

# The use of student-centred learning strategies in the course of *Data Structures and Algorithms*

Liu Chuxiong

School of Earth and Space  
Sciences  
Peking University  
Beijing 100871  
People's Republic of China

chjwei@geoms.geo.pku.edu.cn

## Abstract

This paper first examines the status quo of education of China and then focuses on how to increase the outcome of the curriculum of *Data Structures and Algorithms*. It highlights deficiencies in the current teaching methods in this course, and evaluates how to integrate contemporary effective teaching methods – student-centred learning method – into the course. Four methods have been introduced: problem-based learning; student teaching; problem solving; and BBS. In addition, it explores student evaluation and problems encountered in these new teaching approaches.

## Introduction

Over the past few decades, most teachers in China have employed traditional approaches to teaching. That is, they have focused on transmitting knowledge. Though some teachers are trying new teaching methods, generally speaking, most of those methods are teacher-centred. As far as I know, in some instances some teachers even simply read the textbook to provide explanations. There is little doubt that students are frustrated by this style of teaching because they can obtain the same information from the textbook, and ask ‘What’s the use of teachers?’ Useless. This is an extreme situation. Even in some good approaches, such as problem-based teaching (PBT), teachers commonly give some problems and demonstrate how to use the knowledge learnt in one chapter of a textbook to solve them. Students in class have to accept the knowledge and skills passively; they just follow what the teacher says and have little independent thought of their own.

Nowadays, knowledge is exploding and evolving rapidly; people are facing a world in which much of the work they will do has not yet been imagined and they will constantly need to reinvent themselves. They must have the ability to acquire information and learn by themselves at any time. This is why people throughout the world are trying to find newer and better methods to educate students. Fortunately, many new contemporary and effective approaches are now being used both in teaching and learning. The Chinese government has realized this. The Ministry of Education has launched the ‘Higher Education Institution Teaching Quality and Higher Education Reform Project’ aimed at upgrading the quality of higher education in China. Through this project, many of the teachers in universities who teach core curriculum are sent to the developed countries such as Britain, the United States, Canada and Australia, to improve their learning skills.

I am lucky to be one of the beneficiaries of the program. During the past three months, I have learned many new methods from the Faculty of Science at the University of Sydney in Australia. The instructive methods include: problem-based learning (PBL); case study; concept mapping; and constructivism learning. Many of these are student-centred teaching/learning methods, employed in many main universities around the world and proved to be effective. I will integrate some of these new approaches into the course of *Data Structures and Algorithms* at Peking University.

## Course description

*Data Structures and Algorithms* is part of the core curriculum and compulsory for all science students that attend Peking University. Before learning this course, students must master one programming language – C Language. *Data Structures and Algorithms* introduces some basic data structures such as list, tree, graph and some correlative algorithms, namely, divide and conquer, greedy, dynamic and their implementation. The objectives of the course are:

1. to learn good principles of algorithm design;
2. to learn how to analyse algorithms;

3. to become familiar with fundamental data structures and their best implementation;
4. to become accustomed to the description of algorithms in both functional and procedural styles; and
5. to learn how to apply their theoretical knowledge in practice.

In total, the main purpose of the course is to improve the ability for solving real world problems using a computer.

Many of the concepts in the course of *Data Structures and Algorithms* are extremely abstract. Due to this, they can be used in a great variety of situations. For example, stack is a very basic and abstract concept but is used almost everywhere in programming. Since many students experience some difficulties in using the abstract concepts to solve real world problems, a teacher should direct students through this process. As a teacher, I have used many teaching approaches in this course in order to make the abstract and illusive concepts more acceptable to my students. Below, I give a brief introduction to the current approaches I have employed in the course over the past few years.

## Current approaches used in my course

### ***Problem-based teaching (PBT)***

Sometimes, in the middle of a class, I will give some real world problems and demonstrate how to use the knowledge they have learnt to solve the problems.

### ***Doing exercises in practical class***

As described above, there are some practical classes for the course where the students can do some exercises. It is my responsibility to help them solve the assigned problems.

### ***Doing homework***

I will assign homework to students once or twice a week, and ensure that they submit their work on time. Part of the homework will be checked so that I can know how well they have mastered what I have taught them, and what kind of problems they have. According to their progress, I may assign supplementary material to some students.

### ***Using multimedia and hypermedia in lectures***

I spend considerable time preparing lessons to make them active and impressive, and to make the abstract concepts easier to remember.

### ***Using FTP***

Students can submit their homework to my ftp site, where I also put tutorials and marks. In this way, communication with my students is effective and convenient.

### ***Using email to communicate with students***

With the exception of formal lectures, teachers and students have little time to be together for teaching and learning. Therefore when students experience difficulties, there is little opportunity to ask teachers for help. However, I have found that sending email is a good way for teachers and students to communicate.

## New approaches – student-centred learning strategies

### ***Why should we use student-centred learning (SCL)?***

#### **Traditional lectures and their weakness**

Most teachers in China employ teacher-centred learning as a routine method to transmit knowledge to their students. In this method, teachers deliver lectures, list the main ideas of the content on the blackboard or screen, and possibly ask a few questions whilst the students simply take notes. Individual lectures may last two or three hours, with only one short break halfway through the lecture. After class, students may review the notes before the final examination and then discard them.

#### **Personal experience**

Though I have been trying to use different ways to improve the learning experience for students in the course *Data Structures and Algorithms*, I have not obtained my desired result. After three months' learning in the University of Sydney, I have begun to realize that though I have used some student-centred teaching approaches consciously or unconsciously, I should admit that basically they are still teacher-centred approaches. Generally speaking, teacher-centred teaching approaches lead to surface learning in students. Students cannot master knowledge deeply. In fact, students are the main part in the process of learning, and they are the internal cause of learning well. If motivated, students will spend more time and energy and learn course material actively, instead of passively. It is not surprising that student-centred learning (SCL) methods present good ways for students to learn, because of the following advantages:

- it can nourish and enhance curiosity and the natural desire to learn;
- it can help students achieve the results they appreciate and consider worthwhile, and which builds their self-esteem and confidence;
- it can uncover the excitement in intellectual and emotional discovery, which leads students to become lifelong learners; and
- it can improve the teachers' attitudes, which are very effective in facilitating learning.

There are many kinds of SCL approaches, such as problem-based learning (PBL), student teaching, problem solving, teamwork, etc.

When I return to China, I'd like to integrate some of the SCL approaches I've learned from the project into the course of *Data Structures and Algorithms*.

### ***Types of student-centred learning***

#### **Problem-based learning**

What is problem-based learning? Problem-based learning is a pedagogical strategy for posing significant, contextualised, real world situations, and providing resources, guidance, and instruction to learners as they develop content knowledge and problem solving skills (Mayo et al. 1993). In problem-based learning, students collaborate to study the issues of a problem as they strive to

create viable solutions. Unlike traditional instruction, which is often conducted in lecture format, teaching in problem-based learning normally occurs within small discussion groups of students facilitated by a faculty tutor (Aspy, Aspy and Quimby 1993; Bridges and Hallinger 1991). There are some differences between PBL and PBT. The main difference is that PBL is a student-centred method, and students learn actively in this method; PBT is a teacher-centred method, and teachers transmit knowledge by using problems, and students learn passively. In addition, PBL is different from problem solving. In problem solving, students arrive at decisions based on prior knowledge and reasoning; whereas in PBL, the process of acquiring new knowledge is based on recognition of a need to learn.

Though many approaches for teaching/learning exist, they should not be divided sharply and be used in isolation. The best result will be obtained by integrating several approaches in any individual course. Based on this, I will integrate case study and concept mapping into PBL using the following example:

**Problem:** Develop an electronic English-English dictionary.

1. Divide students into small groups, each group with 3-4 persons.
2. The next step is to give students a case study. In the market, there are already many kinds of electronic dictionaries; two of the classic ones are *Kingsoft PowerWord* and *Dr. eye Translation*. Students should install these two dictionaries and, in small groups, discuss the features, functions and user interface of the two dictionaries. The students should then compare their similarities and differences. They can also compare other kinds of dictionaries that they may have used.
3. Concept mapping

After discussing aspects of the two existing dictionaries, students will have some fundamental idea on the requirements of an electronic dictionary. They will then be required to build a concept map. As shown in Figure 1, this concept map involves two most basic concepts: data structure and algorithm, and the three basic data structures involving list, tree and hash table.

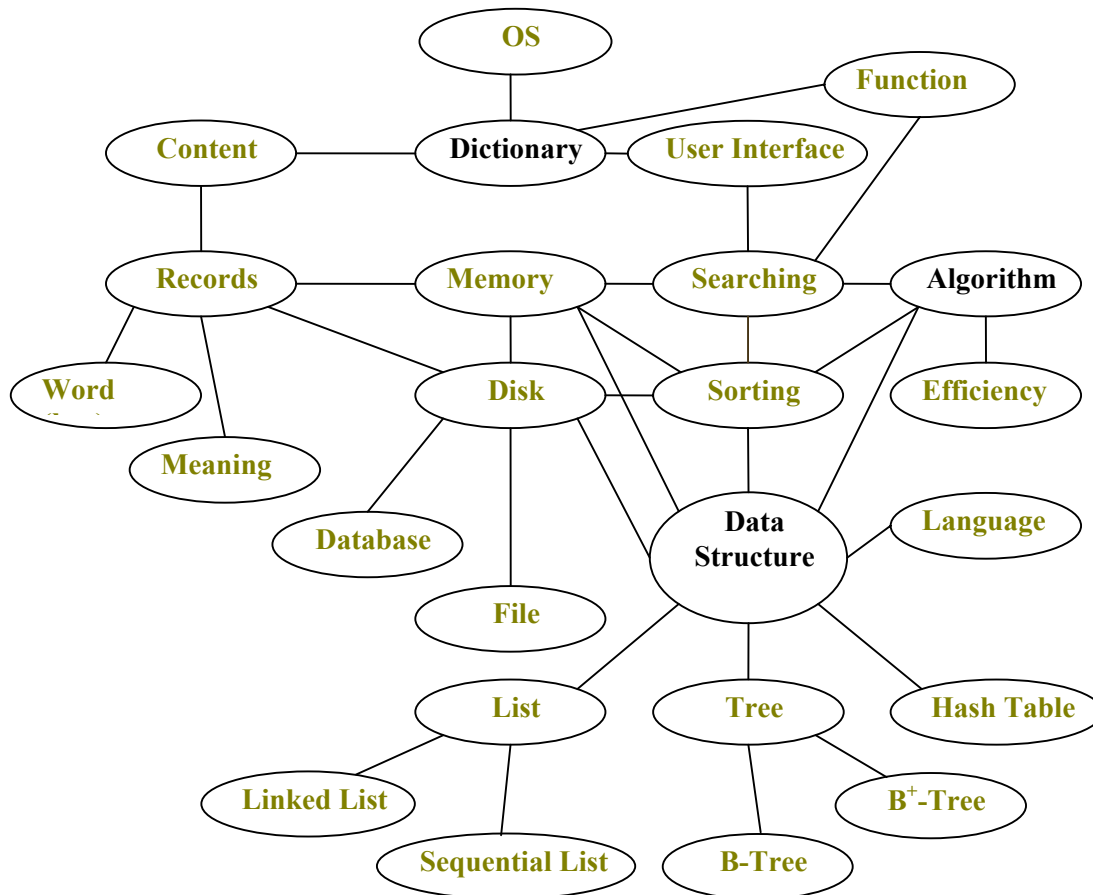


Figure 1. Concept map of a dictionary

4. Mini-lectures

After building the concept map, students will have a clear understanding of the kinds of functions and components that should be included in the dictionary they will develop. They will also have some ideas on how to organize the data in a dictionary and how to select a proper algorithm. However, some concepts will still be unclear to them. To overcome this issue, I will

deliver some mini-lectures centred on the following subjects:

- a. software engineering;
- b. how to develop a good program;
- c. how to evaluate the efficiency of an algorithm;
- d. how to test software; and
- e. references.

Students should still learn to seek more information from textbooks, references or the Internet.

5. Students are required to hand in the following assignments:
  - a. a report covering the process of designing and testing; and
  - b. a computer program that acts as an electronic dictionary.
6. Each student should give a presentation addressing the program design, the programming steps employed and their testing of the problem.

After the presentation, I will ask students to think more about the electronic dictionary. For example, how could they develop an English-Chinese or Chinese-English Dictionary? How could they develop a Chinese-Chinese dictionary? Can they integrate all of the above dictionaries into one big dictionary as done in *Kingsoft PowerWord*?

### **Student teaching**

Most research indicates that students really understand an issue when they need to pass the knowledge on to someone else (Tao 1999). This method encourages students to find related information and improves their self-study skills. Therefore student teaching is also a very important teaching/learning approach. I will use this approach as follows:

1. divide the class into several small groups of 3-4 persons;
2. give each group a certain component of the course content;
3. students should obtain the necessary documents from the textbook, references, the Internet, or any other sources, they can also come to me for help;
4. check how well the students have prepared and suggest improvements one or two days before their lectures;
5. each group then delivers a lecture on their assigned topic; and
6. after each lecture, comment on how well the students addressed their topic, point out any further deficiencies and suggest ways to add more content.

### **Problem solving**

PBL is a time consuming learning method. As it can be hard to find an appropriate real world problem, it is difficult to use many PBL examples in one course. However, problem solving presents a comparatively easy method, as students can be given any problem that correlates with the course content. In addition, problem solving can be used in the midst or the end of each module of a course. Being given many problem solving examples improves students' understanding. This method can be employed in the following way:

1. students should be divided into small groups;
2. each group is given some real or virtual small problems;
3. they then discuss the problems in their small groups;
4. some groups are required to write down their answers on the blackboard;
5. other groups evaluate the answers presented on the blackboard; and
6. finally, the teacher comments on the students' work.

### **BBS**

BBS is also a good method in learning. Students can publish any questions on a BBS; any other students can answer the published questions. Teachers can also log on to the BBS and provide questions for students, or address the published questions. There is no doubt that BBS extends the communication channel both between students, and between students and teachers.

### **Assessment**

Assessment is clearly a very important part of a course. Each teaching approach should have corresponding measurement, and different measurement should be used to evaluate the student-centred teaching/learning approaches. The following assessment methods are some of the proper measurement methods.

#### **Written examinations**

Students should take closed-book mid-term and final examinations to assess whether they have mastered the basic knowledge.

#### **Practical examinations**

Students are given simple problems at the end of the first semester. They should solve the problems in a set period of time. They are allowed to turn to textbooks, notes, or references instead of any other students.

#### **Peer assessment**

In groups, students should assess each other's work and provide a mark. This is to test their teamwork ability.

#### **Self-assessment**

Students should assess their own progress and give themselves a mark.

#### **Facilitators/tutor assessment**

I will also give students a mark on whether they complete the assigned homework and PBL conscientiously, whether they attend discussions actively and whether they prepare the lectures or presentations seriously.

#### **Oral presentations**

A mark will be given on the student's PBL presentation and lecture.

#### **Reports**

A mark will also be given on whether students write reports correctly and seriously.

### **Barriers in the use of SCL**

#### **Language barrier**

This is a barrier both for students and myself. Though I have been learning English at the University of Sydney for three months, it is still not easy for me to deliver lectures in this language. Delivering lectures in English to Chinese students imposes additional learning difficulties on them, as they need to comprehend both language and technical content.

### Students' attitude towards the new teaching methodologies

In China, conventional teaching approaches are widely used both in advanced education and fundamental education. When students go to university, they are accustomed to knowledge being disseminated by teachers in this passive learning style. In student-centred learning, students become the core of a curriculum and are required to participate more actively in the course. The change from passive to active learning needs time for adjustment by the students involved.

### Teacher's change from the role of disseminator to facilitator

Most teachers are familiar with traditional teaching methods, and it is easier for them to employ these methods. The role of teacher in such traditional methods is as knowledge disseminator and the centre of the class. Things are different in student-centred teaching/learning methods, where students become the central figure and teachers should help or guide students in learning the contents of a course. In this case teachers need to spend more time and energy on preparation and translation.

### Summary

From the discussion presented above, it is clear that contemporary teaching methods have many advantages. However, when employing SCL in any teaching course, two points should be borne in mind.

Firstly, generally speaking, SCL is better than the traditional teaching methods, but this does not mean the traditional methods are useless and should be completely discarded. By itself, teaching students learning skills is inadequate for the demands of higher education; students must additionally master some fundamental knowledge appropriate to their chosen discipline. In some instances, traditional methods are more effective in transmitting knowledge to the learner in a limited time.

Secondly, though students are the centre in student-centred teaching/learning, teachers are still very important and their role should be changed from disseminator to facilitator. Teachers should focus on questioning student logic and thoughts, provide hints to correct erroneous reasoning, provide resources for student research, and keep students focused on their assigned task.

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