

# Improving the teaching quality of *Organic Chemistry* by adopting some modern teaching methods

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## Abstract

This paper first gives a description of the tertiary education context in China, which has been greatly influenced by examination-oriented policies. The current curriculum of *Organic Chemistry* and the teaching strategy for *Organic Chemistry* in Huazhong Agricultural University have also been reviewed. To improve the quality of teaching and learning, some modern teaching theories and strategies have been discussed. A detailed description of how to use cooperative learning, concept mapping, and problem based learning in *Organic Chemistry* teaching has been suggested.

## Introduction

### The tertiary education context in China

The education system in China adopts a method of selective progression, only those who have passed a national entrance examination have a chance to receive higher education. If students want to continue to postgraduate study they also have to take a graduate entrance examination. Because of this examination-oriented policy, examinations are always the centre of teaching and studying. This system has strong negative effects on both teaching and learning because teachers usually teach perceived model answers to examinations and students engage in low level cognitive strategies such as rote note taking and developing model answers to cope with examinations (Biggs and Moore 1993). This kind of learning is very passive, it is a surface learning approach. This surface learning approach has also coloured students expectations of the teachers' teaching approach. This teaching and learning approach is in conflict with the aim of tertiary education. Tertiary education should promote people's holistic development in cognitive, personal, and affective domains. University graduates are expected to be competent not only in their respective disciplines, but also as independent lifelong learners. A good graduate should have been professionally trained, with good communication skills, potential for personal development and adaptability for change

### Course description

*Organic Chemistry* is a subject about organic compounds. Organic compounds are mainly composed of carbon and other elements. Organic chemistry has close relationships with a lot of disciplines especially in the life sciences. Life processes are supported by the chemical reactions of complex organic compounds such as enzymes, hormones, proteins, carbohydrates, lipids, and nucleic acids. In the mean time, to improve on nature, chemists have created millions of organic compounds that did not exist in nature originally, such as medicines, synthetic rubbers, rayon, food additives, dyes, artificial flavourings, artificial sweeteners, preservatives, and pesticides. So organic chemistry is a very important subject for such disciplines as chemistry, materials, medicine, agriculture, the petroleum industry and the life sciences.

### *Organic Chemistry* taught in our university

Huazhong Agricultural University is an agriculture university. Organic chemistry is a very important subject to such departments as chemistry, life science and technology, plant science and technology, animal science and technology, veterinary medicine, horticulture and forestry science, resources and environment, fishery, and food science. There are two syllabuses for organic chemistry in our university. One is for the chemistry department, the other is for teaching within other departments. The syllabus for chemistry major students is more advanced than the second one. However the latter has more influence because more students have to choose this course. So I will address the needs of the latter course.

This course involves 50 hours of lectures and 35 hours of laboratory work, and it has a one semester duration. Usually we will give some tutorials, but they have

been taught without payment. The syllabus includes topics on bonding theories, alkanes, alkenes, alkynes, alkylhalides, aromatic compounds, stereochemistry, alcohols, phenols, ethers, aldehydes and ketones, carboxylic acids and their derivatives, amines, heterocyclic compounds, lipids, carbohydrates, amino acids and proteins, and nucleic acids.

During the course there are around 15 assignments which the teacher must mark. Two examinations usually will be given for the course, a mid-term and a final examination. Students get their grades based on their assignments and examinations. Students are most concerned about whether or not they can pass the examinations. The strategies the students adopt mostly involve rote learning, and teaching has been thought of as transmission of knowledge. Although some new techniques have been adopted in the teaching process, such as multimedia assisted teaching and overheads, on the whole it is a didactic style of teaching. The theory guiding our teaching has close relationships with behaviourism even though we practiced it without realising this. Because we developed carefully prepared and presented lectures, carefully selected texts, and reinforced students studying by assignments and tests, students will work hard and increase their knowledge gradually. Students just memorise the contents of the lectures; it is a passive way of learning. When students passed the examinations, they usually forget the material quickly, so we must reflect on the teaching method we adopted in the past to make both teaching and learning more effective.

## Modern contemporary teaching theories

At The University of Sydney we have learnt two modern teaching theories, one is developmentalist views, another is about constructivist views. According to developmentalist ideas, learners go through a series of conceptual stages associated with intellectual growth and learners construct their own understanding through interaction with the environment in many different ways. Schema teaching strategy is in congruence with this theory. As a theory of learning, constructivism's central claim is that knowledge is acquired through a process of active construction (Bruer 1993). Its main ideas of learning are:

- learning is an active process;
- knowledge is constructed, rather than innate, or passively absorbed;
- knowledge is invented not discovered;
- all knowledge is personal and idiosyncratic;
- all knowledge is socially constructed;
- learning is essentially a process of making sense of the world; and
- effective learning requires meaningful, open-ended challenging problems for the learners to solve.

According to constructivism theory, such teaching methods can benefit both teaching and learning when practiced as cooperative learning, case studying and problem based learning. I think all these teaching theories and resulting teaching strategies are very helpful in our future teaching. I plan to adopt some of them in my future teaching.

## Teaching strategies adopted in the future

### Cooperative learning

Cooperative methods share the idea that students work together to learn, and are responsible for one another's learning as well as their own. All cooperative methods involve having students work in small groups or teams to help each other in studying the material. Usually they have team goals and team success, which can only be achieved if all members of the team learn the objectives being taught. Therefore it requires the team members to explain concepts to one another and everyone on the team is ready for assessments such as a quiz, or an examination. Three concepts are essential to cooperative learning: team rewards, individual accountability, and equal opportunity for success (Slavin1983). Cooperative learning is useful in improving students' achievement at a variety of grade levels and, in many subjects, intergroup relations. In particular, there are several types of cooperative learning methods, and some are easy to implement. I will try the following cooperative learning methods.

1. Students are grouped according to their dormitory. This kind of grouping does not consider students' performance levels, sex, nor ethnicity, but in China, universities usually provide boarding, so it is convenient for students to study together in groups.
2. After the conclusion of a lecture, the students work together to do assignments. Students should help each other to make sure all of them have understood the lecture in order to finish the assignments.
3. The teacher checks the assignment and gives a mark to everyone. The average of the team is the score of the team member.
4. All students take a quiz and an examination without the help of their team members
5. Students' scores are compared to their own past averages, and points are awarded based on the degree to which students can meet or exceed their own earlier performances. These points are then summed to form team scores.

### Concept mapping teaching

According to developmentalism, we all have different schema in everything and of varying degrees of sophistication because each of us has different experiences with the world. We should teach by trying to understand our student's schemas, by challenging them and forcing them to assimilate and accommodate new aspects of the schema. Learners learn by modifying these schema through the processes of 'assimilation and accommodation'. If students can accommodate new information in a meaningful way into their existing schema, it means students learn in a deep way. Quality teaching should be aimed at promoting deep level processing of information in the mind of the learner.

Concept mapping is a technique used for representing knowledge graphically in which networks of related concepts are interconnected. The graph consists of:

1. NODES which represent related concepts within a topic, and

2. LINKS which represent the relationship between concepts (Lanzing1997).

Concept mapping can help teachers discover the students' preconceptions and whether students understand the concepts that have been linked together by the map, and can help the teacher focus on a particular aspect of a topic so that the students can see how particular pieces of information fit into the overall schema. By doing one concept mapping exercise before a topic and another after the topic, concept mapping also help students to determine what they have learnt and where they need further effort to grasp a concept (Novak and Gowin 1984). Moreover this method is easy to implement, and many organic topics can be taught in this way. For example, isomerism is a very complex topic. Students can easily get confused with it. If we use the following concept mapping, I think it can promote students' understanding of isomerisation. There are a lot of topics that can be delivered in this way, such as different functional group reactivities, synthesis of certain functional groups, etc. It will really save a lot of time and energy and help students' high level of cognition to the corresponding topic if we adopt this teaching method.

**Problem based learning**

Problem based learning (PBL) is a curriculum design and teaching/learning strategy which simultaneously develops higher order thinking, disciplinary knowledge and practical skills. It places students in the active role of practitioners (or problem-solvers) confronted with a situation (ill-structured problem) that reflects the real world (Illinois Mathematics & Science Academy 1994). So problem based learning is regarded as one form of learning from experience in which learning is focused on problems derived from the real world. The starting point of problem based learning is always a problem situation, and students work with the problem in a manner that permits their ability to reason and apply knowledge to be challenged and evaluated.

PBL has been regarded as one of the most exciting and powerful education methods that has appeared in the last 30 years. PBL embodies most of the principles that we know improve learning: active, cooperative, prompt feedback, tailored to students' learning, preference with students' empowerment and accountability (Nendaz andTekian1999). PBL offers an opportunity for students to practise and use such processing skills as problem solving, interpersonal, group and team skills, the ability to cope with change, lifetime or self-directed learning skills.

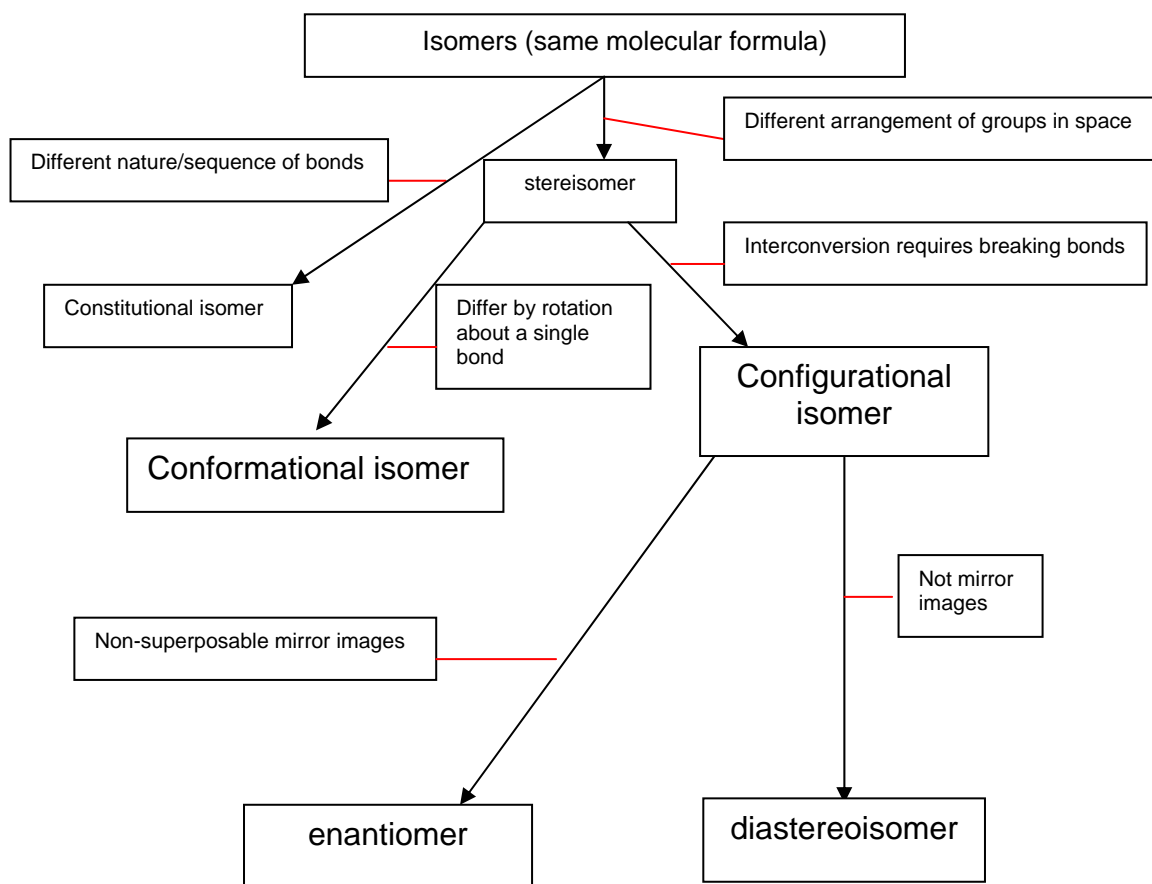


Figure 1. Concept map: classification of isomers

The ever increasing amount of knowledge and the changing nature of contemporary science have lead scientists and students to learn no more than a small fraction of what is known in a given field. Teaching does not mean lists of knowledge and an enumerate series of examples. Students must learn how to learn, reason, and criticise. The traditional content-laden lecture cannot meet those demands. PBL can address many of our concerns and overcome some of the educational shortcomings of our present teaching of science, so many universities have adopted this strategy to teach science (Vernon and Blake 1993). I will try some PBL in organic chemistry, for example:

*About twenty workers in a leather shoe company in Guangdong province were found in very poor health, some even contracted leukemia. Some people suspected the solvent (benzene) used in the making of shoes. But the factory owner claimed that he was innocent. You are invited to investigate the calamity and make a report about this case to the public via a newspaper article.*

In this PBL, students must learn the following knowledge through self-directed learning:

- why benzene is useful as solvent in this factory;
- why benzene is poisonous;
- how to detect the concentration of benzene in the air; and
- how can we use other solvents to substitute for benzene to decrease the poison and why.

*Yesterday, several people bought some cooked food from a market. All of them got diarrhea after eating the food. The food had an appealing red appearance. The concentration of bacteria was below the standard. Some people thought that poisonous chemical additives may have been added to the food to enhance its appearance. The stallholder denied this charge. You are invited to investigate the incident and make a report about this event to the public via a newspaper article.*

In this PBL, students must learn the following knowledge through self-directed learning:

- why sodium nitrate is poisonous;

- how to detect the concentration of sodium nitrate in the food; and
- if sodium nitrate is poisonous, why do people still use it.

Though these two PBL are small ones, the technique can increase students' interest and help students cultivate their own learning abilities. It is my initial program, and if I can succeed in it, I will enlarge my program.

## Acknowledgements

I would like to thank my supervisor, Associate Professor Anthony Masters, for his guidance, knowledge, and enthusiasm. I also wish to thank Associate Professors Mike King and Mary Peat for their excellent teaching and help. The author also wishes to thank Dr Siegbert Schmid for his support and help. I am really grateful to the China Scholarship Council for its funding. Thanks to all those who put effort into this program.

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