

Strategies of teaching and learning in *General Ecology*

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Abstract

In this paper, contemporary theories and strategies of science teaching and learning are reviewed. Following an introductory outline and analysis of issues in the teaching of *General Ecology*, some strategies, such as student-centred Teaching and Learning, Problem Based Learning, Case Study, and Concept Mapping, are discussed. These strategies will be very helpful and instructive in improving teaching and learning and increasing the quality of higher education in the future.

Introduction

In China, the traditional ideology of science teaching and learning has taken a dominant role up to now. It represents the main approach to teaching in most curricula in the university, although some advanced skills and techniques in teaching, such as video, slides and multimedia are used now. Moreover, the increase in student numbers in universities and the rapid developments in science and scientific techniques have to be taken into account. This situation is creating a greater impetus for teaching reform to improve the quality of higher education. It is therefore necessary to introduce new strategies to modify traditional teaching and learning. The aim of this paper is to introduce contemporary theories and strategies of teaching and learning and apply the strategies in the teaching and learning of *General Ecology*.

Background

Changes and trends in higher education

New developments in science and technology are now undergoing a knowledge explosion. The demands on people to improve their personal ability to learn scientific knowledge, get new information and resolve real world problems are much stronger with the rapid development of society and economy. In this ever changing environment, it will not be adequate for students to only get professional knowledge from their education in colleges or universities, they will also need to be able to apply their knowledge and skills to new situations. People have to maintain lifelong learning skills to acquire new knowledge, and improve their own skills and capabilities to resolve the problems independently and adapt to the rapidly changing environment in the real world. It is obvious that self-directed study and lifelong learning will be a basic need of people in their work and life. Recognition of this fact is driving huge changes in science teaching and learning in colleges and universities.

Contemporary theories and strategies of teaching and learning

There has been significant progress in the development and use of contemporary theories and strategies in teaching and learning during the past 20 years. Based on the research in this field, many types of ideas and opinions on science teaching and learning have been put forward, and these benefit the teachers and students working to improve the quality of teaching and learning in universities.

Student-centred teaching and learning

It is very important for a teacher to balance the relationship between teacher and students, i.e. the relationship between teaching and learning. The aim of teaching is to give the students knowledge and skills. However, the outcome of teaching is usually not what a teacher may expect with the traditional teaching strategy known as teacher-centred teaching, which mainly depends on the attitude, subject knowledge and teaching style of the teacher. In contrast, student-centred teaching and learning focuses on the student and is an effective strategy in science teaching. This strategy is very closely related to both the teacher and the student. A teacher using a teacher-centred approach has to help students change from passive learners to active learners, and guide them to adopt a deep learning approach.

Using a student-centred approach, the student can construct his or her own knowledge and develop improved capabilities in learning knowledge and skills, analyzing data and resolving problems independently. Such skills would be very important for a student to learn not only in the university now, but also in the future.

Constructivism

A number of research papers argue that learning is more meaningful when learners construct their own knowledge, following the tenets of the learning theory known as constructivism. Constructivism is a philosophy of learning founded on the premise that people construct their own understanding of the world.

According to this theory, learning is the result of the constructive activities of the students. For students to become good readers and writers, they need to believe in their ability to 'make meaning' out of information. In other words, they need to see themselves as capable of synthesizing ideas, making judgments, and developing well-formed opinions. Students who are confident of their abilities can make sense of things by themselves, rather than waiting for a teacher, a book, or a set of data collected by someone else.

Teaching will therefore be most effective when it supports those activities appropriate to achieving the curriculum objectives, encouraging the students to adopt a deep approach to learning. Being a good teacher now requires taking on new roles to ensure that students learn. For example, the teacher, as a constructor, should understand the subject matter well and appreciate different ways to teach it in order to accommodate students' various ways of learning. The teacher, as an inquirer, should depend heavily on assessment to find out what students have learned and what they need to learn more about.

Problem based learning

Problem based learning is a strategy for encouraging critical thinking and problem solving skills along with content knowledge through the use of real world situations or problems. This is an effective strategy in science teaching because, in this case, learning is driven by the problem the learner is interested in solving, and learning is active, integrated, cumulative, and connected. Students gain an appreciation of how important questions about human experience are interrelated across discipline lines and areas of interest within disciplines.

This strategy is widely applied to make the students realise that they are responsible for finding the information necessary to solve problems. The teacher's role is supportive, not directive. Teachers act as facilitators and provide resources, guidance and instruction to students as they develop content knowledge and problem-solving skills, and give frequent feedback to students about their perceptions of the problem being studied.

Problem based learning may take various forms, such as group discussion of cases or problems and/or projects designed and developed by students. It is more important for the teacher to assess the students by emphasizing the

process of the learning experience and the quality of the integration of knowledge reflected in the solution of the problem.

Concept mapping

Concept mapping is a technique for representing knowledge in graphs. Knowledge graphs are networks of concepts. The networks consist of nodes and links. Nodes represent concepts and links represent the relations between concepts. The strategy of concept mapping is very helpful for teachers and students to generate ideas (for example, brain storming), communicate complex ideas, integrate new and old knowledge, design a complex structure (such as long texts, hypermedia and large web sites), and assess understanding or diagnose misunderstanding. It will help the students to understand the concepts and principles of their discipline and apply the knowledge to all aspects of their life.

Case study

The case study is a method which involves learning by doing, the development of analytical and decision-making skills, the internalization of learning, learning how to debate the issues and resolve real-life problems, the development of skills in oral communications, for example. Cases have a strong appeal for many students who may not be attracted to traditional science courses that are oriented around a lecture format with a focus on facts and content rather than the development of higher-order thinking skills.

There are many specific teaching methods integrated into case studies, which include individual assignments, lectures, discussions, and small group work. These methods can be used in more than one format in a course. Biology lends itself very well to the use of case studies as an integral part of the teaching process. The use of case studies in science teaching will encourage students to critically appraise stories about science they hear through the media, to have a more positive attitude about science, to understand the process of gaining scientific knowledge and its limitations, and to be able to ask more critical questions during public policy debates.

Issues and strategies

The outline of *General Ecology*

General Ecology is open to second year students in the School of Life and Environmental Sciences, the Central University for Nationalities. The teaching of *General Ecology* is composed of lectures in the classroom and practical work in the laboratory and in the field. According to the syllabus of this course, the major content of *General Ecology* should be completed in 54 hours of lectures and 36 hours of experiments. The main objectives of this course are as follows:

Organisms and environment

This section covers the relationships between organisms and their environment. Students learn what the environmental factors consist of and how such factors affect plants and animals. The adaptation of organisms to various habits is introduced at the same time.

Population ecology

Students are introduced to many important theories, which form the basis of theoretical ecology. Populations are a very important concept in ecology and the characteristics of quantity, distribution and genetics of a specific population are definite. The key principle of population ecology involves the dynamic of a population, in which it is a little difficult for students to understand the concept model of dynamic change of population density.

Community ecology

The community is a complex of various species in a specific habit, in which these species interact with each other to form an integrated unit. It is necessary for students to be able to describe the components and structure of a community. A few hypotheses of community succession in classical theories of ecology will be discussed further. They are then challenged by the quantitative stimulation on the continuous distribution of community components.

Ecosystem ecology

An ecosystem is an integrated system including organisms and environment, in which human beings should also be included in modern ecology. The foundational concepts and theories of ecosystems, such as food chains (or webs) and ecological balance, are introduced. It is very important for students to be able to understand and analyze the functions of an ecosystem, for instance, the process and principles of the material production, the element cycle and energy flow in ecosystems and on earth.

Applications of ecology

This section shows the students how theories and techniques in ecology are applied in different fields of the real world such as the issues of biodiversity conservation, ecological restoration and reconstruction and ecological treatment for environmental pollution.

Issues in teaching and learning in General Ecology

The major ideology in teaching in *General Ecology* is that the teacher is responsible for student learning. This is typical of teacher-centred teaching. The students are required to learn the course content according to the outline of *General Ecology*. Based on this ideology and teaching principle, the teacher has to teach the students what they have to learn by using the textbook.

Classroom teaching and learning

It is a common phenomenon in classroom teaching that the students' learning just follows the teacher's teaching. In this format, teaching is based on the contents of the textbook, and the students take note of what the teacher teaches in order to pass the examination and get credit points more easily. Many of the students don't know how to learn independently and actively. They depend on the information given by the teacher. The teacher may improve the teaching by using slides, PowerPoint and other multimedia. As a result many of the students can't be constructive in their learning and take a surface approach.

Practical work in teaching and learning

The practical work in the teaching of *General Ecology* is composed of the laboratory experiment and the field trip,

which are usually more interesting than lectures. Nevertheless, the circumstances for teaching and learning have not been ultimately changed. Students do an experiment and field investigation depending mainly on the guidance of the teacher and the laboratory manual or notebook, as in lectures. Generally students lack both the capability to analyse and resolve the problem independently and their own opinion and ideas about the experiment and the investigation.

Based on the facts above, an improvement was made to the experiments of *General Ecology*. A few of the integrated and creative experiments are taken as an example of encouraging the self-directed study and constructive learning of students. It generates more enthusiasm and activity when students have to construct an independent plan to do the experiment according to their professional knowledge. However, there are still problems when students analyze the experimental results. One of them is that students have not thought deeply enough about possible problems in the experiment before they do it. The other is that they can't explain and discuss the experimental results very well. This is because students can't link the concepts and principles they learn in lectures to the process and results of the experiments.

Strategies in teaching and learning in General Ecology

Much progress has been made in contemporary theories and strategies in science teaching and learning. Some of them can be applied and modified to improve the teaching and learning of General Ecology in our university.

Student-centred teaching and Learning

In the beginning of the course of *General Ecology*, it is very important for the teacher to introduce to the students the outline of *General Ecology*, its application in the real world and the development of this discipline in the future. However, the outcome of the first lecture is often not satisfactory, so that many students quickly forget what they learn because the teaching is boring and the students don't pay any attention to it. This is generally the consequence of teacher-centred teaching.

Teaching could be greatly improved by using a student-centred teaching strategy in this lecture. On the one hand the teacher can show students some current examples of ecological problem and issues happening in the real world by slides, video and so on. Students can be encouraged to put forward their ideas about these problems and issues in the examples. On the other hand the teacher can help the students to know what they should learn and how they can get the relevant information. It is more important for students to understand that they should be responsible for their learning.

Here is an example from the first lecture of *General Ecology*. First of all, the teacher can show the students slides, or video, or tell an interesting story about a real ecological problem. Then some questions are put forward as following:

1. What is happening in the real world?
2. Do you know of any other ecological problem in your hometown and in China?

3. What is your opinion about the reason for the ecological problem?
4. Do you have any ideas about how to resolve the ecological problem?
5. What ecological knowledge should you be learning which can be used now and will be useful in the future?

After that, the students should talk to each other or discuss in a group.

Finally, a list of ecological issues, ideas and opinions of students can be drawn at present and a summary can be given in time in order to form a whole conceptual framework about ecological knowledge.

This way of teaching will help to enhance students' curiosity and positive motivation of why they want to learn and how they can learn to construct their own professional knowledge of ecology and across interrelated disciplines.

Concept mapping

The ecosystem is a very important concept in ecology, and is the basis of contemporary ecology. It is also very

important for students to understand and learn to resolve the real world problems with the concepts and principles of ecosystems.

The strategy of concept mapping can be used in the teaching of the ecosystem concept and the relationships between organisms, environment and human beings.

The following represents the teaching process using the concept mapping method.

In the beginning of this lecture, the teacher can act as a mentor to instruct the students encouraging brainstorming about the topic: *What is the ecosystem?*

After that, students link all the information connected with the ecosystem topic they can get from real life and put their ideas together in a graph.

Finally, similar ideas or information are combined into different groups and united into a concept map of the ecosystem at the end of this lecture (Figure 1).

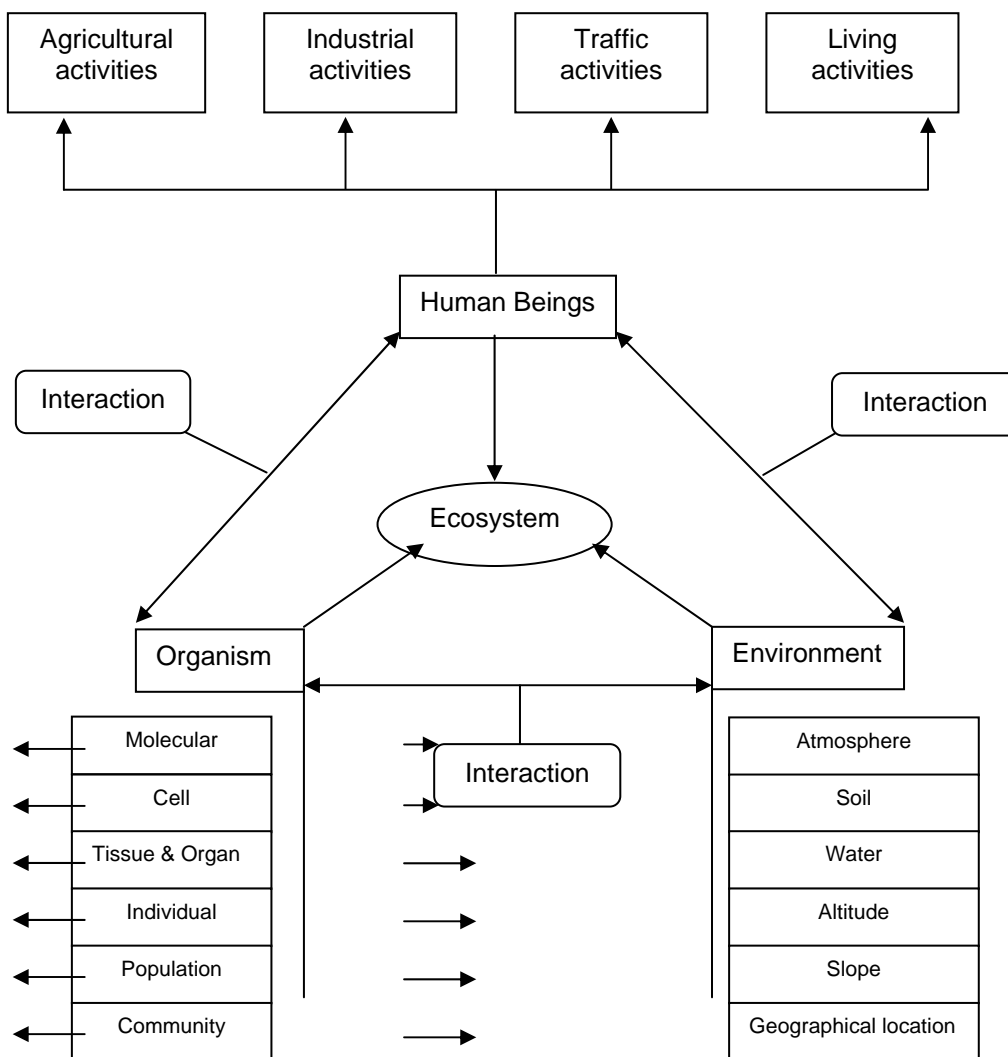


Figure 1. The concept map of the ecosystem topic

Problem based teaching and learning

Problem based learning is a very instructive way of teaching population ecology. The key is to design an interesting academic problem based on a real problem in the world.

Here we use the panda population as the teaching example.

In China, panda distribution and abundance is decreasing in natural environments. The species of panda is in severe danger, and may become extinct if current trends continue. This is a big problem that the Panda are facing.

The topic of the problem is 'What is the matter with the panda population?'

In the first stage of the teaching process, the teacher presents a short written account of the panda with some data and background, and gives students instructive questions about the ecological characteristics of panda populations. These questions are as following:

1. How many panda are there in natural habitats?
2. What happened to the environment where the panda lives? And then
3. What are the characteristics of the panda population, including the quantity, occupied area and genetics?
4. Describe panda activities. Describe the dynamic change in the panda population.
5. Is there a predator of the panda? What is the interactive relationship between the panda and other organisms?

After the students are divided into small groups, each with 5-10 students, the teacher and students together discuss and try to identify the points they consider important, and determine the relevant terms, concepts, principles, tests, procedures, and so on, for which they need more information. At the end of this stage, students agree on how they will divide up the work to search for the needed information in the textbooks, references, libraries and Internet.

In the second stage, discussion in a small groups continues. Students discuss their findings and share opinions. Their search for the possible correct answer narrows down. By the end of the second stage, students have determined what new information they need to uncover and go their separate ways to find it.

In the third stage, each of the groups gives a presentation of their conclusions and solutions about panda population problem. All of the students share their thoughts, data, and understanding. They try to reach closure on the possible answers using the professional concepts and principles of population ecology.

Finally, the teacher gives a summary about the population ecology based on the students' solution for the problem of the panda population.

In the process, students are not expected to find out the 'real' answer to the problem. The knowledge and understanding of the case comes from the search for answers, not from 'the answer' to the particular case. The

power of this method is the interactive approach between thinking, discussion, and searching for more information.

Case study

Many of the concepts and principles in ecology are derived from the phenomena and observation of nature. Case study can be used to teach the relevant content of ecology.

Here we take the Global Carbon Cycle as an example of a case study for the teaching of ecosystem functions, namely material production and energy flow. The handout with an interesting story about the carbon cycle was given to students for case study.

The Global Carbon Cycle (Grace 2004)

Environmental changes on a global scale have been becoming a matter of public concern since the 1960s. One of the most important questions that we face today is how to prevent the relentless rise in the atmospheric concentration of CO₂ and other greenhouse gases which collectively cause climate warming.

The carbon cycle has received particular attention because 60% of the observed global warming is attributable to the increase in CO₂ concentration from about 280 μmol mol⁻¹ in the preindustrial period to today's 360 μmol mol⁻¹. In fact, the realization of a rising trend in the CO₂ concentration of the atmosphere seems to have first been made as long ago as 1896 by Swedish chemist Arrhenius. He measured the concentrations of CO₂ in the ocean and atmosphere, and noting that the ocean had a slightly lower concentration than the atmosphere he inferred the presence of an ocean sink. Charles Keeling started the modern recording of the atmospheric CO₂ signal in the USA in 1958. These data are of paramount importance. They were first used to demonstrate that only about half of all the CO₂ emitted from fossil fuel burning remains in the atmosphere, and by inference, that there must be carbon 'sinks' in the ocean or on land.

It was later observed that this airborne fraction varies from year to year, and the interannual variability is associated with variations in the climate, particularly those caused by El Niño and major volcanic eruptions (Keeling et al. 1995). The records also show the annual seasonal draw-down of CO₂ caused by photosynthesis in the northern hemisphere, demonstrating the importance of the biota in the carbon cycle.

Although the Global Circulation Models (GCMs) are still rudimentary in their representation of several important issues (cloud formation, global photosynthesis and respiration, and feedbacks), they provide a 'crow's nest' view of what may be on the horizon for humankind. The conclusion from the GCMs is that global climate change poses a substantial threat, as many food-producing regions are vulnerable to drought and much of the world's human population is vulnerable to natural disasters involving extreme weather.

Global Circulation Models (GCMs) point to the dire consequences of continuing CO₂ emissions at their present rate (IPCC, 2001), and provide an increased motivation for

making GCMs more realistic. Moreover, the rate of change of temperature will be too fast for many species to adapt or migrate. Already, there are demonstrations of this from alpine regions where temperature increases have been alarmingly faster than average (Nagy et al. 2003).

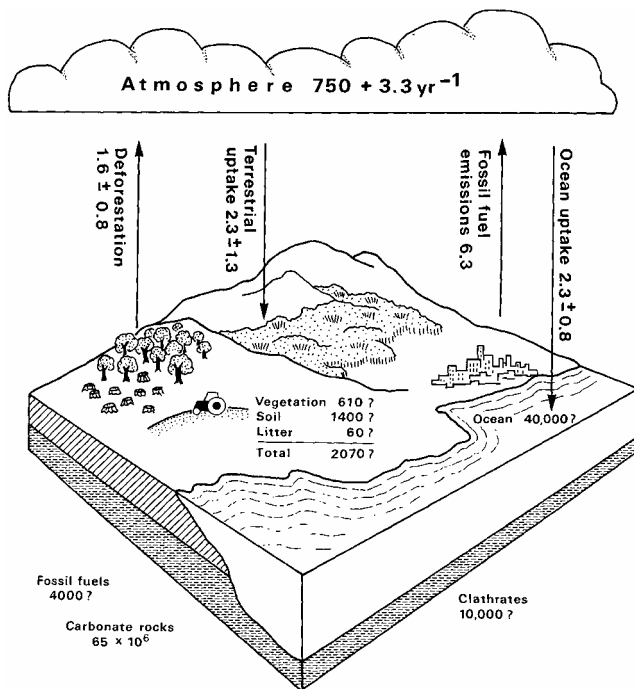


Figure 2. The global carbon cycle (sources and sinks) (from Grace, 2004)

Based on the above material, the students are asked to use all of the knowledge and information they have to answer the following questions:

1. What is the process of carbon cycling in ecosystems and on the earth?
2. What are the pathways of carbon fixation?
3. What is the fate of carbon in plants, particularly trees?
4. Which factors affect the carbon balance in ecosystems and on the earth?
5. How about the transformation and transfer of energy in ecosystem?
6. What is the feedback of CO₂ enrichment of ecosystems and the earth?
7. What are the effects of human activities on air CO₂ enrichment and carbon cycling in ecosystems and on the earth?

Conclusion and discussion

1. It is most important for a teacher utilise contemporary teaching strategies and try to translate from teacher-centred teaching to student-centred learning.
2. Generally, the contemporary strategies and skills will help to improve teaching and learning. However, no single strategy fits all the teaching contents and not all strategies suit every teacher. The teacher should alter and modify each strategy depending on his/her own style, experience and characteristics in teaching and the content and characters of the course.

3. A teacher should help their students to learn a broader range of knowledge at university and facilitate their capacity to resolve any possible problems by self-directed study. It is very important for a student to accept, apply and adapt the new learning strategies and to develop lifelong learning skills.

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