Thinking towards teaching *Physical Chemistry* in China: How to increase the learning interest in this course

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Introduction

With the aim of transforming the student experience from surface learning to deep learning and to encourage the development of lifelong learning skills, the author has considered changes to current teaching by introducing some contemporary teaching methods and strategies to upgrade the teaching quality in *Physical Chemistry*. Considering the current situation in China, this paper considers the problem, of how to increase student interest and what techniques and approaches might be used to stimulate students' interest in this course, especially given its long duration. Being the course students find the most difficult, it is necessary to carefully prepare the lectures and allocate teaching times over a range of activities in the future.

Background

The characteristic of physical chemistry

Physical chemistry, alternatively theoretical chemistry, is a main branch of chemistry, which establishes and develops the subject in terms of the underlying concepts of physics and the language of mathematics. It is a course for 3rd year undergraduate students in most Chinese science universities. The total lecture time exceeds 126 hours over two semesters. Most students believe *Physical Chemistry* is the most difficult course in the School of Chemistry, because it consists of lots of complicated mathematical calculations and has an extensive theoretical base. In fact, it is the theoretical basis, which is most important for those students, because most chemists believe the most useful knowledge for the learner is to learn how to think about real problems in the chemical world through academic eyes. At the same time, this is an excellent opportunity for students to organize the knowledge, which they had previously learned in other chemical courses, such as inorganic chemistry, organic chemistry and analytical chemistry, and so construct an overview of the whole chemical world and develop the abilities to tackle real problems.

The theoretical course is always perceived as difficult for a learner lacking strong learning motivation. And the students quickly lose interest in learning early in the course as they become bored by the learning process of the course. This is especially common when only surface learning is required. On the other hand, teaching is now being organized to meet the needs of the learner in China. Teachers changing their teaching methods need first to consider the content and characteristics of the course itself. At the same time, paying more attention to increasing the learners' interest and transforming the learning to deeper and deeper levels is an additional impetus to current teaching in *Physical Chemistry*.

The links are the most important parts in this course

There are many concepts in physical chemistry that are not only very abstract for the learner, but are also difficult to teach. Most of the learners' interest will be lost if the teacher ignores using links as a teaching method. Establishing the links among the concepts of physical chemistry is the most important task in developing deep learning, which is very useful in meeting the aim of training the learner in scientific methods. How to teach the concepts is the key to this kind of course with a big theoretical base, because the bigger that theoretical base, the more concepts are needed. So the teacher should pay more attention to the links than to the nodes and do their best to guide the learner in effectively understanding them.

The typical links among the concepts is shown in the chart below, which is constructed with several 'closed cluster concepts'. These cluster concepts consist of several interrelated concepts (each represented by a letter), which contribute to the main concept (which is represented by a number). All of these key concepts are needed to satisfy the main objective, which is to solve some real world physical chemistry problem. Although this is only a model of the complex system, it is enough to explain their relationships.

However, whilst the motivational problem is easily addressed at the beginning, it must be reinforced during the whole process, because it is only after students know and understand all of those links that they will have the ability to successfully resolve the real problem. To lead students though the complex array of concepts and to finally construct an integrated system of knowledge, the instructor should use modern teaching strategies, such as student-centred learning and case studies. Recognizing the current state of teaching and learning in China, it becomes really important to reorganize the whole studying style.

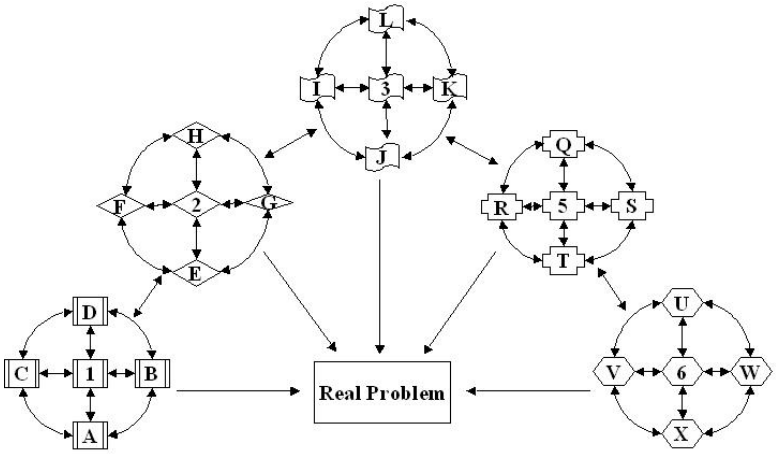

Figure 1. The model of the relationships between concepts

Enhancing the learners' interest

In the lecture

For greater clarity in explaining those links and to facilitate the students' understanding of them, significant changes must first be made the design and presentation of lectures.

It is necessary to devote most time in the lecture to the relationship between the individual concepts and clearly illustrate the purposes for citing and using them, especially clearly demonstrating the contribution of each to the key conceptions.

Restructuring the time and allotting the main part of the lecture to the links is very necessary. Allocating particular segments of time for the students to discuss and link the concepts by themselves will lead a deeper learning. This discussion of questions from the lecturers should last 10-15 minutes each time. At the end of the discussion, it is better for the lecturer to make a summary and lead the students' critical analysis.

Adding some interesting historical cases to introduce some basic information about the conceptions will be useful and helpful in supporting the explanation in the lectures. It also has a value for the lecturer to lead the learner into thinking about what the physical chemist had thought in the past, which is the best way to help students think about the scientific method and so develop their academic thinking skills.

Case studies will help to teach the links

First, give the students a relevant case to think about and discuss, and then explain the relevant knowledge. Finally lead the students' discovery of the solution to this problem and the thinking process itself. It is a very useful way to train their academic and critical thinking abilities. Once the students feel they own the solution, they will become motivated. Clearly explaining the concepts and giving students time and opportunities to think about the method itself will increase their interest and provide motivation to learn. At the same time, there is an opportunity of asking students some relevant questions to stimulate their thinking and to enable them to discover the path themselves.

Use and perform some demonstrations in the lecture

These will give the learner time to link the theoretical items with the real subject. Alternatively, a demonstration provides an opportunity for students to practice and review their own theoretical concepts. Using modern tools to support the lecture is also very necessary to successfully accomplish these kinds of complex teaching.

In the tutorial

Give a tutorial after each important lecture to cover special topics. The approach can be varied from the simply mathematical calculation to the deep linking of the knowledge between the old and the new. Providing some non-compulsory web sites and good structure to provide support for what they have learned and to broaden their outlook. By using and designing some interesting games encourage the students to follow the thought processes step by step, for example, a game designed to link some concepts.

In the assessment

Adding a part of the assessment to their activities both in the lecture and the tutorial thereby increasing their participation and stimulating interest in the whole studying process. It will count towards 15% of the final mark of that semester. A special additional mark will also be used as the estimate of their ability in resolving problems, which will encourage them actively to take part in the discussion in the lecture and to ask questions in the tutorial.

Encouraging the students as homework to review the web sites provided and so encouraging their self-directed

learning. Open a platform in the LAN (Local Area Network) so the students can raise and discuss questions outside of the lectures. The lecturer can encourage them to answer the questions themselves. Not only can students be given a mark as an assessment of their contribution to the whole process, but this approach can also be useful to increase their interest in learning.

Connected the theory with the real world

During this kind of teaching, the teachers need to pay close attention to the theory. Basic concepts are used to solve the complex problem, beginning with the key principles and emphasizing the application of theory in this course. Demonstrations are useful in helping subjective thinking. Problem-based learning is also a powerful method for interactive learning, but it takes lots of time and energy, especially before the accomplishment of the whole system. For this reason, it is better to divide a big real world problem into several small parts, frequently reminding the students of the problem and lead their thinking step by step. Try to deduce the theory by arranging the teaching process into a series of smaller learning tasks, which are logically ordered and sequenced.

Use interactive way to practice

Interactive practices are the best way to develop active learning. Make the links clearly with a funny game in the tutorial or do some interesting exercises in the computer. The tutorial and the lecturer are the guides to direct the students to think about and resolve a problem correctly, instead of just giving them the right answer.

Use of modern teaching technology

Using a web site and the Internet both during and outside the lecture, such that students consider these as the main support for teaching, provides support and encouragement for lifelong learning. It will enlarge the learners' thinking field and enhance the traditional learning methods, and not limit the students to the contents of a textbook. At the same time, it is the only way for Chinese teaching to keep pace with modern developments in higher education.

However, it will not be easy to change the current situation. For successful reform, the teacher should do their best firstly to promote this basic change. They need a large number of support materials on the Web and in the laboratory. And it also needs more recognition for the fundamental lectures and teamwork among the staff.

Summary

Carefully preparing and presenting the lecture is the most basic issue for increasing the learner's interest in this course. Deeper learning will be accomplished not only by introducing changes in study styles but also by using modern teaching methods. A new teaching design focusing on the links will be very useful for improving the teaching quality in *Physical Chemistry*.

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Reference

Fahmy, A. F. M. and Lagowski, J. J. (2001) Systemic Approach to Teaching and Learning Chemistry: SATLC in Egypt. *Chemical Education International*, **3**(1).

Lerman, Z. M. (2000) Chemistry for the People Who Will Shape Our Future. *Chemical Education Journal*, **4**(1).

Norton, L. S., Tilley, A. J., Newstead, S. E. and Franklyn-Stokes, A. (2001) The Pressures of Assessment in Undergraduate Courses and their Effect on Student Behaviors. *Assessment and Evaluation in Higher Education*, **26**(3), 269-284.

Thomas, G. P. (1999) Student Restraints to Reform: Conceptual Change Issues in Enhancing Students' Learning Processes. *Research in Science Education*, **29**(1).

Zeegers, P. (2001) Approaches to Learning in Science: A Longitudinal Study, *The British Journal of Education Psychology*, **71**(1), 115-129.