

# The reform of teaching in *General Chemistry*: Establishing student-centred teaching strategies

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## Abstract

This paper gives a general view of how to establish student-centred teaching strategies in the curriculum design of *General Chemistry* in Jilin University of China. The author will modify this course by combining traditional teaching methods with advanced teaching techniques and contemporary teaching theories. In the process of teaching and learning, different methods will be used according to different types of teaching content.

## Introduction

Teaching styles are classified into three general categories: discipline-centred, teacher-centred, and student-centred (Dressel and Marcus 1982; Woods 1995). Student-centred teaching focuses on the student and, in particular, on the cognitive development of the student. The students are not passively receiving information and they should participate in the process of teaching and learning, in particular, they should participate in the process of thinking.

How teachers teach is influenced to a great degree by what they teach and by how their courses are organized. The usual focus in organizing a course is the content. Although the students have the responsibility for learning, the teachers have the responsibility for activating students' interest in learning and for teaching students how to learn and/or for developing their lifelong learning skills. The university teacher's job is to:

- establish students' self-confidence in learning;
- clarify complex theories using simple language;
- assist students in constructing new meanings of knowledge;
- help students grasp the development of knowledge;
- activate students' interest in learning through different teaching strategies;
- encourage and help students to challenge difficult problems;
- put forward interesting real world problems;
- develop the students' intellectual and imaginative powers;
- develop the students' abilities of inquiry, understanding, independent judgement, analysis and creation; and
- develop the students' problem solving, communication and self-learning skills.

There is no one best teaching strategy to teach students in all courses or contents. Teachers should use different teaching strategies according to different situations of teaching content. Although there is no universal best way to teach, experience shows some general principles can be applied (American Association for the Advancement of Science 1990a; McDermott, Shaffer and Somers 1994; Mazur 1997).

We have learned many teaching strategies at The University of Sydney, which relate to behaviourist theory, constructivist theory, concept mapping, problem-based learning (PBL), case study and use of the Web. No matter what teaching strategy we use, it may contain following teaching methods:

- lectures (using multimedia technologies, models, diagrams, figures and illustrations);
- cooperative group activities and teamwork (student discussion, debate, communication, peer assessment and sharing information);
- self-directed learning (student projects, self-assessment, reading books and using web sites);
- presentations (oral presentation, mini-lectures, poster and written reports);
- tutorials (the teacher discussing problems with students, and checking students' homework);
- making students practice the relevant skills; and
- using multimedia technology and *WebCT*.

## Description of the course

*General Chemistry* is a course for the first year students at Jilin University of China. This course has its own knowledge system and its content linking up with those of high school and is the foundation for subsequent courses in chemistry and in other related disciplines. The main goals of the course are to let students understand the basic chemical principles deeply, become acquainted with the main properties of important elements and their compounds, learn problem solving skills using chemical knowledge, and gain independent thinking ability.

In our college, *General Chemistry* contains 64 hours of lectures, 68 hours of chemical experiments and 10 question-answer courses. We have used multimedia technology and demonstration experiments in lectures, and we have been reforming experimental teaching – designing multiform experiments.

In traditional teaching methods, students learn knowledge mainly from the teacher's lectures, so students learn passively and employ surface approaches. In particular, students are over-dependent on lectures and are regulated by teachers.

## Modification of the course

The goals of our modification are establishing a student-centred teaching model, giving students an active learning context and training students' lifelong learning abilities. We will attempt to introduce many more contemporary teaching strategies in the *General Chemistry* course. All these efforts are designed to activate students' interest in learning. It is not important for teachers to teach specific knowledge to students, but it is very important for teachers to teach students how to learn or how to gain the ability for lifelong learning.

### Using problem-based learning

Problem-based learning (PBL) is a learning environment in which the problem drives the learning. Before students learn some knowledge they are given a problem. Students find that they need to learn some new knowledge to solve the problem. So the PBL is a strategy for encouraging critical thinking, cooperative learning and enhancing problem solving skills through resolving real world problems.

Many real life problems are suitable for the course of *General Chemistry*. Some examples I have selected are the following:

- what is the greenhouse effect?
- what are the main sources of greenhouse gases?
- why does the ozone layer hole form?
- how can we purify our water?
- how is acid rain formed?
- how does acid rain interact with soil?
- how can we reduce air pollution from automobiles?

### Using concept mapping

Concept mapping derives from constructivism 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 maps can serve as a key plan for a teacher in working out the best way to teach a topic. It can also be used to help teachers to explain why they are focusing on a particular aspect of a topic so that the students can see how particular pieces of information fit into the overall schema. Concept maps can be used to help students know what it is they have learned and what it is they still do not understand and retain a mind map of the information they are studying.

Much knowledge in *General Chemistry* can be designed into concept mapping: atomic structure, molecular structure, coordination compounds, nitrogen fixation and circulation, carbon dioxide circulation. I would like to take molecular structure as an example (Figure 1).

### Using a case study

A case study is a story with message and a question, and it educates through stories. Stories should be interesting, relevant, motivating and related to the real world. Case studies help students to build analytical and synthesis skills, apply concepts, develop problem solving skills, develop mature judgment and critical thinking skills, and enhance communications skills. In a case study, the teacher guides students through the maze of a case discussion by questioning, redirecting questions, clarifying, probing and highlighting points or issues. Many real life events related to chemical properties of the elements are fit to be used in *General Chemistry*. I can give some examples as follows:

- global warming;
- greenhouse effect;
- air pollution;
- lead pollution; and
- properties of some compounds.

A case study example: we give students the picture (Bruce and Clyde 2002).



Then tell a story: 'the factory is really near your family. Any plant near this factory couldn't grow...'. Finally the students are asked some questions:

- what inorganic gases are emitted from the factory?
- which gases are poisonous?
- why could the smoke affect the environment?

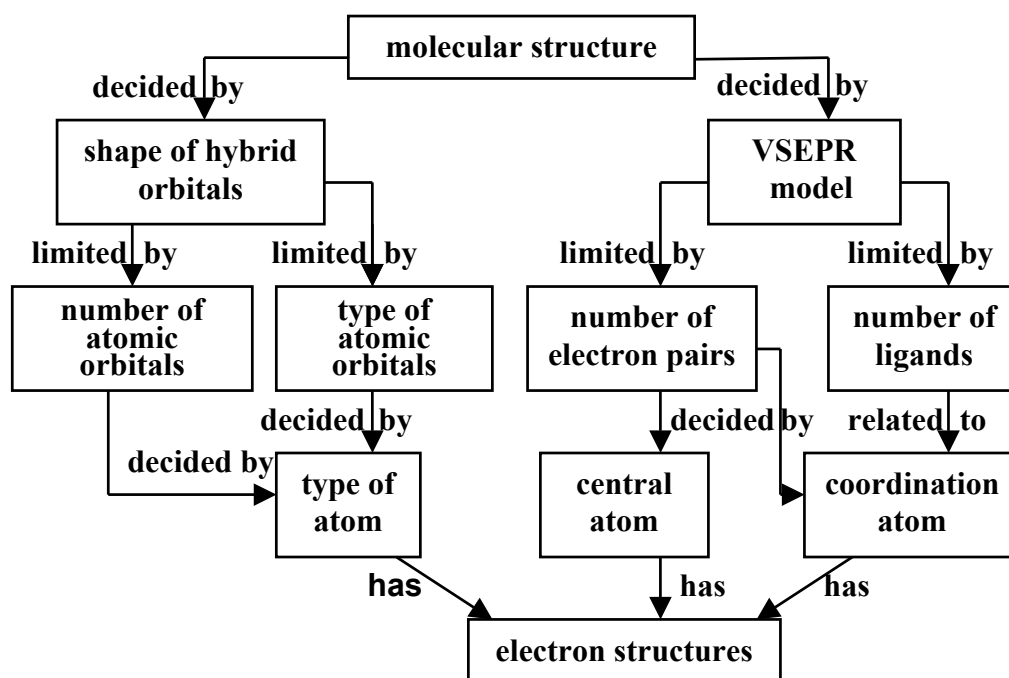


Figure 1. Concept mapping of molecular structure

### Using web site: online teaching and learning

In a short period of time, the Internet has become extensively used for online teaching and learning. Using the Web as a medium for integrating computer based learning into an organized course has proved to be an interesting and

beneficial exercise (Redfern 1999). It is convenient and interesting for a student to learn new knowledge, seek information, gain feedback on assignments and communicate with teachers and other students via a web site. A teaching procedure on the Web is as follows:

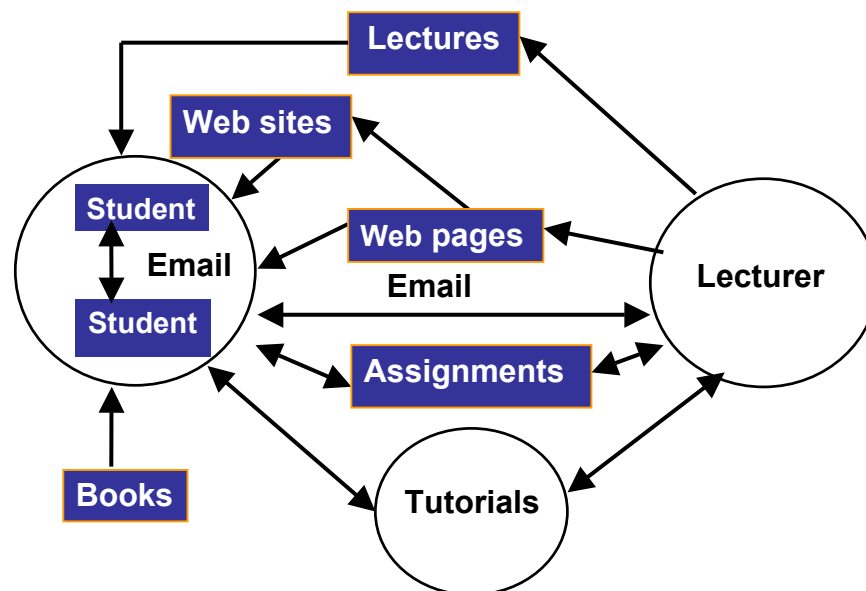
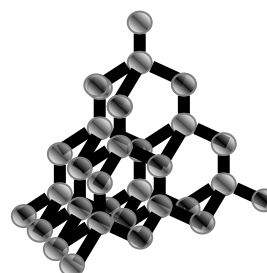


Figure 2. Teaching procedure using the Web

### Using multimedia technology in lecture

We have used multimedia technology in teaching *General Chemistry* for five years. The multimedia technology gives students wonderful stereo models and clear and accurate characters, especially regarding the structure of atoms, molecules and coordination compounds. It can increase teaching efficiency and it is very easy for a teacher to add or reduce the contents. Here we take the diamond structure as an example:



**Using demonstration experiments in lectures**

We have been using demonstration experiments in *General Chemistry* lectures for a long time and have gained excellent impacts on teaching. Using demonstration experiments can help us to enhance students' interest in learning, activate the classroom's atmosphere and increase the effectiveness of teaching. Many experiments can be designed as lecture demonstrations, for instance the swing experiment, fading colours of flowers, the reactivity of

ozone, volcano reactions, the fountain experiment and so on.

**Using diagrams and figures in lectures**

We always use diagrams and figures in *General Chemistry* lecture. The diagrams and figures give students clear guidance and many concepts in *General Chemistry* can be described with diagrams and figures, for example:

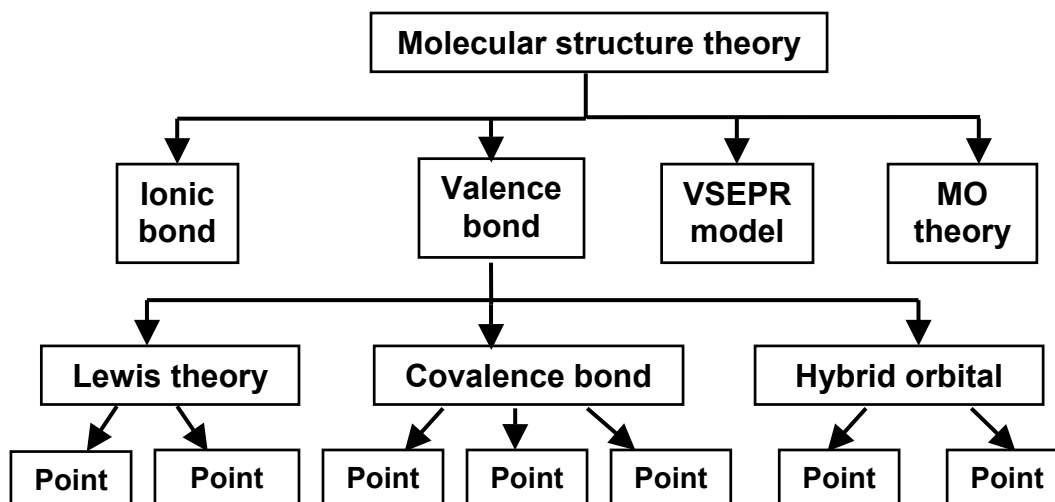


Figure 3. Hierarchical diagram of the theory of molecular structure

**Designing new questions for study exercises and examination**

Study exercises and examinations are important approaches through which students are able to review their learning outcomes and consolidate the knowledge they have learned. We must decrease the use of insipid questions or the questions which only assess knowledge by rote. The characteristics of good questions are:

- they link to several areas of knowledge;
- they reflect real world problems; and
- they are designed to integrate knowledge.

the main emphasis in the reformation of experimental teaching is establishing multiform experiment system, it includes:

- appointed experiments;
- optional experiments;
- integrated experiments;
- serial experiments;
- designing experiments;
- opening laboratories to students; and
- looking at demonstration experiments recorded on video tape or VCD disc.

**Reforming experiment teaching – multiform experiment**

Chemistry is an experimental science. The experiments or laboratory work are very important for students to understand the meaning of chemical knowledge. We have been reforming experimental teaching for a long time, and

Here is a serial experiment containing the synthesis of a series of compounds. Students use iron powder as the starting material to synthesize four important salts:  $\text{FeSO}_4$ ,  $(\text{NH}_4)_2\text{SO}_4\text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ ,  $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3] \cdot 3\text{H}_2\text{O}$  and  $\text{Fe}_2(\text{SO}_4)_3$ , which contain a simple salt, a compound salt and a coordination compound.

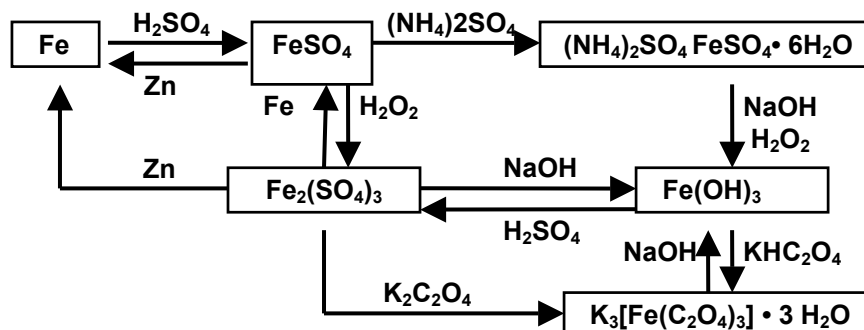


Figure 4. Example of serial experiment

## Conclusion

This is a time of knowledge explosion and teaching reform, in which we are required to transform the concepts and practices of teaching from current teaching models to contemporary models. We have made substantial reforms and we have more work to do in the course of *General Chemistry*. We will encounter many difficulties that must be overcome, such as lack of facilities and classrooms, time limitations, reconstructing the curriculum, and changing the role of students and teachers. Teaching reform is a long-term and complex task. It needs our enthusiasm and unremitting efforts. We have the responsibility for sustaining teaching reform.

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