molecular Biology Lab	BIO32200L	2.0	40	8	
Genomics	BIO42200T	2.0	32	8	

A, B, and C represent 3 majors: A, Bioengineering; B, Pharmaceutical Engineering; C, Biotechnology.

2.2. Biochemistry Teaching

According to the previous experience on teaching, this course was divided into two parts, which are static biochemistry and dynamic biochemistry, and each of them takes 36 hours. The structure, character, and function of biomolecules are related in the static part. And in the dynamic part, teachers will explain in detail on dynamic changes,

metabolism process, and correlation of biomolecules *in vivo*. The two parts are inseparable, taking mid-term examination as the dividing line, forming a complete system of the course. According to the science and engineering specialty of BUCT, a teaching plan on each chapter, from static to dynamic, focusing the main points, has been made, as shown in Table 3.

Table 3. *Hours Distribution on Each Chapter.*

Part	Chapter	Hours
Static	Introduction	1
	Carbohydrate	6
	Lipid	5
	Protein	8
	Nucleic acid	6
	Enzyme	8
	Vitamin	2
Dynamic	Biological oxidation	4
	Carbohydrate metabolism	7
	Lipid metabolism	6
	Amino acid metabolism	4
	Nucleotide metabolism	4
	DNA and RNA synthesis	5
	Protein synthesis	4
	Metabolic regulation	1
	Recombinant DNA technology	1

With the fast development of life science, the teaching contents are also in an incessant adjustment and renewal. Until now, besides the basic knowledge in biochemistry textbooks, in order to reinforce students' ability of applying theory to practice, more time has been spent in class to teach them how to use the knowledge of biochemistry to develop valuable products in the area such as agriculture, industry, medical science, and environmental protection.

2.3. Problems Occurred in Teaching

China has a long history as well as its education. Though the education mode in China is getting better and better, problems left over by history and formed in tradition have some bad effects on modern education. Because of the "imperial examination system" in ancient times and the "college entrance examination system", students get used to paying their attention to school works and getting higher grades, while many of them don't know what actual significance the knowledge they have learned in class has, seriously lacking of the connection of theory and practice. What's more, teachers prefer to dominate classes, they talk most of the time, want to teach everything in textbooks until the bell rings.

Even in college courses, problems mentioned above sometimes occur, especially in biochemistry courses. Biochemistry is a subject which has complex content and intensive knowledge. Restricted by limited hours, teachers usually dominate the class and adopt the traditional "spoon fed" method to teach their students [5]. This somehow facilitates teachers' teaching design, but does ignore students' initiative and comprehensive exercises [6]. After statistical analysis, the average final examination points of biochemistry in BUCT during 2007-2013 were around 75. Classroom atmosphere was boring, communication between teacher and students was poor, and the students who preferred to sit in the back of the classroom were usually absent-minded. It's hard for previous teaching mode to fully activate most students' enthusiasm of independent thinking and learning.

2.4. The New Tasks Based on the Washington Accord

Joining the Washington Accord is an important act to improve the quality of engineering education and promote the engineer training in accordance with international standards. And it is of great significance for the Chinese engineering education to face the international challenge and go out to the world. As one of the key engineering universities, BUCT must take the initiative to meet the needs of the Washington Accord. In all items, the graduate attribute (GA) is the most important one to judge whether a member has reached the standard. Each signatory has its own standard, but they are equivalent on certification. Here are 10 GA requirements (Table 4) of Chinese Engineering Education Accreditation Standard devised by CAST, they are the same in essentials with the Washington Accord GA profiles [7].

Table 4. *Ten Graduate Attributes Devised by CAST.*

No.	Content
1.	Have humanities and social science literacy, sense of social responsibility and engineering professional ethics.
2.	Have the ability to apply knowledge of mathematics, natural science, economy and management to engage in engineering works.
3.	Have the ability to apply basic engineering knowledge and the basic theory knowledge of this major to solve problems; Have the experience of systematic engineer practice; Get to know the present situation and development trend of the frontier.
4.	Have the ability to design and implement engineering experiment, and be able to analyze experimental results.
5.	Master the basic method of innovation, have the attitude and consciousness to pursue innovation; Have the ability to apply theory and technic methods to design systems and process, be able to take together various constrict factors such as economy, environment, law, security, health, and ethics during the designing process.
6.	Master the basic methods of literature searching, data query and using modern information technology to obtain related information.
7.	Get to know the principles, policies, laws and regulations on the production, design, research and development, environmental protection and sustainable development of the occupations and industries related to this major, be able to understand the impact of engineering to the world and society correctly.
8.	Have certain ability of organization and management, expression, interpersonal interaction, and being effective in a group.
9.	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
10.	Have the international perspective and the ability of cross-cultural communication, competition, and cooperation.

Reaching the targets above needs to put all the elements, such as course teaching, course design, experiment training, social practice, and so on, together. Being one of the most important courses, and possessing the highest credit hours, some initiative actions have been taken to adapt the requirements of engineering accreditation and some reforms have been performed.

3. Teaching Reform Content and Its Achievements

Facing the Washington Accord, especially 10 GA of Chinese engineering education accreditation standard, after summarizing the disadvantages of previous education mode, some reforms have been carried out in biochemistry teaching of 10 classes (300 students) in last three years.

3.1. Expanded Learning

First, discard the old teaching method that teachers taught mainly from textbooks. Rather, a lot of engineering practice cases were shown to students in class [8]. Taking famous professor's industrialization achievements in BUCT and the newest research achievements of pilot plants as a model, the students were enlightened and their understanding of biological products industrialization and the prospects of the major were increased. Penetrate "case based learning" into each knowledge points as possible as we can. So, a thought that puts basic research, application and exploration, and industrialization into one package was established and put into action. For example, Tianwei Tan's research group of BUCT started from the basic research of lipase secretion by microbes, cloned and expressed efficient lipases, and applied them to the area of waste oil recycling and bio-diesel production successfully [9-11]. Through this example, students can not only learn and review a lot of knowledge such as properties of lipids, catalytic reaction of enzymes, DNA recombination and expression, fermentation, and purification technology, but also get to know how to apply theory to practice. During the explanation of cases, some guidance reading to some research articles was also given. Through this methods, it's easier for students to establish a concept of "learning to use, learning for practice, lifelong learning". The benefit that this reform brought to us is that students be closer to meet the requirements of item 3, 5, 6, 7, and 9 mentioned in GA.

3.2. Heuristic Teaching

Second, try to build a mode of heuristic education. In this way creativity has been fully trained [12-14]. For example, in the past when teachers were talking something about the history of the interpretation of genetic code, they would list the scientist's contribution one by one chronologically. Some students had the idea that those people were genius who won Nobel Price, so they were far distance away from an ordinary student. Others might think these historical stories had no relationship with their final examination so they were useless. Now some reforms and changes were brought into the class. Instead of being "told", students were "guided" step by step. At first we ask some questions faced by the "genius" at that time, for example, how many nucleotides combined together can at least meet the requirement of 20 amino acids? Then guide them to think, and try to solve the problems by themselves. After that comes the second question: How to prove that triple nucleotides encodes for one amino acid? Then the last question: How to get to know that which codon specifying an amino acid? Finally they will find out that what they are thinking in class is remarkably similar to George Gamow, Francis Crick, Sydney Brenner, and Marshall Nirenberg a few decades ago. Distance between genius and students was shorten and students were likely to increase their confidence and find the interests on learning since then. In this way, students' abilities mentioned in item 3, 5, and 9 of GA can be trained.

3.3. Student-Centered Mode

Besides, the "teacher-dominating mode" has been changed to the "student-centered mode" to some extent through encouraging students as teachers to teach some chapters. Students were asked to organize a team of 4 people freely, each team would be distributed a title in the textbook. Then they needed to preview the lesson, collect information, and prepare to give a lesson and answer questions on the platform. Many of them have never experienced being as a teacher. Finally, the real teacher would make some comments on their performance, summary and replenish the emphases. Their performance would count towards the final grades by 30%. In the past, students were asked to give a presentation in class using Powerpoint. But giving a presentation had many disadvantages. Some students just followed the script, bowing their heads, purely in order to complete the tasks. In this way, being as a teacher and working in a group, students' abilities of expression, management, and organization are fully trained, corresponding to the requirements of item 3, 6, 8, and 9 of GA.

3.4. Database Construction

What's more, there's a plan to further cut down the credit hours of biochemistry course in order to raise the independent learning abilities [15]. We cut the credit hours from 80 to 72 3 years ago, and plan to cut it to 64 by 2017. In order to ensure the effectiveness of teaching, much attention was paid to the construction of teaching database. Pictures, videos, audios, coursewares which were related to biochemistry were put on the website and students could browse the site freely. Some knowledge points in the final examination will be chosen from the website. The ability of self-learning could be trained in this way. In this part, attributes 6 and 9 were trained.

3.5. Outside Class Education

At last, students were encouraged to take part in nationwide competitions. Under the guidance of teachers, 5 groups of 19 students in biochemistry course have received extracurricular

scientific research training, and have participated in several matches including "The Challenge Cup" and "National Competition for Energy Conservation and Emission Reduction", etc, which are very famous among university students. And they won a few awards. In the preparation process and during the competition in other cities, students not only obtained a wider perspective, but also improved their abilities of writing, expression, practice, and teamwork cooperation, which corresponds to item 6, 8, 9, and 10 of GA.

3.6. Results

The reform attempts do have borne some fruits. First, statistics showed that although the credit hours of biochemistry have been cut and more attention has been paid on things outside textbooks, students' examination scores barely moved, moreover, their satisfaction to this course increased year by year, shown in Figure 1.

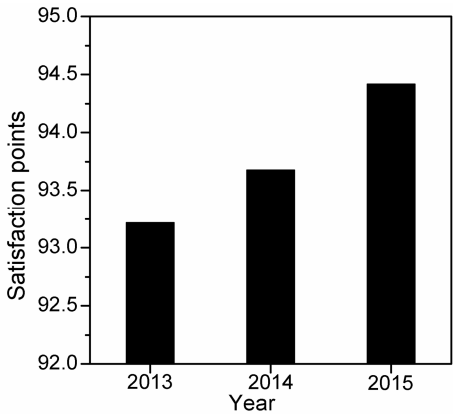

Figure 1. *Students' satisfaction to biochemistry courses from 2013 to 2015.*

Satisfaction point is an evaluation index that students who attended the course give based on their own feelings and opinions. Specific evaluating indicators are shown in Table 5.

Table 5. *The Evaluating Indicator of Satisfaction Points.*

Evaluating indicator	Weight
1, I learned a lot from this course, mastered and understood the main content that teacher taught	0.2
2, Teacher was full of passion and confidence when teaching this course	0.1
3, Teacher was well prepared for this course, lectures were clear and understandable	0.1
4, Carefully corrected homework and paid attention to analyzing problems	0.1
5, Appropriately use of teaching methods	0.1
6, Easily to communicate inside and outside the class, encourage students to express their opinion	0.1
7, Be able to teach students in accordance with their aptitude	0.1
8, Compared with other teachers, the overall evaluation I'm on him/her is	0.2

Each indicator has 5 options, A for 95 points, B for 85 points, C for 75 points, D for 60 points, and E for 50 points. The total points were then obtained according to the weight. Item 1 and 8 are the largest weight, indicating that students felt better and better, learned more and more from this course. And compared with previous teaching, current teaching methods were more and more accepted and loved by students.

Second, the achievement degree of final examination (ADFE) increased after reform (Table 6).

Table 6. *The ADFE in last three years.*

Year	2013	2014	2015
Points	65	70	80
ADFE	0.7778	0.8223	0.8221

ADFE is also an evaluation index required by engineering accreditation to measure the effect of teaching. Questions around 70 points to test students' ability of designing and carrying out experiments and their mastery of basic theories would be designed. And ADFE was calculated by diving the actual points by the designing points. This is a well known way in China to measure students. It's desirable that the ADFE reached 0.8 after reform.

More importantly, students' abilities, which cannot be shown by numbers and figures, did improve a lot during the reforming. Some students were interviewed about their feelings to the new teaching methods, and most of them thought that they had benefited from these reforms. Jian Shen, who scored high points being as a teacher, said during the interview: "Our topic was polysaccharide hydrolysis and its industrial application, I clearly remember that. I was looking forward to the day that I stand in front of the class talking something. So my teammates and I did well-prepared job before. Besides the knowledge in textbooks, we searched and read a lot of materials related to our topic, so we could share more things to others. In the end we received your praise and recognition and we were so happy. Polysaccharide hydrolysis is a part that I know the best in our textbook, I worked out related problems in the final examination easily."

While, Xuejian Li, when asked about being as a teacher, he said: "I am kind of introverted, so when I heard that someone needed to teach something as a teacher, I felt nervous and a little scared. Then I was forced to join a team. In order not to drag my team, I had a good preparation job. At last, we had a good performance in teaching and I found out it was not that hard. I hope I can be braver and more positive next time. "

Wenshi Xie is a girl who was active in class, she said during the interview: "This semester you introduced many cases to us, some were lab researches, some are industrial applications. For example you once told us something about production of humanized glycoprotein, another time you explained in detail about how to improve the whitening effect of cosmetics by glycosylation. They are fresh and interesting and made our classes less boring, I really love these cases. Cases can also help me to consider and choose my subject and experiment I'm interested in."

4. Conclusion

In conclusion, like many other universities in China, there existed some problems in biochemistry teaching in BUCT before. But facing the Washington Accord, a series of positive

adjustments have been introduced to both the students and the teaching of biochemistry at BUCT. Targeted reforms had been carried out according to 10 GA requirements of Chinese Engineering Education Accreditation Standard. After that, in the teaching process, some good results were shown. This course avoided students to be bookworms and live in their own world to some extent. The abilities of students which were indicated in 7 items out of 10 mentioned in GA requirements of China were well trained. Being as a teacher provided them with courage and expression ability; heuristic education reinforced their confidence; database construction increased self-learning ability. These are not enough, many courses need to work for it together if two majors, "Pharmaceutical Engineering" and "Bioengineering" in BUCT want to pass the engineering accreditation. And, biochemistry teaching, will be as an example keeping adjusting itself and reforming facing the Washington Accord and GA requirements. The results could provide some references and offer a model to other universities or majors to make adjustments for engineering accreditation, and thus to comprehensively improve the quality of engineering education in China.

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Biography

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