The Development of a Microbiology Course for a Large Class of Students of Diverse Backgrounds: A Review of Seven Years of Change in Zhongshan (Sun Yet-Sen) University, China

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Abstract

The Chinese higher education sector has been undergoing dramatic reforms during recent years. Zhongshan (Sun Yet-Sen) University is one of the leading pioneers in these reforms and the present paper is a review of a seven-year period of change in the University during which a Microbiology course has been remodelled to suit an increasing number of students of diverse educational backgrounds. The main purpose of this paper is to provide the general landscape about what we have been doing, and what we are going to do, and reflecting on some concepts of contemporary teaching strategies. The main content includes a brief introduction to current Chinese higher education reforms, using the Microbiology course in Zhongshan (Sun Yet-Sen) University as an example. The specifics of the paper will focus on student-centred teaching, and the restructure of teaching strategies to suit larger classes, focusing on student-centred learning. A description of this trial will be valuable in providing a window for western colleagues to understand the higher education reforms in Chinese universities, as well as providing an example for Chinese colleagues for reference.

Introduction

The development of a Microbiology course for a large class of students with diverse backgrounds has been conducted over a seven-year period in Zhongshan (Sun Yet-Sen) University. The main purpose of this paper is to describe what has been achieved already and what is going to happen in the future. The paper consists of three parts. Firstly, Chinese higher education reforms that are occurring will be introduced, using the Microbiology course in Zhongshan (Sun Yet-Sen) University as an example. Secondly, the current teaching strategy being used will be described. Thirdly, a change of teaching strategy, focusing on student-centred learning, appropriate for larger classes will be discussed.

The Chinese higher education system has undergone dramatic reforms during recent years. Zhongshan (Sun Yet-Sen) University is one of the pioneers in this reform process. This university is located in Guangzhou city, which is the capital of Guangdong Province with 2,800 years of history, making it one of the oldest cities in China. Guangdong Province, situated in southern China adjacent to the South China Sea (Figure 1), has been very important to China through its pioneering leadership in economics and politics during the past two decades. Hong Kong and Macau are near to Guangzhou city, being about 150 km away.

Zhongshan (Sun Yet-Sen) University is named after Dr Sun Zhongshan, also called Sun Yet-Sen. Dr Sun Zhongshan established the first republic in the five thousand years of Chinese history. He was the first President of the Republic of China, and was the former President of this University. Currently there are three campuses in Zhongshan (Sun Yet-Sen) University. The main campus is in Guangzhou City, and is more than one hundred years old. The oldest building on the campus was built by an American professor, Dr Martin, in 1891, which is still functioning very well today. It is one of the most beautiful university campuses in China, and attracts many scholars and teachers. Two years ago, a new campus was started in Zhu Hai City, near to Macau. On the new campus the Teaching Building is probably the largest teaching building in the world, starting from one hill and ending at another hill. This building caters for 12,000 students in class at the same time. The modern Library Building is also well equipped with modern facilities.

Microbiology is considered a very important discipline by this university. During the last seven years we have made a number of innovations to the teaching as well as following the Undergraduate Microbiology Curriculum Recommendations of the

American Society for Microbiology (ASM) (http://www.asmusa.org/edusrc/edu32a.htm#Core). We believe that these changes give valuable insights for western colleagues in understanding the higher education reforms in Chinese universities, as well as providing an example for our Chinese colleagues for reference. Some results from different stages of development have already been published in Chinese journals (Ai and Meng 1999, 2001, 2002a), and this substantiates our claim as leaders in teaching in this field in China.

Figure 1. Location of Zhongshan (Sun Yet-Sen) University. Guangdong Province and Guangzhou City (left), Guangzhou campus (middle) and Zhu Hai new campus – a large teaching building (right).

Current strategy for teaching Microbiology course

Microbiology course curriculum

Microbiology as a discipline is of worldwide importance as acknowledged by the American Society for Microbiology setting very high standards for the undergraduate curriculum, as reported by Cundell (2002). Some of the core themes and corresponding core concepts are illustrated in Table 1 (Fass, 2000), such as microbial cell biology, microbial genetics, interactions and impact of microorganisms with humans, interactions and impact of microorganisms in the environment, and integrating themes. The ASM recommends an emphasis is placed on health, better living and survival, and for this, training in Microbiology is essential. The course at Zhongshan (Sun Yet-Sen) University provides a modern approach including modern concepts, such as biotechnology, molecular biology, genetic engineering, microbial drugs, microbial disease and transmission, microbial evolution, and microbial diversity.

Core Theme	Concepts
1. Microbial cell biology	Information flow within a cell Regulation of cellular activities Cellular structure and function Growth and division Cell energy metabolism
2. Microbial genetics	Inheritance of genetic information Causes, consequences and uses of mutations Exchange and acquisition of genetic information
3. Interactions and impact of microorganisms and humans	Host defense mechanisms Microbial pathogenicity mechanisms Disease transmission Antibiotics and chemotherapy Genetic engineering Biotechnology
4. Interactions and impact of microorganisms in the environment	Adaptation and natural selection Symbiosis Microbial recycling of resources Microbes transforming environment
5. Integrating themes	Microbial evolution Microbial diversity

Table 1. ASM undergraduate microbiology curriculum recommendations

Increase in student numbers and associated course changes

Microbiology as a discipline is particularly important to the developing countries including China, and the teaching of it at Zhongshan (Sun Yet-Sen) University has been radically modified in recent years. These are reviewed in Ai and Meng (1999, 2001, 2002a) and they have received positive acknowledgements from their Chinese colleagues. Table 2 highlights the increase in student numbers enrolled in the course since 1996. In 1996 there were 25 students majoring in microbiology from the life sciences school. One year later in 1997, there were 100 students enrolled from various schools. Three years later in 2000, there were 200 students enrolled who were taking a variety of majors, and by 2002

there were 250 students enrolled. In the coming year 2003, there will be 400 students including some now majoring in medicine. These data reflect the fact that the Chinese higher education system is undergoing dramatic growth, and our university is very successful in attracting students nationwide.

Categories	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Class size	25	96	118	178	198	220	250	400
Schools/ Departments	Life	Life Environmental Sciences	Life Environmental Sciences	Life Environmental Sciences Chemistry Pharmaceutics	Life Environmental ..Sciences Chemistry Pharmaceutics	Life Environmental Sciences Chemistry Pharmaceutics	Life Environmental Sciences Chemistry Pharmaceutics	Life Environmental . Sciences Chemistry Pharmaceutics Medical
Majors	Microbiology	Microbiology	Microbiology	Biotechnology	Biotechnology	Biotechnology	Biotechnology	Biotechnology
Non-majors		Biology Biochemistry Pharmaceutics Environmental Sciences	Biology Biochemistry Pharmaceutics Environmental Sciences	Biology Biochemistry Pharmaceutics Environmental Sciences	Biology Biochemistry Pharmaceutics Environmental Sciences	Biology Biochemistry Pharmaceutics Environment Sciences	Biology Biochemistry Pharmaceutics Environment Sciences	Biology Biochemistry Pharmaceutics Environment Sciences Medicine

Table 2. Numbers of students from four schools during Spring 1996 - Spring 2003

Student-centred teaching

A student-centred teaching strategy has been developed during the past seven years. This strategy has been documented during its development (Ai and Meng 1999, 2001, 2002a). Components documented in the strategy include 'active-study-teaching' components, assessment and evaluation methods, and linguistic arts and teaching strategies suitable for large classes. This paper will focus on the 'active-study-teaching' components including problem solving, oral presentations, class debates, mini-projects, laboratory teams, literature review and writing, and community services. At the curriculum level we chose relevant issues in order to help motivate students to take responsibility for their learning. These include bioterrorism, biological warfare, biocontrol, antibiotic resistance, AIDS, prions, etc. (Baker 2002). We provided good support with the development of a virtual learning environment as well as offering talented students mini-projects to challenge them. Finally, at the curriculum level, we decided to teach our science in English to enable us to use our collaborators' English-version website (e.g. Kaiser 2002). This is necessary because there is new information being placed on the website continually and it is too time consuming to translate it into Chinese for the virtual learning environment. For the past two years the course has been given in English. In 2001, this was in bilingual mode of English and Chinese as a transition to English only occurred in 2002. Student feedback is strongly supportive of this move to English.

There are up to about 250 students in the lecture class but in the laboratory class the students are divided into small groups, to enhance interaction and team work. Students are provided with a virtual learning environment, with the computers connected by broad bandwidth to the Internet. In this way, students can access the English-version website materials from our collaborators all over the world (e.g. http://www.asmusa.org/pasrc/bioprep.htm; http://www.hopkins-biodefense.org/). For part of the course assessment requirements and focusing on generic skills training, each year all students are asked to prepare a mini-literature-review and mini-review paper (either in Chinese or in English) with a maximum of five thousand words. There is a choice of topics. Some of the talented students are asked to give formal oral presentations to the whole class on the basis of their reviews. These written assignments resulting from the students' web activities are a challenge to mark. Plagiarism is a potential problem and the rule is that if one student's work has up to 70% similarity with another student, these students will be asked to explain this similarity, or submit an alternative piece of work for re-review. No explanation will result in a zero score for the assignment.

The talented students are given advice and help with their mini-projects by graduate students from the Microbiology laboratory. As some talented students hate traditional examinations, and would prefer to do a written literature review, this has been adopted as an alternative. In fact one student, with good English and science skills, worked on some very complicated papers on antibiotic resistance from the *Science* Journal (e.g. Archer and Bosilevac 2001; Zhang et al. 2001) and produced such a good written review in English, that she gained a score of 100% for this piece of work.

Some of the examples we have built for the virtual learning environment are adapted from the English-version materials from our western collaborators around the world, including the Vienna University of Technology in Europe and Cornell University in the United States. However it is expensive to develop these types of learning resources and this is limited by the availability of funding.

Student evaluation of Microbiology course and their final grade outcome

The evaluation by students of the course is very positive. They speak very highly about the teaching styles used, including the examination style and the bilingual language teaching style, indicating that these are creative, interesting, informative, valuable and enjoyable experiences. Table 3 shows student response to statements used to evaluate the teaching and the course. Almost 80% of students agree or strongly agree to all of the statements. Table 4 shows that about 80% of the students gained a credit or better in the final grade. No one withdrew from the lecture course; however a few students withdrew from the laboratory course. These students were not majoring in the discipline and found the laboratory course extremely difficult. This reminds us that we should think about how to make multiple modules available for those students who come from a diversity of majors and with different difficulties.

Evaluation item	Student responses (% of respondents)[a]				
	Strongly agree	Agree	Disagree	Strongly disagree	No response
The course was organized, logical, and coherent	47	47	6	0	0
The course encouraged questions and discussion	32	58	3	0	7
Texts and readings were useful	56	44	0	0	0
Major points were established	59	36	2	0	3
Course objectives were clear	51	49	0	0	0
The course workload was more than in other courses	37	41	22	0	10
The course encouraged critical thinking	83	17	0	0	0
I learned something valuable in this course	84	16	0	0	0
I would recommend this course to a friend	90	10	0	0	0

[a] Voluntary response from all students of the course (n=976), total enrollment was 1085 in the last seven years

Table 3. Student evaluations of the Microbiology course

	% Students in test[a]	
	Lecture	Laboratory
A	10	13
B	37	42
C	33	28
D	17	13
F	3	2
W[b]	0	2
Total	100 (1085)	100 (1085)

[a] Combination of data for the last seven years and A=90+; B=80-89; C=70-79; D=60-69; F=fail (that is <59)

[b] Withdrew from course

Table 4. Final grade distribution

Changes to teaching strategy to cater for larger classes

One of the inevitable outcomes of major reforms to the current education system in the People's Republic of China is an increase in the number of students attending university. For Zhongshan (Sun Yet-Sen) University, with its high reputation for science teaching and research, this means larger classes. From Spring 2003, our teachers have to develop an appropriate teaching strategy to cater for this increase in numbers.

New challenges and new trials

The new challenges include larger classes, an increased diversity of students with respect to their discipline major, possibly distance teaching and teaching entirely in English. Student-centred learning approaches will be used as the fundamental teaching strategy. Three aspects will need to be taken into consideration. Firstly, students will be offered a stimulating and motivating course and they will be encouraged to take responsibility for their own learning and to develop their skills through relevant training experiences. Secondly, teacher-structured and supportive processes will be provided during the duration of the course. Thirdly, students will be encouraged to develop the skills for lifelong learning by focusing on learning outcomes and generic skills.

Course motivation

The course will continue to follow the ASM Undergraduate Microbiology Curriculum Recommendations. Maintaining this high standard will allow our students to be qualified in the field of Microbiology for work anywhere in the world. Talented students within the course will be able to choose their own mini-project, with the top 10 talented students given the opportunity to join the research group for summer research training. In this way the top students will be focused on the development of all their generic skills, as well as being encouraged to become professional scientists when they graduate.

Teacher-structured and supportive processes

The virtual learning environment will be a key component in supporting students in their learning. The learning environment will be structured by the teaching staff, maybe using a web management tool like *WebCT*. Such a tool has advantages in the online delivery of resources including online lecture-movies, in providing web-based discussion, quiz, assessment, and in supporting the computer-based mini-projects. This will be further discussed in Ai et al. (2002b) in a consideration of the teaching of Bioinformatics.

Generic skills training and lifelong learning outcomes

For lifelong learning, students need to be able to self-evaluate or self-assess their understanding and knowledge, and this will be particularly relevant to the area of Microbiology in the future. This self-evaluation is like a coin which has two sides, one is associated with self-esteem, making students feel good about themselves and optimistic about their futures, the other is the ability to self-mirror, making students better able to judge their skills and abilities by mirroring the actions of other colleagues. This ability is a difficult one to develop and students need guidance in the development of these skills.

In addition, we will try to figure out what is the best learning style for our Chinese students by doing a large-scale data collection and statistical analysis. This will be a large project for 2003, but one that may develop international links for comparisons.

The pace of change – transition

The main problem would be the pace of this transition. Already the trials have started with teaching Microbiology in English and the initiation of student-centred learning during the last seven years. We have some experiences in dealing with students' motivation and self-evaluation and experience in keeping a balance between generic skills training and the teaching of academic content. In addition, we must monitor the needs of students and staff with respect to these changes to ensure that they are within their comfort zone for effective learning and teaching, as well as informing our senior managers in the institution of the outcomes of these changes so that they can publicly acknowledge and support them.

New opportunities

The new opportunities for us include: (1) setting-up a team to develop curriculum and evaluate the process – the team will be a professor-centred group with the professor taking the central role but with every team member having a specific responsibility; (2) continuing to implement new teaching strategies to enhance student learning outcomes; and (3) nurturing the growth of established international cooperation and collaboration, including Cornell University, The University of Sydney (the Faculty of Education, the School of Biological Sciences, the School of Molecular and Microbial Biosciences); and (4) the introduction of a web management tool like *WebCT* for the Microbiology course.

Summary

In summary, the importance of Microbiology as a discipline and the objectives of the Microbiology course are described, along with the current teaching strategies used. Modifications for promoting student-centred learning within growing class sizes are suggested, including increasing student involvement in active learning. Anticipated problems for the future are indicated along with suggestions for solving them.

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Copyright statement

References

Ai, Y. C. and Meng, F. M. (1999) Active-study-teaching methods for Microbiology course. *Microbiology* (in Chinese), **6**, 97-100.

Ai, Y. C. and Meng, F. M. (2001) Evaluation and assessment methods for teaching Microbiology course. *Microbiology* (in Chinese), **2**, 147-150.

Ai, Y. C. and Meng, F. M. (2002a) The development of linguistic arts and teaching strategy for large class of diverse majors. *Zhongshan University* (in Chinese), **6**, 47-54.

Ai, Y. C., Firth, N. and Jermiin, L. (2002b) Building Bridges in Teaching Bioinformatics: The Use of Student-centred Teaching and Problem Based Learning in Cross-discipline Courses. *The China Papers: Tertiary Science and Mathematics Teaching for the 21st Century*, **1**, 51-56.

Archer, G. L. and Bosilevac, J. M. (2001) Signaling antibiotic resistance in *Staphylococci*. *Science*, **291**, 1915-1916.

Baker, N. R. (2002) Summary of bioterrorism curriculum recommendations from the ninth ASM undergraduate education conference in Salt Lake City. *Focus On Microbiology Education*, **9**(1), 20, http://www.asmusa.org/memonly/edusrc/nltrf02.asp.

Cundell, D. R. (2002) Development of a microbiology course for diverse majors: Longitudinal survey of the use of various active, problem-based learning assignments. *Microbiology Education*, **3**(1), 12-17, http://www.microbelibrary.org/Journal/me2002.htm.

Fass, M. F. (2000) Teaching emerging disease: A strategy for succeeding with non-majors. *Microbiology Education*, **1**(1), 20-25, http://www.microbelibrary.org/Journal/me2001.htm.

Kaiser, G. E. (2002) Creating a website of reusable learning objects for use in teaching microbiology lecture to both traditional and web-based students. *Focus On Microbiology Education*, **9**(1), 8-10, http://www.asmusa.org/memonly/edusrc/nltrf02.asp.

Zhang, H. Z., Hackbarth, C. J., Chansky, K. M. and Cha, H. F. (2001) A proteolytic transmembrane signaling pathway and resistance to beta-lactams in *Staphylococci*. *Science,* **291**, 1962-1965.