Improving teaching and learning in a plant biology course further and deeper

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Abstract

On the basis of a complete review and comment on the current state of teaching and learning in a plant biology course in China, this paper discusses how to improve teaching-learning further and in more depth according to the constructivist perspective and student-centred approaches. The traditional teaching and learning viewpoints, contents and methods have not been suitable to modern education, and educational reform is imperative in this situation. Our teaching goal should be to train biology-based professionals of the highest calibre. As the traditional lectures consume a great deal of hours, it is advised that hours of lectures are reduced so that student-centred approaches may be incorporated. In this paper, using the example of a plant diversity course, the teaching strategies of concept mapping, problem-based learning and case study are applied. Finally, the author discusses the advantages and the best applications of the different teaching strategies.

Introduction

Nowadays, in the theoretical development, the constructivist perspective and viewpoint of how people learn science have been in the ascendancy. In practical development, student-centred approaches and student active learning have been adopted as an appropriate teaching technology, which is seen as compatible with the constructivist view of learning. Nevertheless, strategic plans for developing effective teaching and learning environments are rarely found (Entwistle 1998). A single teaching strategy is never appropriate to all learning contexts, nor is a single teaching method superior to another in all situations (particularly in terms of student performance). Effective teaching means designing the teaching/learning context so that students have every encouragement to react with the level of cognitive engagement that our objectives require.

The information society tends to organize itself around patterns of cognition. Therefore, the pivotal emergent property conditioning the future of these different societies is learning. Students are seen to have to construct their own knowledge, and learning is a process of inconsistent movement itself, which cannot be replaced by a teacher. First of all, we have to think about students' requirements and approaches to learning, and how their learning motivation is produced. In the teaching process, we can arouse student's review of their prior understanding of concepts and knowledge, then put forward new problems and facilitate their enthusiasm of learning further. To do this most successfully we can cite examples of crucial problems in real world, and thus mobilise their enthusiasm for learning. For example, when teaching the practical protection of plant diversity, the existence of the problem of sandstorms in Beijing is first referred to, before focusing on the implications for the need for the protection of plant diversity in the area.

Learning outcomes depend on an interaction between the characteristics of the student, the teaching style and methods of the teacher, and the policies and practices of the department and institution (Entwistle 1998), so teaching and learning are very complex processes. This paper uses an example of plant diversity and discusses some viewpoints about further improving the teaching-learning of the plant biology course, from the basis of an introduction to the background and development of the course.

The current state of teaching and learning

Introduction of plant biology

In China, the botany course has maintained a traditional pattern for a long time, in its teaching objective of training botanists. The teaching content is now considered dated, since it basically concentrates on classical morphology and taxonomy.

Nowadays, the plant science field is developing rapidly, and new offshoot disciplines and research fields come forth continually. Previous teaching content and methods may not be relevant in these contexts.

As a result of the facts mentioned above, since 1996, we have attempted to improve the teaching of the Plant Biology course, and have already published a textbook in 2000, and will publish a guide to laboratory tasks later this year. Botany or plant biology is a major subject in my university curriculum, and especially one of four required professional basic subjects for first year students majoring in biology. It is only in recent years that the plant biology course has come into existence in China. I believe that plant biology is a course which introduces the basic concepts and principles, the general research contents, methods and the latest dynamics of plant science. It is remarkable that the course is being reorganised within the whole discipline. In my opinion, the characteristics of the course should be vivid, integrated (but the system of discipline is not necessary) and cross-disciplinary, so that applying modern teaching methods is most appropriate. We have to present a course for the first year students of the biological field, in such a way that students form a knowledge 'web' in their brain. The 'web' will be a foundation that students use to learn the professional courses further and thus will be useful in training biology-based professionals of the highest calibre. The comparison between general plant biology teaching and my teaching content about plant diversity is listed in Table 1. To reflect fully the new developments in plant science, the reproduction, growth, development or evolution, the phylogeny and the maintenance of plant species diversity are added. At the same time, the detailed description of plant groups is reduced to create a more balanced course.

Content	General	My course
The basic knowledge of plant taxonomy	Yes	Yes
Introduction to researching methods and contents	No or less	Simple, but general
The extant Prokaryotes	Detailed	Simple
Diversity of eukaryotic alga	Detailed	Simple
Diversity of higher plants	Very detailed	Simple
Origin of lives and of Prokaryotes	No or less	Yes
Occurrence and evolution of eukaryotic alga	No or less	Yes
Occurrence and evolution of bryophyta and ferns	No or less	Yes
Occurrence and evolution of gymnosperms	No or less	Yes
Origin and evolution of angiosperms	No or less	Yes
Classification system of angiosperms	No or less	Yes
The law of a plant evolution	No or less	Yes
The produce of plant species diversity	No	Yes
The maintenance of plant diversity	No	Yes

Table 1. The teaching content of plant diversity in plant biology

At the moment, in my university this course covers 120 hours per year and is divided into two semesters: correlative contents of plant morphology and physiology are taught in the early half of a year, while plant diversity and ecology are taught in the later half of a year. There are 4 teachers and 2 laboratory staff with responsibility for this course, which involves lectures, experiments and field practice. The teaching plan is as shown in Table 2. In laboratory work, some experimental technologies are introduced. In field practice, essential for integrating and applying knowledge fully, plant biology is practised together with zoology, so teaching contents can cover a wider perspective, for example, involving correlative contents of taxonomy, biodiversity, biogeography, ecology, living resources, etc. At the same time students are trained in basic field researching skills.

We ask students to learn the subject knowledge and to acquire lifelong learning skills, problem solving, group skills, self-assessment skills, and communication skills. Subsequently testing them only on the factual subject knowledge is obviously inappropriate and will compromise effective learning. We need to assess what we believe are the knowledge and the skills being developed. Black and William's (2000) developing a theoretical framework of formative assessment, emphasises the interactions between teachers, students and subjects within 'communities of practice'. In the assessment of the student's learning achievement complicated methods are adopted. The final assessment of students' competence in the subject involves 4 parts: theory examination (50%), laboratory work examination (20%), field practice examination (20%), special topic/project in workshop (10%). Hands-on activities are meant to help students develop inquiry-based skills, which are important and integral to scientific research (Finn, Maxwell and Calver 2002). Therefore, the last three examinations need especially to involve interactions between teachers, students and subjects within 'communities of practice'.

The current approaches to teaching-learning

At the moment, the constructivist perspective has been introduced, and the teaching technology of student-centred learning has been applied. Most of teaching strategies have been related to and have been used by turn, for example, case study analysis, small group investigation tasks, problem-based teaching approaches, role play activities, simulations, interactive teaching/learning sessions, discussion questioning, programmed instruction, independent learning tasks, community activities, etc.

Barnett and Griffin (1997) calls for teaching to become more research-like, while Hattie and Marsh (1996) suggest that marrying teaching and research by enhancing the relationship between them is a desirable aim of universities. In field practice and laboratory work, some grouping experiments and researching practices are designed for students and are accomplished by themselves.

Although it is as above, it is fractional and not a systematic application, so it is clear that there are many shortcomings in the teaching process still. Learning is a hard and difficult process that depends on teachers as much as learners. On the base of elaborate teaching plan, it is urgent that the constructivist ideas and student-centred learning strategies are applied more widely and further.

Lecture (total 26 hours)	Laboratory work (total 24 hours)	Field practice	Special topic/ project
The basic knowledge in researching plant diversity (1 hour)	Diversity of alga and bacteria (3 hours), bryophyte, ferns and gymnosperm (3 hours)	Practice together with zoology Involved in correlative contents of taxonomy, biodiversity, biogeography, ecology, living resources, etc Training in basic field researching skill **a week**	Teachers recommend, or students in workshop, select it by themselves One per person, one presentation per workshop Hand in a report per person at the end of semester **a semester**
The extant Prokaryotes (1 hour)	Diversity of Magnoliidae and Hamamelidae (3 hours)		
Diversity of eukaryotic alga (2 hours)	Diversity of Caryophyllidae and Dilleniidae, the comparative observation of pollen characters (3 hours)		
Diversity of higher plants (4 hours)	Diversity of Rosidae, the comparative observation of epidermis characters (3 hours)		
Introduction of basic class groups in angiosperms (8 hours)	Diversity of Asteridae, the statistical analysis of the data of basic characters (3 hours)		
Origin of lives and evolution of plant diversity (4 hours)	Diversity of Alismatidae, Arecidae and Commelinidae (3 hours)		
The development of plant species diversity (3 hours)	Diversity of Liliidae and Zingiberidae, the comparative observation of chromosome evidence (3 hours)		
The maintenance of plant diversity (3 hours)	The methods of taxonomic analysis about phytochemistry evidence (optional laboratory work, 3 hours)		

Table 2. The current teaching plan in the plant diversity part of the plant biology course

Improving teaching and learning further

In teaching content, part of plant diversity included the correlative knowledge of plant taxonomy, ecology and biogeology, but it has been integrated and reorganised according to the clue of current state, history, evolution and maintenance of diversity. In teaching strategies, although some modern methods have been carried out, there is fractional, not systematic application. At present, there has not been a moment to be lost in improving of teaching strategies.

There are some teachers who complain about the reduction in hours for basic courses, with the development of teaching and learning reform in high education. As long as we think over, we can find out that the traditional lectures consume a great deal of hours for infusing material knowledge. Students are not satisfied with traditional content and methods, which are to study characteristic of groups dryly and to observe plant material with magnifier passively, even some students said that to memorize many plants is taxonomist's thing, but they need to realise diversity only. They desire to learn more from the course actively. A review of the literature indicated that most lectures were ineffective, presenting too much detail and too little illustrative material, and offering few opportunities for active involvement by the students (Gardiner 1994). To accept our role as coach/facilitator as opposed to the familiar lecturer, while the teaching hours of traditional lectures are reduced, some modern strategies must be applied more widely. On the basis of constructivist perspective, firstly, the teaching content is researched carefully and the inner relationship within the knowledge is thought out. Then, the concept maps and learning problems are designed systemically. Finally, the lectures are developed continuously by means of the concept maps and learning problems. Through the development of problems and concepts step by step, the students can achieve the deep approaches. Numerous studies have shown correlations between students' deeper approaches to learning and higher quality learning outcomes (Trigwell, Prosser and Waterhouse 1999). Otherwise, the strategies of problem-based and case study are useful for parallels between motivation at work and for learning and promoting synthesis of multidisciplinary perspectives.

Using concept mapping to make teaching and learning effective

A major goal of biology teaching is enhancing students' biology learning. In teaching practice, we often pay attention to more knowledge than skills, and students gain very detailed knowledge. However, with rapid developments in biology, knowledge is exploding so that we cannot give students all the knowledge they need in university. Students need to achieve self-directed and lifelong learning skills, and integration of relevant knowledge, they are active learners. Learning is a process that the concepts change continuously and of self-construction by students. We cannot force them to do it, but can help them to do it by using concept maps. Ability to apply knowledge requires a stable conceptual framework (Ekborg 2003). Generally speaking, the concept map reflects inner relationship between knowledge and correlation between concepts, it is useful to forming systematic knowledge 'web' in the brain so that students can apply this knowledge and concepts flexibly. Modern development of biology desires the integration of knowledge and concepts strongly. Biggs (1999) argues that meaning is constructed through learning activities and, therefore, teaching and learning must be about conceptual change. Concept maps have been described as working as 'spark plugs' or catalysts for discussion because students have something to start with (Kankkunen 2001). The concept mapping approach was summarised as six steps by Kinchin (2003).

Concept mapping is seen by some as a method that encourages the acquisition of 'a habit of changing habits' (Kankkunen 2001). For teachers to change their 'habits of teaching' will, in many cases, require a fundamental shift in their basic assumptions about teaching and learning (Kinchin 2002). As a part of teaching, content of plant diversity is designed into a concept map (Figure 1). On the basis of reconstruction of teaching contents the problem of plant diversity is illustrated by the four aspects: current state, history, evolution and maintenance of diversity, and is involved in the four levels: gene, individual, community and ecosystem. In real teaching, the concept map will be introduced step by step. After all content of plant diversity is learned, the whole map will be displayed and linked completely.

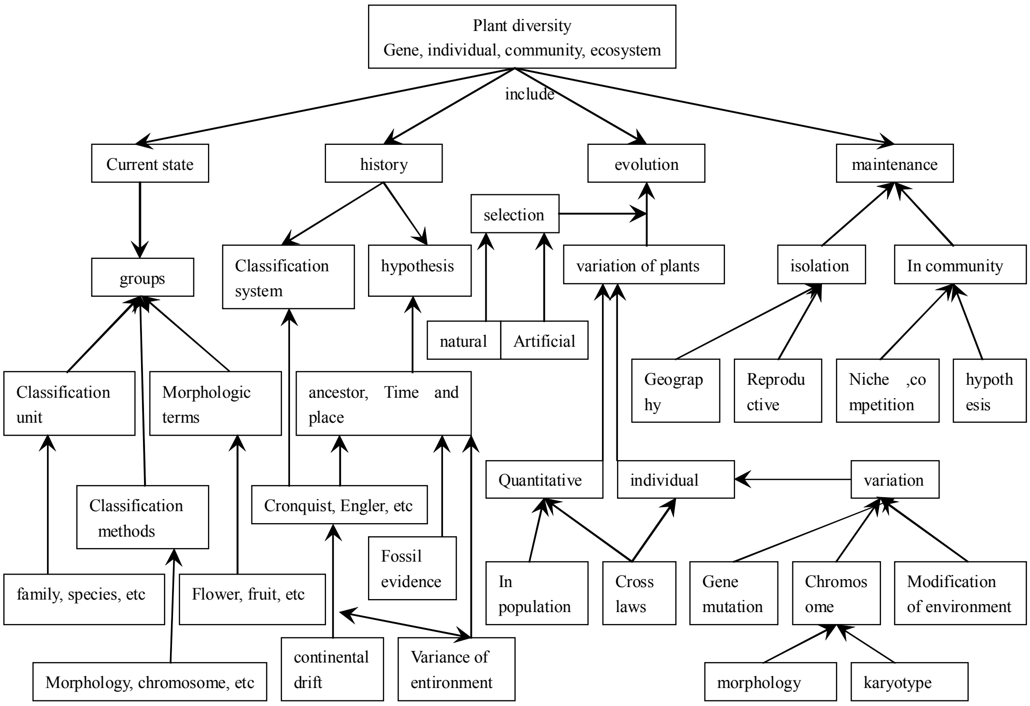

Figure 1. The concept map of plant diversity

Using problem-based learning to improve teaching and learning

Problem-based learning is a curriculum design and a teaching-learning strategy and is about learning subject knowledge in the context of using and developing process skills. It is powerful because it is a learning environment that embodies most of the principles; it forces the students to learn the fundamental principles of the subject in the context of needing it to solve a problem; and it offers an opportunity to practice and to use many processing skills (Wood 1994). Students learn concepts and how to apply them while working with the cases, they reconstruct prior knowledge and continue learning from there and finally, they take responsibility for their own learning and are trained to actively seek information, structure and present it (Schmid and Bouhuijs 1980). In the face of the problem in the real world, students' epistemic motivation are enhanced easily, they can take part in the teaching activities on their own initiative and their self-directed, cooperative and thinking skills are trained. On the other hand, the knowledge in their brain is reconstructed and integrated.

In designing a problem, we must simultaneously focus on two aspects when students devote their attention to solving problems as an active role as a practitioner: to develop both higher order thinking; and academic knowledge bases and skills. Learning is conceptualised as inter-psychological process of participation in social practices, and it is not reserved for activities and interactions intentionally organized for learning (Billett 2002). First of all, the selective problem must be one in the real world and be complex enough so that epistemic motivation and enthusiasm to learning further are facilitated enormously, thinking and cooperative skills are trained deep, and knowledge and concepts are integrated as soon as possible. The degraded problem of the ecosystem has a concern in each of us, and it is a fatal topic in China, so it is selected as an important problem to probe in the process of learning. This problem is involved in complex concepts and theories, and integration of them. For example, degradation of ecosystem, biodiversity, competition, disturbance of ecosystem, ecological stable state, and moderate disturbance hypothesis, etc. (see Table 3).

Problem	How will we solve the degraded problems?
Situation	Students will go to some different serial plots in the grassland. After observation, teacher will put forward the problem. Afterwards, students will take measures for their task in a group of 4-5 persons.
Expectant development of problems	Degrading characteristic Numbers of species reduce Surface soil is exposed Worthless grass increase, etc. Degrading reason used in excess, etc. Methods to solve enclosure grazing in rotation reducing number of livestock conserving ecological balance and biodiversity, etc.
For students to do	Observe and compare among the different sample plots Investigate and collect information Analyse and discuss in workshop Put forward advice about improving grassland Present their reports
Expectant concepts deepened	When grassland is degraded, enclosure is an effective measure, but enclosure for long term is harmful for grassland, especially for high-production grassland, grassland ecosystem needs moderate disturbance.
Problems further deriving from the activities	How to improve economic grassland? How to manage a natural reserve effectively?

Table 3. A example of problem-based learning

Using case study to improve teaching and learning

Case study is different from problem-based learning, it tell a real and complete story, is usually interdisciplinary, has academic and professional significance, and has social implications. As the teaching strategy is interesting, relevant, motivating for students, it is used in teaching process widely.

Algal blooms is a significant problem in procreative practice and academia, it has occurred many times historically in the world. Its appearance would often bring tremendous tragedy to aquatic animals and plants, furthermore, affect production in aquaculture. The occurrence and prevention of algal blooms is involved in complex and interdisciplinary issues (see Figure 2).

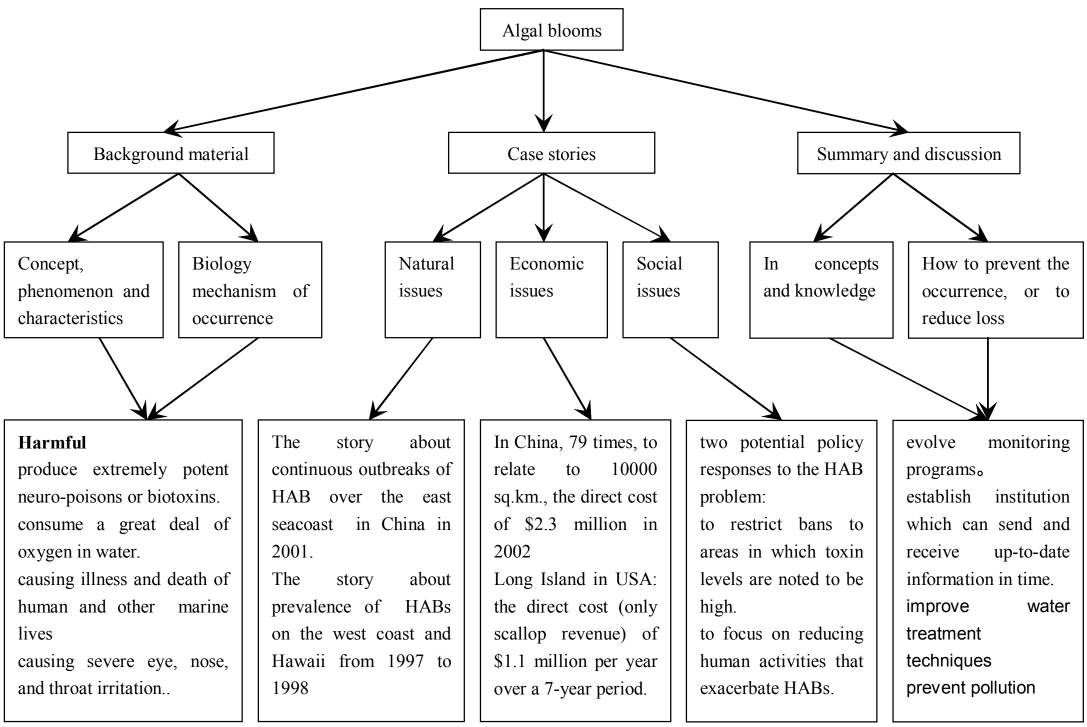

Figure 2. A case study of algal blooms

The problems which might be encountered and a scheme to solve

In China, students have been used to the teaching strategies of how to deal with examinations in middle school, so how the teachers control and develop the teaching process gradually will be the most important key of achieving the teaching aim.

The Piagetian model of intellectual development thinks that each individual must learn in a manner to adapt to his or her present level of development for advancing to the next level of development. Research showed that pupils' prior knowledge could significantly influence classroom teaching and learning (Lumpe and Staver 1995). Teachers should be aware of students' prior knowledge and misconceptions, because they are strong predictors of student achievement in science, and the teacher should examine why these misconceptions occur (Alparslan, Tekkaya, and Geban 2003). Before classes, it is necessary that the background of students is researched. Under the circumstances that we realize the foundation of students adequately, students are led to our objective through different strategies to be carried on in order. Of course, the teaching process is always dynamic, so our strategies need to be adjusted by feedback from students. For the first year students, they need to be introduced step by step, it may be the best way that the different teaching strategies are used by turn.

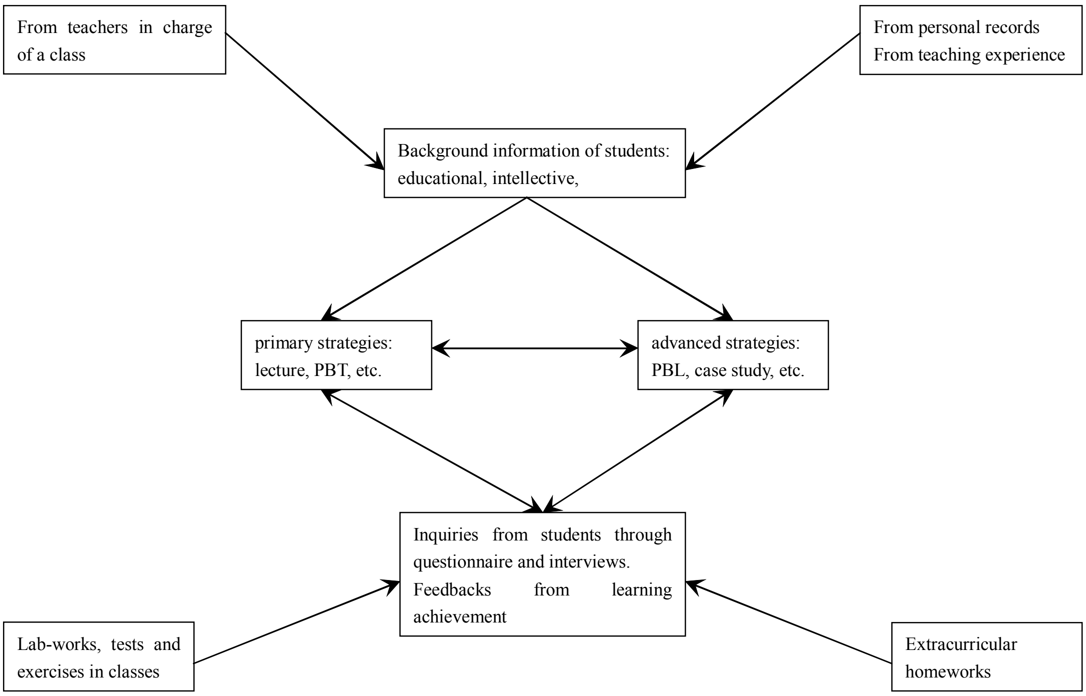

Figure 3. A scheme for using teaching strategies

Summary

The constructivist philosophy is likely to challenge the core beliefs of many traditionally objectivist biology teachers (Kinchin 2002). This may be a reason for some teachers to choose not to adopt such a constructivist approach (Kinchin 2001). In any case, it is main trend that student-centred approaches replace teacher-centred approaches in teaching practice, and that constructivist perspective substitutes traditional viewpoints in the development of teaching theories. The traditional teaching-learning viewpoints, contents and methods have not been suitable to modern education, educational reform is imperative under the situation.

A great deal of researching reports indicate that any teaching strategy or method may not be appropriate for all students and teaching situations, strategies are often matched to objectives, so we must adopt different strategies according to teaching contexts by turn. Our teaching goal should be to train biology-based professionals of the highest calibre, so student-centred approaches must be carried on. To suit students to development of modern science and society, their self-directed, lifelong learning, thinking and team skills must be trained entirely. I believe that these teaching strategies, as concept, problem-based learning and case study, are effective means of improving this course. However, students' enhancement in the above skills is not simply a question of a course. To achieve its potential, any course's reform needs to be viewed as a whole university initiative and an integral part of the university's provision for teaching.

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