A review and recognition of teaching strategies in *Cell Biology*: A shift to student-centred teaching

Ni Hong
Nankai University
Tianjin
People's Republic of China

Abstract

This paper gives a general overview of the curriculum design and teaching strategies for the course *Cell Biology* in Nankai University. Based on the theory that learning is an active process in which the learner must be involved, a curriculum redesign, involving concept mapping, problem based learning, case study and online learning approaches, is suggested and discussed in terms of encouraging student-centred learning.

Introduction

The birth of the cloned sheep Dolly and the culmination of the Human Genome Project are indicative of our entry into a new century, which belongs to the life sciences. The cell is the basic structure and activity unit of living things, and cell biology is the study of the fundamental life activities and regulation mechanisms of the cell. The main content of the *Cell Biology* course includes: the structure and function of the cell and its organelles; the mechanisms of important activities of the cell and their regulation, such as the proliferation and differentiation of cells; single transduction in the cell; gene expression and regulation in the eukaryote cell; and the origin and evolution of cells. Thus cell biology is an important basic course for all students of life science. The aim of this course is to ensure that students have a good background in the structure and function of the cell, and basic laboratory skills, such as the use of the microscope and spectrophotometer, cell culture techniques and molecular biology and immunology techniques, so that they can continue to more advanced study.

Over the last two decades, our understanding of cell biology has grown rapidly, and the information upon which this understanding and knowledge is based is growing exponentially. Many of the long held biological axioms concerning genetics, differentiation, structure, development and even taxonomy have been dismissed or disproved by new powerful 'definitive' techniques, such as recombinant DNA technology, monoclonal antibody production, cell culture and organismal cloning (Mason 2004). To work in this environment life scientists of the future should have greater enthusiasm, creativity, ingenuity and skill ability. Thus, the students we are teaching now will be the scientists who will face huge challenges in the future. We should therefore reflect on our current traditional teaching strategies and methods and, where appropriate, make changes to integrate new teaching theories into our classes.

Current approaches of teaching and learning

In my university, *Cell Biology* is a basic course for second year students. It usually includes 54 hours of lectures and 54 hours of laboratory work, with two or four lectures per week. About 200 students attend each lecture and there are 30-40 students in each laboratory class. There are three teachers and two laboratory staff responsible for this course.

Lectures

The cell biology textbook we used was written by the most famous cell biologist teaching in the universities of our country, and has been adopted as the required textbook of cell biology courses by most universities in our country. Every year we usually discuss the teaching plan before the course begins to decide what the students should master, understand, and know. The teacher organizes every lecture's content, derived primarily from the textbook. Students spend most of their time listening and taking notes in lectures. After the lecture they read the textbook and review their notes. There is little further motivation for the student to do more than try to understand what the teacher has said or what the textbook says.

In recent years, we have used some multimedia teaching techniques in our lectures to animate the teaching of biological knowledge and to stimulate students' interest in the course.

Laboratory class
The major aim of the practical course is to train students in technical skills and to enhance students' understanding and appreciation of the knowledge learned from the lectures.

In the laboratory class, teaching staff usually give the students a brief introduction to the laboratory task at the beginning of the class, including the related theory, the process of the work and safety cautions. Students work in groups, usually 2-3 students in a group. After the laboratory class, they need to hand in their report for marking. The teaching staff are responsible for giving students feedback on their reports and explaining the questions.

Assessment
The examination is the major part of the assessment and is worth 80% of the final mark for the course. The other 20% comes from quizzes conducted during the lectures. The exam questions include filling in the blanks, multiple choice questions and short answer questions. In the last semester we replace the quiz with an assignment to prepare a review paper about one of the 'hot' research areas in cell biology. Feedback from students is very positive and some excellent papers are produced.

Some issues in the learning of students

Curriculum background
Cell biology is a required class for students of life science, biotechnology and medicine majors in our university. There are about 400 students who enroll in the class each year. The State's target of enabling 15 per cent (currently 10.5%) of school age people to attend universities by 2010, means that in the next few years the numbers of students in our classes will constantly increase.

Insufficient resources for self-directed study
Currently there are insufficient resources available to enable students to engage in self-directed study in our university. Trying to balance the cost of the textbook with the amount of content presented can also be a problem. At same time, there are very few foreign original edition books in our university library. About 30% of students have a private computer and 70% of students are able to access the Internet.

Quality of learning
Our students come from all over the country, with different academic backgrounds. Most of the students are used to being passive recipients of information: reading what the teacher requires, and reviewing what the exam will cover. Most students lack the ability to transfer knowledge and problem skills to the real world. In particular, most of the students are too shy to ask questions in the class, and even after the class there are few students who ask me questions. The teacher still plays a leading role and transfers information, and is regarded by students as the authoritative expert.

Modifications to teaching for a student-centred approach

Many teachers in western universities have changed their teaching strategies to work with the incoming technical revolution. They have recognized that the professionals of the future need to know how to keep their knowledge up-to-date, how to apply their knowledge to solve real world problems, and how to become a functional part of a team. This revised view of the workplace compels educators to rethink and reinvent the ways in which professionals are prepared (Hmelo and Evensen 2000).

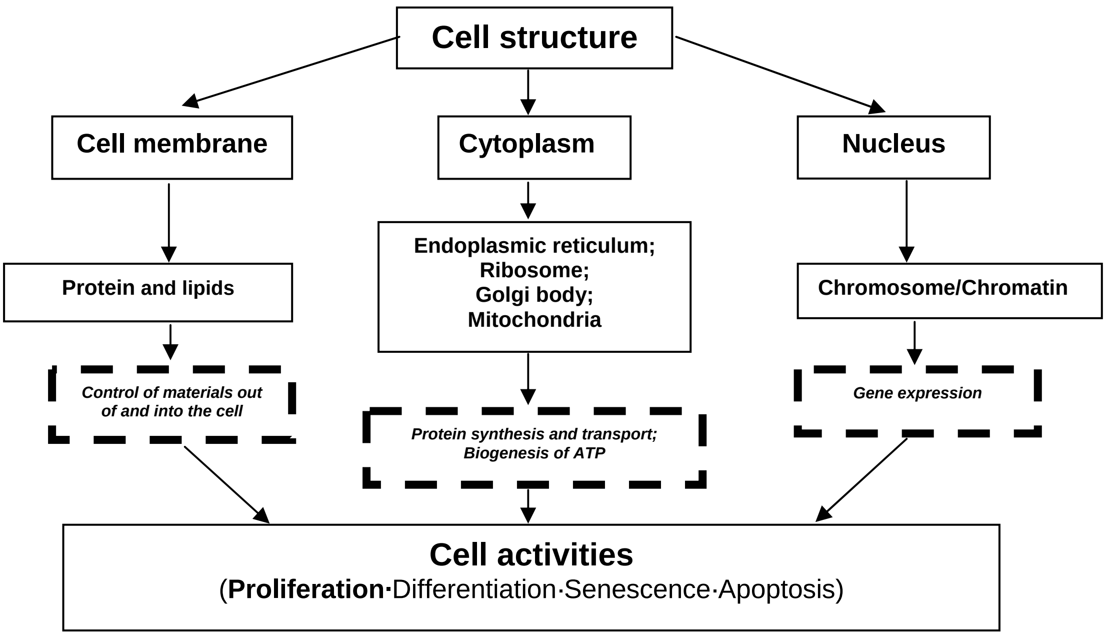

Figure 1. Concept mapping the components of cell biology

Using concept mapping

Concept mapping is a graphical technique for representing networks of knowledge. Networks consist of nodes (points/vertices) and links (arcs/edges). Nodes represent concepts and links represent the relations between concepts (Lanzing, 1997).

The concept mapping technique was developed by Prof. Joseph D. Novak at Cornell University in the 1960s. This work was based on the theories of David Ausubel, who stressed the importance of prior knowledge in being able to learn about new concepts. Novak concluded that 'Meaningful learning involves the assimilation of new concepts and propositions into existing cognitive structures' (Lanzing 1997).

This developmentalist view sees learning as the process of developing a learner's personal schema towards a more complex and sophisticated conceptual structure (King 2004). The concept map can serve as a guide map for the teacher to introduce the student from an old concept to a new concept. It can also be used to help the educator arrange the teaching order in such a way that students move to new concepts in a logical manner. A concept map can assist students to know the overall conceptual structure of a topic, so that they can realize where they are, where they will go and where they came from in their learning.

Figure 1 is an example of concept mapping in cell biology. It gives us a clear outline of an important concept related to the structure and function of the cell. From this concept map, we can see all the basic information on one page. We can easily figure out the links among the key ideas and the relative importance of each idea. This map makes recall and review more efficient and is particularly important for creative work such as essay writing.

Using problem based learning

During recent decades, problem based learning (PBL) has become very common in the teaching of science in western countries. PBL is a curriculum design and teaching/learning strategy that helps students learn to think and to solve problems. Too frequently, these skills may not have been acquired in traditional university course work. It uses an authentic, complex problem as the impetus for learning and fosters the acquisition of both disciplinary knowledge and problem-solving skills. Professors introduce a confusing, open-ended problem, like those faced in the workplace and in everyday life, which leads students to an investigation from which subject matter content and instruction emerge. Thus PBL is a very effective method to develop learner critical thinking, self-directed and lifelong learning, problem solving and teamwork skills (Woods 1994; Hmelo and Evensen 2000). It is well documented in the literature that PBL is a very good teaching strategy that has been successful in several fields, for example medicine (Norman and Schmidt 1992) and engineering (Hessami and Gani 1993).

The cell is the basis of life activities and a microphotograph of life. The cell represents not only the diversity and integrality but also the complexity of life. Eighty years ago, the great classical cell biologist, E.B. Wilson said that 'The key to every biological problem must finally be sought in the cell'; today this is still true. No matter what popular life research area you study today, for example reproduction, development, aging and disease, you always find that your answer is inside the cell (Figure 2).

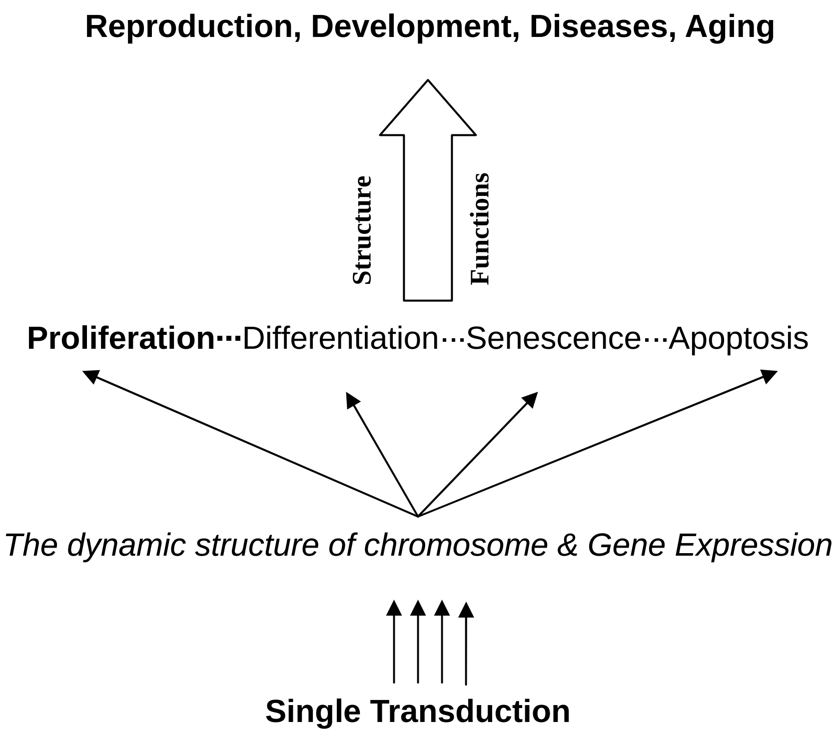

Figure 2. The relationships between the important life activities and functional activities of cells

Here are some sample questions:

1. All of us are aging. We have no choice but to age. How can we prevent or postpone aging?
2. According to China's national statistics (1.57 million sample survey) in 1987, limb disability is 0.53%. This means there are about 7,950,000 limb disability patients in China. Could you make their limbs regenerate?
3. Using your knowledge of cell biology, what strategies can you propose to combat cancer?

All of these questions come from the real world. They help make learning relevant and useful to students by establishing connections between life outside the classroom and knowledge inside the classroom, addressing real world concerns, and developing real world skills. The process of thinking and answering these questions will simultaneously develop both problem solving strategies and disciplinary knowledge bases and skills of the students. It is clear, from the map in figure 2, that the students must study all of the essential and important concepts and knowledge if they want to answer any one of these question above. It is deeper level processing of information that we are seeking, not superficial (King 2004).

Using case studies

Study after study has shown that students are not able to use the science they have learned to address 'real-world' problems (for example, White 1988).

In attempting to solve this problem, the use of case study scenarios is a very appropriate teaching method for the sciences, and has been employed in western higher education for many years (Christensen and Hansen 1987; Barrows and Tamblyn 1980; McNair and Hersum 1954; Barrows 1986). Case studies need to be real or imaginary stories dealing with realistic situations so that the students can immediately relate to the 'story'. Case studies serve to illustrate facts, general principles and good practices. One of the values of the case study is to show great scientists in action. It is not so much to teach content, but to demonstrate the process of scientific research, its limitations and to develop higher-order learning skills.

Case studies are extraordinarily flexible as a teaching tool. The use of a good case gives a teacher an immediate advantage, since it is easier to hold a student's attention. Depending upon the case, teachers might employ different types of teaching methods such as thinking, discussion, and searching for more information. It helps the students work through the facts and analyze the problem and then consider possible solutions and consequences of the actions that they might take. A good example of a case study is Dolly's story. She was the first cloned sheep, and thus, currently, the most famous sheep in the world. This example has been used by many teachers to help students understand cloning techniques. Today, although Dolly has died, the case study remains relevant for discussion.

Dolly's death leaves researchers woolly on clone ageing issue (Giles and Knight 2003)

Dolly was put down on 14 February, suffering from a virus that caused a tumour in her lung. Ian Wilmut, leader of the team that created Dolly at the Roslin Institute near Edinburgh, says that the post mortem revealed no other gross abnormality, apart from her arthritis, which was diagnosed last year.

Dolly, born six years ago, was the first mammal to be cloned, but since then six other mammalian species—cow, mouse, pig, rabbit, goat and domestic cat—have also been copied. The cloning process is inefficient: only around 3% of cell nuclei that are transferred to donor eggs result in live births. But no large-scale follow-ups of those births have been done, so little is known about whether clones really are likely to die young.

The health of adult clones has been studied most extensively in mice. At least 200 live mouse clones have been created in 10 or so labs around the world. In one study, Narumi Ogonuki of the National Institute of Infectious Diseases in Tokyo tracked the health of 12 mouse clones and found that 10 died — probably of pneumonia or liver disease — before their average natural lifespan of 800 days (N. Ogonuki et al. Nature Genet. 30, 253–254; 2002). However, other researchers say that problems seen at birth or shortly afterwards, such as obesity, can reverse as the animals age. The offspring of other cloned mice have also been reported to be normal (K. L. K. Tamashiro et al. Nature Med. 8, 262–267; 2002).

Researchers say that experiments with larger numbers of animals are needed, but are difficult to carry out given the difficulties associated with creating clones. Work on some animals is hampered by a lack of time and money. "You need to follow them for life. We're talking 15-plus years for cows," says Keith Campbell, a cloning researcher at the University of Nottingham, UK. (Nature 421, 776 (20 February 2003); doi:10.1038/421776a)

This case study provides students with an opportunity to discuss animal cloning and its moral implications. This case can be given to students at the conclusion of a unit on cell differentiation in which cloning has been thoroughly discussed. The case makes use of a teamwork format. I can divide the students into 10 groups. Students read the case and review the topic of cloning, including what cell differentiation is, what genetic cloning is and what it involves. Students discuss the question assigned to their group. Finally, students will be asked to report their answer by presentation or poster. I think this case study will enable the students to gain a deeper understanding of cloning techniques.

Example questions:

- Why should we think carefully about the death of Dolly?
- Why is it that '*only around 3% of cell nuclei that are transferred to donor eggs result in live births*'?
- The cloning of a human being is very dangerous: why?
- What should we know if we want to clone ourselves safely?

Using online learning approaches

The Internet is a library without walls

The rapid development of Internet gives us a new way to communicate. Online learning provides a new learning environment often called the learning network. It is the 'emerging paradigm for education in the 21st century' (Harasim, Hiltz, Teles and Turoff 1995).

It is a fast and convenient way to locate the most current, detailed information on any topic. It takes almost no training, just point and click. For example, by entering 'concept mapping', 'problem based learning' and 'case study' as key word searches in the *Google* search engine, thousands of web pages are identified. Taking full advantage of the Internet, we can alleviate the lack of self-directed study resources in our university.

The Internet is an interactive classroom

In realizing the new paradigm, the shift of control over learning from the teacher to the student is very significant. 'Indeed, the learning network is truly a learner-centred environment' (Doherty 1998). 'It is a model that emphasizes active and interactive learning, research and problem-solving. Implicit to this model is the intent to foster learner control by facilitating the learner's ability to guide his or her own learning' (Doherty 1998).

Last year, we built up a web site for our course. The course information includes course overview, lecture timetable, lecture notes, assessment and references. Contact details have also been put on the web. Students can ask questions by email at any time. When I return to my University, I will further perfect our site, drawing on the experience of *WebCT* building at the University of Sydney.

Summary

The future belongs to the student, as they are to be the masters of the future. They will solve the problems that we have not been able to solve, they will learn new knowledge that we may not have taught them, they will use new techniques not yet invented and face new challenges that human beings haven't faced before. They need to be able to learn by themselves, and therefore should take responsibility for their learning. To train students suitable for the development of modern science and society, we must help them to equip themselves with the skills of self-directed study, lifelong learning, independent thinking and team work.

To introduce changes into traditional teaching is tough and difficult in the beginning, as has been the case in many western universities. I must therefore prepare myself to face huge challenges and difficulties in the future. However, no matter how hard it is to get staff to accept the new teaching strategies, no matter how tough it is to gain support from senior management and no matter how difficult it is to introduce curriculum reform, I must focus on my teaching and learning goals, because it will benefit our students.

Finally, I need to make certain that the new teaching strategies that I have learned in the University of Sydney over the last 4 months, such as concept mapping, problem based learning and case study, continue to help me succeed in training the learning skills of the students. At the same time, I also know it can be achieved by a simple change of teaching methods to enhance the students' learning skills. It requires us to have courage, confidence, determination and strong mindedness. It requires that we, the teachers, cooperate more closely, and that we continue sharing our teaching experiences regularly in the future as we do now.

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