Reforming organic chemistry teaching using student-centred methods

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Abstract

The reform of organic chemistry teaching in Central South University in China is reviewed in this article. According to the skills likely to be needed in the 21st century, this reform is still teacher-centred teaching and does not meet with the modern concept of lifelong study and assessment. To reform organic chemistry teaching deeply, a student-centred teaching system should be introduced into our teaching, new methods such as problem-based learning (PBL) and case studies should be used strategically.

Introduction

With the rapid developments in science and technology, organic chemistry, which is the fundamental to many disciplines, is becomes increasingly important. The number of organic compounds and their many different applications begs the question, how can we teach all the knowledge to students? To meet with the needs of society, reform in organic chemistry teaching has taken place all over the world. However we cannot teach students everything in this rapidly developing world. Accordingly, most academics agree that we should just teach students how to learn and apply organic chemistry. It is also the case that if people want to keep up with the development of knowledge, they should keep studying and assessing all their lives. To solve this problem, some reform in organic chemistry teaching within other chemical courses has taken place in Central South University in China and there have been some useful experiences. However because the reformat has concentrated on knowledge structures, our teaching methods are still teacher-centred teaching, not student-centred and do not encourage students to achieve lifelong learning and assessment. Some possible student-centred teaching methods will be discussed in this article with the view to reform our teaching more extensively.

Reform of organic chemistry teaching in Central South University in China

Organic chemistry is a very important fundamental curriculum in lots of disciplines such as chemistry, mineralogy, metallurgy, materials, environmental science, medicine, pharmacy, biology etc. in Central South University in China. In China, the reformat of the chemical curricula commenced in 1995 when the teaching week was shortened from 6 to 5 days, with a subsequent reduction in the amount of time devoted to the curricula. During the 10 years experience, we have adjusted our teaching programs according to different disciplinary requirements and have combined four fundamental chemistry curricula into a two-year course, rearranging the content. Traditionally, fundamental chemistry can be divided into general and inorganic chemistry, analytical chemistry, organic chemistry and physical chemistry. Students are trained through lectures and experiments. When all disciplines are combined into one 200 hour course (*Chemistry*) some overlapping content can be rationalised, and the content of the course becomes more systematic, and easier for students to accept. In this two-year course, organic chemistry will be introduced in semester 2 or 3, after structural chemistry and physical chemistry, according to different disciplines. The contents of the rearranged organic chemistry section are listed in Table 1. All these topics are covered in 32 to 80 hours within different disciplines. In order to consolidate the experimental skills of students, we separate experiments from the course and set up an independent two-year experimental curriculum. This 100-150 hour course includes four aspects of training: basic skills training, synthesis methods, modern analysis methods and physical chemistry characterisation methods. Traditional organic manipulative skills are covered in basic skills training, and organic synthesis with inorganic synthesis consists of synthesis methods. This new

Table 1. Reform of organic chemistry teaching in Central South University

Traditional organic chemistry	Organic chemistry in ***Chemistry***
1. Introduction 2. Hydrocarbon – nomenclature – physical quality – chemical quality 3. Spectrum 4. Functional group compound – nomenclature – physical quality – chemical quality 5.Experiments	Chapter 16: Basic concept and spectrum in organic chemistry 16.1 introduction 16.2 nomenclature 16.3 fundamental spectrum introduce Chapter 17: Character and reaction of organic compounds 17.1 the rules of physical quality 17.2 the rupture of covalent bond and the mechanism of different type of reaction 17.3 the reaction of hydrocarbon 17.4-8 the reaction of functional groups 17.9 introduction to organic synthesis 17.10 introduction to bioorganic chemistry Chapter 18: Introduction to polymer compounds

teaching system was adopted in 1996, and continues to develop. Students and teachers agree that this is a more systematic teaching mode.

Although we have achieved improvements in organic chemistry teaching to some extent, we are still exploring ways of further attracting the interest of students. The survey responses of third year and final year students show that they are not very impressed by fundamental organic chemistry, and are not sure what they have mastered, let alone believe they have developed skills to solve problems using the knowledge of the course. Thus, the effects of the existing reformation are limited, and cannot meet with the demands of the 21st century. Compared with traditional teaching, our reformat concentrates more on knowledge systems but pays little attention to students, so basically it still uses teacher-centred teaching methods, and whilst it helps systematise what students have learned, it is not good at developing all their abilities.

Modern society demands the abilities of finding, analysing and solving practical problems. To do this students should have the capability for lifelong learning and assessment, ease of communicating and cooperating with others, not just demonstrating how much knowledge they can remember. It is obvious that our reform thus far ignores these aspects. To meet with the demand, we should reform more deeply. In particular, we should introduce student-centred methods into our teaching, and train our students in how to find, analyse and solve problems. Problem based learning and case studies are two suitable methods.

The character of PBL and case studies

It has been summarised that there are different teaching approaches such as behaviourism, constructivism, schema, concept mapping, case studies and problem based learning (PBL) employed in western universities. Different approaches emphasise different principles. Among them behaviourism represents a kind of teacher-centred approach, while case studies and PBL are student-centred teaching approaches which have been applied effectively. It has been demonstrated that case studies and PBL may be the most effective approaches to lifelong learning and assessment. These two teaching approaches can train students in such characteristics as teamwork, enthusiasm, motivation, leadership skills, interpersonal skills and organisational skills which are all desirable talents in the 21st century.

Problem based learning is a curriculum design and a teaching/learning strategy which simultaneously develops higher order thinking, disciplinary knowledge bases and practical skills by placing students in the active role of practitioners (or problem-solvers) confronted with a situation (an ill-structured problem) which reflects the real world. The basic characteristics of PBL are that it is context-based using 'real-life' situations, focuses on thinking skills, requires integration of inter-disciplinary knowledge, is self-directed and develops lifelong learning skills and can be applied in small groups. Students are driven by a posed real-life problem and become interested in its solution. To solve the problem, they should learn how to: actively integrate knowledge; accumulate and connect skills; and work cooperatively. As the teacher's role is one of support, not direction, it is obvious that PBL is a student-centred teaching approach.

Case studies are stories with an educational message. They have been used as parables and cautionary tales for centuries, yet their formal use in the science classroom is recent. Harvard University has been the leader in developing cases studies for educational purposes.

Cases are typically written as dilemmas that give a personal history of an individual, institution, or business faced with a problem that must be solved. Background information, charts, graphs, and tables may be integrated into the tale or appended. The teacher's goal is to help the students work through the facts and analysis of the problem and then consider possible solutions and consequences of the actions that might be taken.

The case study method of instruction offers a less didactical approach to instruction in the natural sciences. The case method stresses the development of students' communication and higher order thinking skills; it encourages them to engage in critical analysis and involves active student participation as its hallmark.

From the introduction above, we can understand that if we teach students this way, they will be interested by real-life

problems or cases and study more enthusiastically. When they manage to solve the problem or case, they will succeed in lifelong learning skills and assessment.

How to use PBL and case studies in organic chemistry teaching in Central South University

Organic chemistry in our university is a part of a two-year chemistry lecture course. Before organic chemistry is introduced, some fundamental physical chemistry principles have been taught to students, this providing a good foundation for teaching through PBL and case studies.

To attract their interest and develop their ability, we should design the problems and cases to reflect their majors. For example, for students who are studying environmental science, we could pose a current serious problem in China and ask their assistance. As a developing country, the chemical industry is fundamental to China's progress. This has resulted in the establishment of numerous chemical factories, and environmental issues are becoming increasingly important. What should we do with this contradiction? From our experience, although many students don't like chemistry because of the pollution and poison, they express much interest in this problem. We can bridge organic chemistry to green chemistry using PBL and case studies.

To do this, we give students a big problem: As a large country, we do need a chemical industry. How can we develop our chemical industry in harmony with the environment? The PBL teaching can then be carried out as described below.

1. The teacher helps the students analyse the problem statement and establish a learning agenda.
2. The learning agenda is organised around several questions—what is the main pollution in chemical industries? How has this pollution been produced? Is it necessary to produce these chemical compounds in China? And can we produce those compounds with green chemistry methods?
3. The teacher gives some lectures and tutorials on chemical compounds and chemical reactions.
4. Information is organised during the development of the problem and to track progress. As each area is clarified, issues are removed and replaced with new learning questions that arise from new information.
5. Techniques include:
   i. using libraries, teacher-gathered materials, and experts in the field; and
   ii. 'Time-out' activities—laboratory experiments are conducted, guest speakers brought in, or the teacher presents information.
6. Once it is gathered, the information is evaluated for its usefulness and how it changed the nature of the problem.
7. Finally, at the end of the unit of study, the students develop a resolution to their problem. The resolutions are tested for their positive and negative consequences which are compared. The costs and benefits of alternate decisions are considered.

To help students consider environmental problems deeply, we can set up some cases for them to solve at the same time. For example:

A family had moved into a new house about one year ago. They now complain that the air in the building smells odorous and acidic, they worry about their health, and ask for help from a specialist. If you are the specialist, what will you do for them?

To help the students, the teacher can provide them with some basic data such as the concentrations of formaldehyde, toluene and benzene etc.

Students may not complete all the cases solving the entire problem successfully. But if they are interested in the problem, some of them may keep studying this for a long time, even a lifelong study. It is easy to understand the merits of such a method of teaching. They underpin the training of skills required in 21st century. But we still don't make sure it is a closed problem in the fundamental curriculum because there are always some limitations in every problem and case. The best outcomes should be that we can teach students systematic knowledge and train them in the abilities needed in the 21st century.

Conclusion:

Although we have been reforming our organic chemistry teaching for a long time, the teaching mode is still a teacher-centred approach. To reform our teaching more extensively and keep up with the demands of the 21st century, we can introduce student-centred approaches such as PBL and case studying into our teaching. Both methods have their merits and short comings, the best strategy is to combine them in an integrated approach.

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Reference

Albanese, M.A. and Mitchell, S. (1993) PBL: A review of literature on its outcomes and implementation issues. *Academic Medicine*, **68**, 52-81.

Biggs, J.B. (1992) The psychology of educational assessment and the Hong Kong scene. *Bulletin of the Hong Kong Psychological Society*, **28/29**, 5-26.

Dressel, P.L. and Marcus, D. (1982) *On Teaching and Learning in College*. San Francisco: Jossey-Bass.

King, M. (2002) Course delivered to *Teaching Sciences in English*, a collaborative project between the China Scholarship Council and The University of Sydney.

Lanzing, J.W.A. (1997) *The concept mapping home page*. [Online] Available: http://users.edte.utwente.nl/lanzing/cmhomehtm.

Oliver, R., Osmari, A. and McLoughlin, C. (1999) Planning and developing a PBL environment for large on-campus classes using the WWW. In G. Cumming, T. Okamoto and L. Gomez (Eds) *Advanced Research in Computer and Communication in Education. Proceedings of ICCE99*, 720-727.Amsterdam: IOS Press.

Oliver, R. and Omari, A. (1999) Replacing lectures with on-line learning: Meeting the challenge. In J. Winn (Ed.) *Responding to Diversity*: Proceedings of the 16th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education, 257-264.

Ramsden, P. (1992) *Learning to Teach in Higher Education*. London: Routledge.

Woods, D.R. (1995) Teaching and learning: what can research tell us? *Journal of College Science Teaching*, **25**, 229-232.