

An exploration of problem based learning teaching in *Organic Chemistry*

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Abstract

Through a general overview and analysis of the curriculum design and teaching strategies for the course *Organic Chemistry* in Peking University Health Centre, based on contemporary educational theories, some innovations are developed for increasing the wide-ranging abilities of students. A series of strategies which are involved in problem based learning, concept mapping and online communications, are suggested and discussed in terms of encouraging student-centred learning.

Introduction

Description of the course and goals

Organic chemistry is a compulsory course for all students in Peking University Health Science Centre (PUHSC). There are four syllabuses for organic chemistry in PUHSC. The first is for students studying clinical medicine and stomatology (long-term 8 years doctoral students); the second is for Pharmacy (6 years graduate) students; the third is for Pharmacy (4 years undergraduate) students; and the fourth is for students studying basic medical sciences, clinical medicine, preventive medicine, stomatology, nursing, medical laboratory diagnosis and biomedical English. Students in this first group are taught in Peking University. The second and third groups are students who are majoring in pharmacy and who would spend one academic year learning organic chemistry as a core course in their second year. The fourth group is the largest cohort in PUHSC and consists of students who are studying in diverse majors, so their syllabus would be described in detail as representative.

As a fundamental course to all non-pharmacy students, this course involves 72 hours of lectures and 36 hours of laboratory work in one semester of first year and has an approximate enrolment of 350 students. The syllabus includes topics on alkanes, alkenes, alkynes, stereochemistry, aromatic compounds, alkylhalides, alcohols, phenols, ethers, aldehydes and ketones, carboxylic acids and their derivatives, amines, heterocyclic compounds, carbohydrates, lipids, amino acids and proteins, and nucleic acids. Student assessment is by a mid-term and a final written examination. The main objectives of this course are: to introduce the characteristics and principles of organic compounds, to provide the foundations for subsequent courses such as pharmacology, biochemistry; to provide students with strategies to solve realworld organic problems, especially those relevant to life sciences, by using their acquired knowledge; to enhance comprehensive abilities of analysing, understanding and solving problems, developing in students an appreciation of the scientific method; and to equip students well for the skills of lifelong learning.

Composition of students

Since it is one of the most famous universities in China, Peking University Health Center has high quality students who come from all over the country, as well as about 70 students from Hong Kong special administrative region and Tai Wan region and 70 international students from various countries. Before they learn organic chemistry, the first-year students have learned inorganic chemistry in their first semester and have some basic organic chemistry knowledge learned in high school.

Current teaching methods in the course

In the mid-1990s, the Chinese government completed its reorientation for higher education and established its reform guidelines. As one of the nation's leading institutions of medical education and a renowned medical school both at home and abroad, in order to create an internationally standard medical institute and to offer

first-class medical education for the health of all human beings, Peking University Health Science Centre is continuing innovation. As a common course supplied for all the university students, *Organic Chemistry* is considered important and has been undergoing reform for several years. Some innovations are discussed below.

Lectures

New textbooks are used including some English references, more realistic and meaningful tasks related to the students' future careers are provided. Modern multimedia techniques such as *PhotoShop*, *Flash* and movies, which can explain the chemical reaction mechanisms easier than traditional teaching styles, are incorporated into lectures; *PowerPoint* files replace writing on the board, making the course more interesting and active; a web site of online learning releases the students and professors from the constraints of space and time by offering new learning contexts. Meanwhile, the students are encouraged to join more activities, for example, attending academic lectures being delivered by famous scientists. There are numerous famous scientists visiting Peking University each year, and their excellent speeches are inspiring to the students. The more the students learn, the more they clearly understand what they know and don't know, the more they study. Other activities include short presentations by students, and role plays which illustrate chemical reaction mechanisms. A proverb says that 'interest is the best teacher', all these measures greatly increase the interest of students and make teaching more effective.

Tutorials

Tutorials are divided into three parts. The first is one-to-one tutorials scheduled one per week for all students. The students go to teachers' rooms and discuss problems with their teachers. The second is two formal tutorials in one semester, the teacher will have a general review of all chapters and give the students some exercises. The third tutorial is for international students only, and is aimed to help them overcome the obstacles of language and grasp the organic knowledge.

Laboratory

New laboratory books and videos are used, and students learn more from the videos. A range of more interesting experiments are recommended, such as some drug synthesis, and the extractions of vitamins. All these experiments are related to real life and are entertaining for students.

Although all these strategies have significantly improved the teaching and learning, we are still exploring new teaching methodologies in order to increase the comprehensive abilities of students.

Modifications of teaching and learning in *Organic Chemistry*

According to the modern educational theories, there are three main teaching strategies, i.e., behaviourist, developmentalist and constructivist, which derive many approaches such as schema, concept mapping, case studies

and problem based learning (PBL). Combining these multiple teaching strategies and using them correctly will greatly improve teaching and learning. Based on those theories, and considering the reality of PUHSC, some new ideas are considered. The most important of these is the development of problem based learning skills.

Problem based learning is a curriculum approach which helps the learner frame experience through a series of problem solving activities and where the process of learning unfolds through the application of knowledge and skills to the solution of real world problems, often in the contexts of real practice (Bligh, 1995). Problem based learning uses problems to motivate students to acquire knowledge rather than relying on the exposition of discipline knowledge (Boud and Feletti, 1991). PBL has been regarded as one of the most exciting and powerful education methods to have appeared in the last 30 years. Jonassen (1991) argues that 'the most effective learning contexts are those which are problem or case based and activity oriented, that immerse the learner in the situation requiring him or her to acquire skills or knowledge in order to solve the problem or manipulate the solution'.

A key feature of PBL is that students take greater responsibility for regulating their learning. Students' self-regulation involves planning, monitoring and evaluating learning, regulating effort, managing time and seeking help from peers and staff (Ertmer, Newby and MacDougall, 1996; Vermunt and van Ruswuk, 1998). For teachers, PBL should be designed related to: realworld practice, interdisciplinary based knowledge, experiential knowledge/skills, skill development, values and professional behaviours. Furthermore, a PBL problem should provide context, time, place and, if possible, put the student in the role of the practitioner. The more interesting, challenging and unusual the problem, the more it will grab the attention of the students (King, 2005).

Based on the aforesaid theories, the following PBL question has been designed.

Consider yourself to be a pediatrician with a chemistry background. You go to a small city and work there for a year. One day a mother with a severely mentally retarded child comes to see you. The patient is a boy, almost 4 years old, who cannot speak or walk, eat or drink on his own. He is unable to fix his eyes on anything; stool and urine habits are those of a baby. He has a lighter complexion than his siblings, with blond hair and blue eyes. There is a characteristic 'mousy' odour on his breath, skin, and urine. Clinical examinations show that his plasma phenylalanine concentrations are persistently high. Urine examination indicates there is a higher phenylpyruvic acid level than normal. Further examinations prove he is a PKU (phenylketonuria) patient.

Question

1. What causes PKU?
2. What are the normal metabolic pathways of phenylalanine? What kind of metabolism would occur if phenylalanine accumulates in body? What kind of metabolic products' deficiency causes the above syndrome?

3. Would you be able to simulate the *in vitro* synthesis of those compounds by using chemical methods?
4. Is PKU an inherited disease? How can PKU-related conditions be reduced or prevented? How should PKU be treated?
5. PKU was first described in 1934 by a Norwegian doctor named Asbjorn Folling. He identified phenylpyruvic acid by basic chemical analysis. If you were him, what kind of tests would you use? What tests may be used to determine PKU today?
6. What kind of isomers exist *in vivo*? If you eat a racemic mixture of isomers, what will be found in your urine?

Student learning objectives are:

1. to learn the chemistry of aldehydes and ketones, carboxylic acids and their derivatives, amino acids, proteins, and nucleic acids, their function in human bodies;
2. through the simulated synthesis of tyrosine, phenylpyruvic acid, 3,4-dihydroxyphenyl alanine (DOPA), melanin, phenyllactic acid, to recognise the multiplicative reactions among amines, carboxylic acids, alcohols, amino acids and so on;
3. through the laboratory examination of PKU, to learn about some laboratory techniques such as chromatography, isotope techniques, etc., and to be able to identify aldehydes and ketones;
4. review the knowledge of stereochemistry: chiral compounds;
5. to understand some gene therapy and genetic knowledge; and

Background

PKU is a genetic metabolic disorder in which the body lacks a liver enzyme (phenylalanine hydroxylase) needed to process phenylalanine, an essential amino acid, into another amino acid (tyrosine) used by the body. Left unconverted, excessive amounts of phenylalanine in the bloodstream are toxic to brain tissue and the central nervous system; if untreated in newborns, PKU can cause brain damage and mental retardation. Because phenylalanine is involved indirectly in the production of melanin, the pigment responsible for skin and hair colour, children with phenylketonuria often have lighter complexions than their unaffected siblings. There is a characteristic 'mousy' odour that results from the accumulation of phenylacetic acid. This odour may be detected on the breath, skin, and urine if the condition has not been treated immediately from birth or if foods containing phenylalanine are consumed. Related knowledge is shown in Figure 1 (Ophardt, 2003).

Students work in groups and search related documents in order to find possible answers. They are scheduled to attend 4.5 weeks of lectures directly related to the current problem. Finally each group would be required to give a formal paper. The teacher facilitates the students in analysing the situation, identifying areas of learning and potential learning resources.

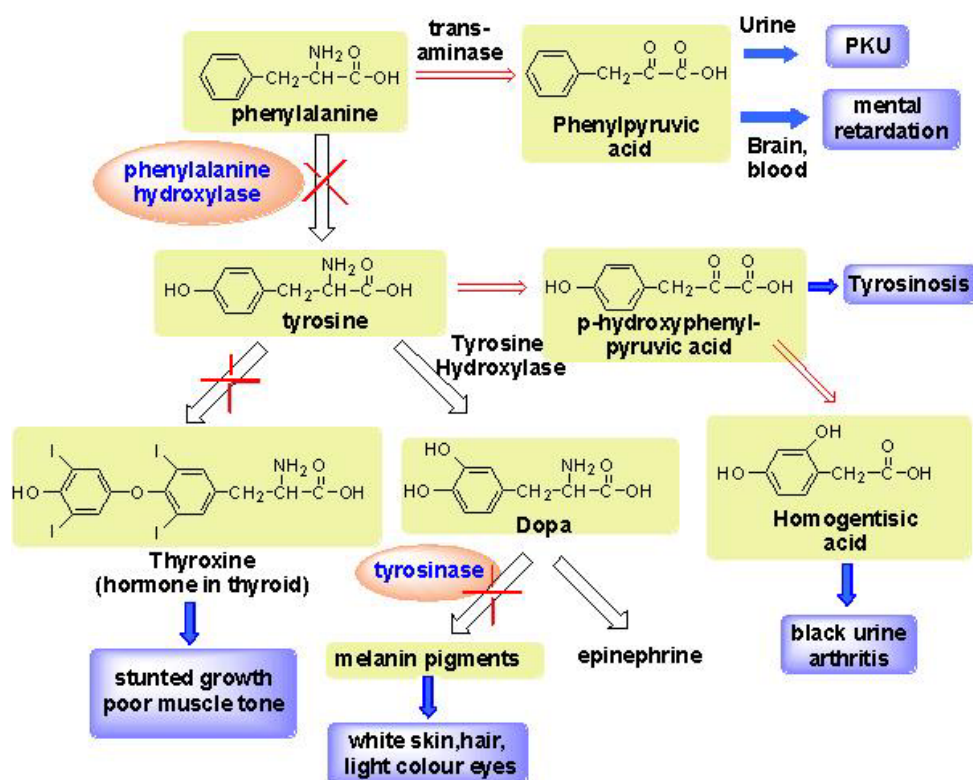


Figure 1. Chemical imbalances that produce the symptoms of PKU

Conclusion

In contemporary society, students face a world in which much of the work they will do has not as yet been imagined. Universities need to deliver not simply specific skills and specific knowledge but also the attitudes, aptitudes and problem solving skills for lifelong learning. Undoubtedly, problem based learning is an excellent strategy, however, for successful teaching an over-dependence on one way of teaching and learning should be avoided. Combining multiple teaching styles and training students' wide-ranging abilities will gain the largest rewards.

Acknowledgements

This work has been completed within the program *Teaching Science in English*. The author wishes to acknowledge the support of the China Scholarship Council and Peking University. Special thanks to Associate Professor Tony Masters for his generous help and excellent seminars. Many thank to Associate Professors Mike King and Mary Peat for their teaching of contemporary teaching theories and strategies. Sincere thanks to Dr Siegbert Schmid, Dr Adrian George and all other staff in the School of Chemistry for their lectures and help. Finally, the author

also is grateful to all classmates for their valuable discussions and companionship.

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