

# Considerations of student-centred teaching strategies in *Organic Chemistry* teaching

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## Abstract

Based on an analysis of current teaching and learning status, the author focuses on helping students develop deep-level learning and lifelong learning skills. Some contemporary education theories have been suggested in to facilitate the transfer from teacher-centred teaching strategies to student-centred teaching strategies in the teaching of organic chemistry at the Fourth Military Medical University. The author also provides a feasible blueprint and some practical examples to reform teaching methodology for first year students.

## Introduction and course description

*Organic Chemistry* is a subject that studies organic compounds. Organic compounds are hydrocarbons and their derivatives. Every living organism is made of organic chemicals. The foods you eat, the medicines you take, the wood, paper, plastics, dyes, pesticides, food additives, and fibres that make modern life possible, are all organic chemicals. Since organic chemistry is a subject that touches the lives of everyone, anyone with a curiosity about life and living things must have a fundamental understanding of organic chemistry.

At The Fourth Military Medical University, all students major in life science, medicine or pharmacy. After graduation, some of them become doctors in large hospitals including hospitals affiliated with our university; some of them become pharmacists or life scientists. Since organic chemistry is so relevant to human beings, organic chemistry is a compulsory course for all first year students in the second semester at the university. This course usually involves 50 hours of lectures and 50 hours of laboratory work. It is a core basic course for all the students and it will benefit students to study subsequent courses such as pharmacology, biochemistry.

Before they come into the organic chemistry course, students have learned general chemistry, inorganic chemistry and some simple organic chemistry. They know the basic functional groups, classifications and some simple organic reactions.

The main objectives of this course are to: provide a basic understanding of some organic principles; introduce students to the characteristics of several kinds of organic compounds; enable students to learn how to design and synthesise some important organic compounds; and help students learn to use some basic theory to solve real-world organic problems especially those relevant to life sciences.

## Status analysis

As a teacher in the chemistry department, I am frequently required to answer calls from doctors in affiliated hospitals. The typical question is: How can I prepare a buffer solution in the laboratory? Does a certain carbohydrate react with ferric trichloride? Is a certain compound stable? They are very simple questions, and the doctors were all top students and learned very well in their first year. However they forget it all after graduation. As a teacher, it's a shame to hear those simple questions from good students. My colleagues and I have *contemplated* this phenomena, and we realised this is the typical outcome of rote learning, i.e. surface learning.

In my opinion, the traditional 'spoon-fed' teaching we have used for many years has three characteristics. Firstly, separation of knowledge from real life. We teach just organic chemistry, not the applications. Secondly, the use of rote learning is prevalent among the students. Rote learning characterises surface learning, which is arbitrary, verbatim, and not related to experience with events or objects, and lacks effective commitment on the part of the student to relate new and prior

knowledge. So, students frequently abandon their knowledge after graduation. Thirdly, the teacher only focuses on explaining theory, but ignores how the students learn and what they learn. These are called teacher-centred strategies. That means, we only care that we teach them in what we believe is a perfect way, but we seldom consider that the students themselves are the real subjects of education. The obligation of a university teacher is not only giving students knowledge, but also teaching them how to learn. Today there is a knowledge explosion, and it's impossible for teachers to teach everything to students. It's crucial to develop lifelong learning skills.

Since 2000, we have in fact developed many strategies to improve teaching quality, such as reducing the lecture time from 50 minutes to 40 minutes, carrying out laboratory workshops among the top students, using *PowerPoint* and other modern multimedia technologies in lectures. The effect of this reform has been to some extent, positive. But the students are still in a passive position, and the knowledge they learn is 'fed-in', i.e., stopping at a surface level, not a deep level learning.

In the past three months at The University of Sydney, I learned many contemporary teaching and learning theories, such as behaviourist theory, development theory, constructivist learning theory, problem based learning, case studies, concept mapping, use of the Web and modern assessment systems. Some of them I have used subconsciously, others are a new concept for me. Reappraising organic chemistry, I have found many practical ways to transfer from teacher-centred methodologies to student-centred learning, from behaviourist to constructivist; from shallow learning to deep level learning. It may be another perspective on how students learn and how we might teach.

## Modification assumptions

### Using concept maps in lectures

Organic chemistry is quite a systematic discipline, however students often complain there are too many different functional groups, different reactions in different conditions with complicated mechanism, to say nothing of three dimensional molecular structure and competing reactions. A good way to learn and to teach these concepts systematically may be concept mapping.

Concept mapping is derived from the constructivist theory. Concept maps are diagrams, in which various forms or lists of information are classified and their links are shown. Usually, a concept map is divided into nodes and links. Nodes represent various concepts, and links represent the relationships between concepts (Lanzing 1997). Words are used to label the links in order to depict the relationships more explicitly (Anderson-Inman and Zeitz 1994). Concept mapping can be used to generate ideas (brainstorming); design complex structures; to communicate complex ideas; to aid learning by explicitly and graphically integrating new with existing knowledge; to assess understanding (assessment tool); and to diagnose misunderstandings and misconceptions. Figure 1 shows the concept map of hydrocarbons. According to the constructivism perspective,

the process of learning involves the constant construction and reconstruction of meaning and each individual's construction starts from a different point. Students' learning processes are assimilated in the context of these prior conceptual constructs. So in my lectures, I will ask students to construct two concept maps for each topic: one at the beginning of the course and the second when they have completed each topic. This concept mapping exercise is designed to help students build a knowledge framework and a mental connection between the main concepts and their relationships and master the knowledge system.

By using concept mapping, I will try to encourage students to form the concept map in each topic for themselves and allow them to see what it is they have learned and how their knowledge of the topic has changed.

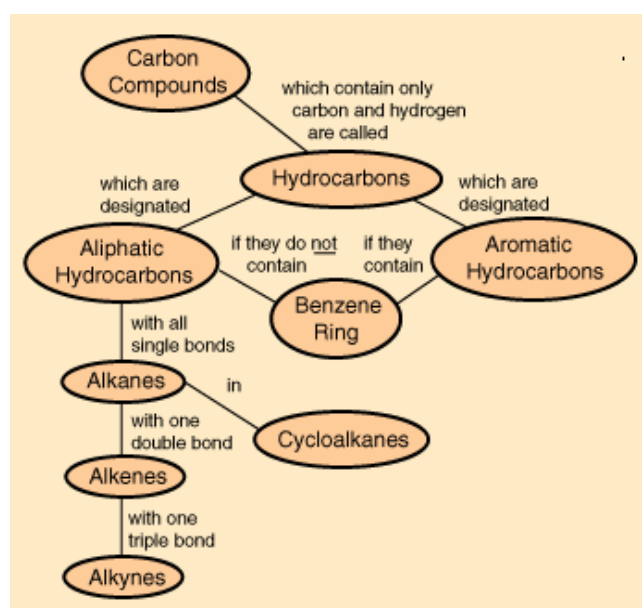


Figure 1. Concept map of hydrocarbons

### Using case studies to teach abstract concepts:

In addition to readjusting the content of the textbook with more examples from real life and increasing the interdisciplinary knowledge in lectures, I want to use another strategy to engage students in organic chemistry. That is by the use of 'case studies' of real scientific problems.

A case study is an educational story with a message and a question. The case is a real and complete story, is usually interdisciplinary, has academic and professional significance, and always has a social implication. It can be a critical incident, slice of life account, appraisal consultant report, personal story/narrative, newspaper story, case history, scenario, and video case/trigger film and simulation activity. A good case study should integrate many disciplines and relate to the real world. The case study method involves learning by doing, developing students' analytical and decision making skills, integrating knowledge skills, and learning how to deal with real-life problems.

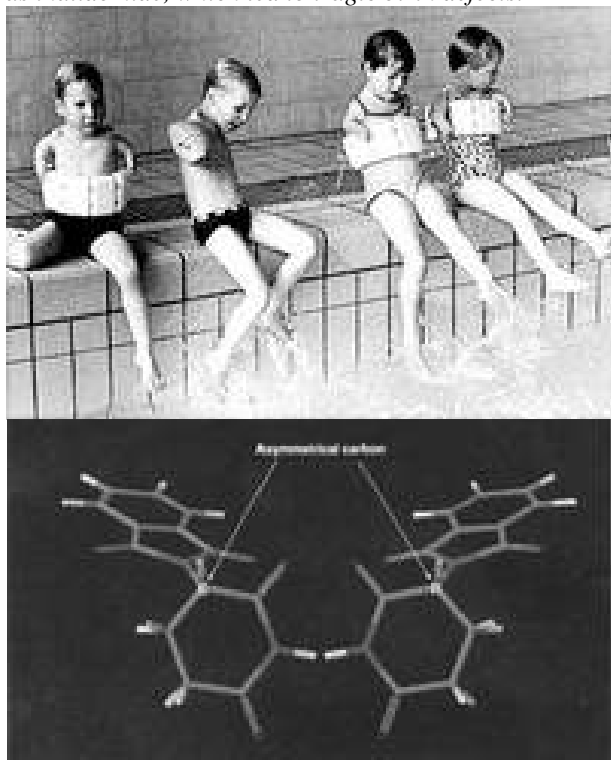
In my opinion, case studies is one a very powerful strategy especially for abstract concepts. In this way, students may learn with fun, interest, and increased motivation since they

find the process is relevant and related to the professional and real world.

I will use the following case study to introduce the concept of optical enantiomers, which is one of the most abstract, difficult, but important concepts in organic chemistry.

Case study:

*In the early 1960s, there were more than 10,000 children around the world who were born with major malformations. When their mothers were pregnant, they took drugs to treat morning sickness. One of these drugs was thalidomide, which led to tragic birth defects.*



**Figure 2.** Thalidomide children and the molecule's chemical structure

The following questions would be posed to students.

1. Was thalidomide an effective drug for morning sickness?
2. What is the reason for thalidomide causing birth defects?
3. Do the two structure of thalidomide have different spacial arrangements?

The suggested process used in PBL is the following:

1. Read the Problem
2. Brainstorm
 

hypotheses	what do we know in support of the hypothesis? what do we need to know to test the hypothesis? learning issues
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3. Identify/Discuss/Assign
 

essential issues (for everyone to look up) specific issues (for individuals to look up) overlapping issues	
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4. Individual Reading - Research - Experiments
5. Return review case so far
 

report and discuss assess progress - continue page/next page/complete self-evaluation - How did things go? Any suggestions for next time? next problem	
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4. Can you find other drugs having enantiomers with different biological activities?
5. How are the different spacial structures of those drugs identified?
6. How are the enantiomers separated from each other?

This case study is well defined and focuses on particular concepts and issues—optical enantiomers. It has a social significance and it requires students to be active in developing ideas further. It also needs knowledge from several disciplines and provides scope for asking a range of different questions of different levels of difficulty. Many other concepts in organic chemistry can be introduced with case studies.

### Using problem based learning (PBL) in workshops in the laboratory

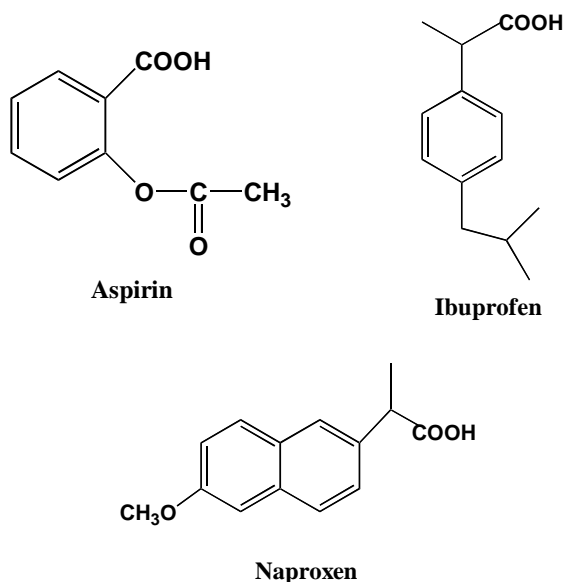
In our university, we have carried out workshops or student projects for several years. In the past however, the lecturers design the project in detail for students. For example, a multistep synthetic route was given to students, and the students validate it in the laboratory. In this way, students do get a chance to practise their experiment skills, however, as far as higher education is concerned society needs scientists rather than skillful labour. So giving a problem to students and encouraging them to solve it in their own way can improve learning more effectively. This methodology is called problem based learning.

Generally speaking, 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 (ill-structured problem) which reflects the real world. Many studies show that the PBL teaching method not only enhances students' knowledge of the basic principles, but also has the potential to develop students' self-directed lifelong learning skills, critical thinking skills, communication skills, to increase students ability to solve real-world problems, and to increase students' motivation for learning (Nendaz and Tekian 1999). PBL is now increasingly entering the repertoire of instructors in many universities. In fact, over 80% of medical schools are using PBL to teach students about clinical cases (Vernon and Blake 1993).

### A PBL example aspirin and other aromatic NSAIDs

The following scenario can be used in the workshop as a first year students' project.

As you know, whatever the cause- tennis elbow, a sprained ankle, or a wrenched knee, pain and inflammation seem to go together. Both problems are often treated using a common, over-the-counter medication called NSAID (nonsteroidal anti-inflammatory drug). The most common NSAID is aspirin, however it can cause stomach bleeding and allergic reactions in long-term users. Even more serious is a condition called Reye's syndrome, a potentially fatal reaction to aspirin sometimes seen in children recovering from the flu. How can a potent, but less side-effect NSAID be found? What is the structure of aspirin? Is it still used in the drug market? What is the safe dose for a child? In the last two decades, have any other NSAID appears? How have they been developed? Do they have any side effects? What's the chemical structure of those drugs? Design a practicable synthesis route for them. Can you conduct the experiment in the lab and provide a pure sample of the drug?



**Figure 3.** Chemical structures of aspirin, ibuprofen and naproxen, which have the same potency but is less prone to cause stomach upset

This is a problem from real life. So, the procedure a teacher might use is not the only way to solve this problem. Students will be encouraged to propose their own innovative methods. In problem based learning, the problem may not be solvable, but nevertheless it provides a rich environment for learning. The aim is to learn rather than to solve the problem. In fact, it is difficult for trained scientists to develop a new drug without side effects to treat pain and inflammation.

The student's oral presentations and written assignments were useful in assessment. Through the process of inquiry, idea generation, discussion and doing by themselves; each student developed a deeper understanding of various aspects of the field of chemistry as practiced by the professionals in the discipline of chemistry.

### Online teaching and learning project

The spread of Internet use and the availability of a wide range of information posted on the Internet makes it necessary to present at least some aspects of internet use as a teaching tool. As an alternative way of education, teaching and learning on-line has recently attained a lot of attention. A customised set of web-based tools to support the learning environment has been designed and built. (Oliver and Omari 1999; Oliver, Omari and McLoughlin 1999).

Studies show there are advantages and disadvantages of teaching and learning online are shown in Table 1 (Ophardt 1998). In my view, it is not possible for all the students to learn the same thing at the same time in the same way. As far as students are concerned, students have personal control of information in the process of teaching and learning online. They learn online because they want to learn instead of being forced to do so. They may use time more effectively. Easy access and learning at one's own pace are unique features of the Internet that offer exciting opportunities to learners for greater participation, interaction and collaboration in the education environment. Without doubt, it will help us to develop student-centred learning strategies.

**Table 1.** Advantages and disadvantages for online course delivery

Advantages	Disadvantages
Faculty becomes facilitators of learning	Faculty role is not face to face teaching
Adult students with busy schedules	May not actually have time for course
Need mature, self motivated student	May not actually have time for course
Any time delivery, asynchronous	None
Chat room discussion	Time when all are available
Computer technology	Computer literate, computer access
Advanced software, 'plug-ins'	Less than 'state of art' computer available.
Promotes increased communication	Lack of personal contact with students
Students interact more with content	Need independent study skills
Create 'virtual' text book	Good internet sites may 'disappear'
Graphics, simulations, audio available	Need 'plug-ins' for student computers
Very current, up to date content	Time consuming searches, HTML page set up, continuous monitoring

After I return to my university, I will apply a program: teaching and learning organic chemistry online. I will invite some experienced colleagues and students to cooperate with me. The content may include: pre-laboratory experiments; online assessment; discussion section; feedback; course-tested exercises; the latest developments in organic chemistry; multilayered and multidimensional demonstrations of complicated molecules; vivid models of abstract mechanisms; syllabus, textbook, and *PowerPoint*; useful links, etc.

## Conclusion

Concept mapping, case studies, problem based learning, and teaching and learning online are some strategies that may be used to develop student-centred learning, as well as lifelong learning. Actually, these strategies are not completely new concepts for staff. Their own skills were developed from this teaching and learning process. For example, many teachers have used concept maps to introduce a topic. However teachers just use them to express their own idea clearly rather than involving students in the process. So when we try to reform the model of teaching and learning, we may face a lot of obstacles from students, from colleagues and ourselves. In education, evolution is probably better than revolution. We can try to reform step-by-step. Based on experience, enthusiasm, high motivation and unremitting efforts, a bright future for higher education is on the way.

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