

# The introduction of contemporary teaching approaches to improve student learning in *Fundamentals of C Programming*

**Jie Wu**

Dept of Computer Science  
Guangzhou University  
Guangzhou 510006  
People's Republic of China

tanwujie@sohu.com

## Abstract

Current teaching practices used to introduce students to the *Fundamentals of Programming* at Guangzhou University are described. The likely outcomes of the introduction of a variety of contemporary teaching strategies and techniques are investigated and discussed; these strategies will probably be: case study examination, concept mapping and group project work. Expected improvements in student learning and likely barriers to introducing change are outlined.

## Current practice and circumstances

### Course description

*Fundamentals of C Programming* is a compulsory course for first-year, civil engineering students at Guangzhou University. Before taking *Fundamentals of C Programming* students should have completed a preparatory unit *Foundations of Information Technology*, but most of them will not have had any formal instruction in, or experience of computer programming. *Fundamentals of C Programming* provides 72 contact hours unit divided equally between lectures and practical classes (1½ hours of each per week). The aim of this unit is to give students an understanding of the basic principles of programming language *C* and students should be able to write and compile functional programs in this language by the end of the unit.

*Fundamentals of C Programming* content and concepts can be divided into seven discrete parts:

1. data types, operators and expressions;
2. flow control;
3. functions, arrays and pointers;
4. structures;
5. files;
6. input; and
7. output.

Most first year students find this unit extremely difficult and report two main problems: firstly, they have not yet become accustomed to the requirements of university study which they find to be distinctly different from their previous educational experience of primary and secondary school; and secondly, they indicate that they are not well-equipped with the necessary skills in logic, analysis and problem solving to become competent programmers due to the fact that programming is, in its essence, abstract and challenging.

### Teaching approaches

Currently, the dominant form of instruction in most of China's universities and colleges is the lecture. The centre of the class is an actively delivering teachers focused on transmitting large amounts of content to passively receiving students. It is still common for lecturers to write lists of outline points on the blackboard, or to use slides or overhead transparencies to demonstrate and explain concepts and principles. In order to help students understand typical programs deeply, demonstrations are also widely used. Student engagement during lectures is generally achieved by means of the teacher asking, and students answering questions – this is the prime method used to draw the students' attention to important points. Unfortunately, most teachers deliver large amounts of content during lectures and are mainly concerned with getting through their material in its entirety. With each content-heavy lecture lasting 90 minutes without a break it is obvious that students will have difficulty concentrating on and comprehending the lecture material. Those students who do manage to keep up with the lecturer and take notes are unlikely to have really understood what the teacher has said.

Mentors

**Bing Bing Zhou**

School of Information  
Technologies

**Tom Hubble**

School of Geosciences  
Faculty of Science  
The University of Sydney

In our university, laboratory staff are responsible for maintaining the computers and completing the related administrative work. Therefore the teachers act as both the supervisor and the tutor in the practical classes. My classes provide a typical example of practical classes in this discipline. More than 70 students require my guidance and assistance to complete their laboratory tasks. I work unassisted with the students in a large computer laboratory. Obviously, it is impossible for me to pay close attention to every student and it is very difficult for me to give those students who are struggling with programming the amount of assistance they really require. Students have less than two hours to complete their practical work each week. This is insufficient time for students to finish the tasks that we have set them. Generally, students have just finished typing their code into computer when the 'bell rings' and their time is up. The other tasks we wish them to complete, compiling the code, testing it, debugging it and refining it, are just not possible.

When it comes to assessment, it is an unfortunate fact that only the monotonously traditional ones are used. Students are evaluated with quizzes and final examinations. In their turn, students evaluate my performance in the middle of the semester, but the evaluation results are submitted to the administrators directly rather than to me and I do not receive detailed feedback about my performance or the teaching materials used.

### Effects

The defining characteristic of our current instructional practice is that it is teacher-centred. The teacher takes the dominant role in the process. While there is a lot of teaching, there is little deep learning because, as has been widely demonstrated, teacher-centred strategies tend to result in passive learning. Since the students have simply followed the pace of teacher's teaching they have not engaged with the content and concepts deeply and have not been able to master the knowledge. Some students do, of course, get high examination marks but these students often report feelings of confusion when they are required to put their knowledge into practice. They also report a sense of inadequacy because they find that what they have learned has not equipped them to solve real-world problems.

### Plan for the future teaching

To remedy the situation described above I plan to apply some of the contemporary teaching strategies that I have learnt about at The University of Sydney. I will apply those approaches that are suitable for my students and will improve the quality of my teaching and their learning. My teaching goals are centred on the following important questions.

1. What do students want?
2. How do students learn? and
3. How do I enable students to become more active in the process of learning?

Let us think about these questions deeply and globally. Students indicate that they want clear goals, high-quality teaching, the opportunity to develop problem solving skills, conscientious teaching staff, and appropriate, assessments

aligned with the curriculum (Hubble 2006). Apart from recognising these expectations we should also apply the findings of research into the way students learn, as well as conduct our own research into the specifics of our own teaching situation. There are seven characteristics of students' learning: constructive, cumulative, self-regulated, goal-oriented, situated, co-operative and individual (King 2006). I plan to use multiple teaching approaches to refocus my teaching to address these seven characteristics. The strategies that are probably most appropriate to my situation are: concept mapping, case study examination, group project work and more comprehensive assessments that are aligned with the curriculum. Furthermore, it will be necessary to improve students' active involvement so that they engage with the material. I think the most important objective is to foster and enhance the students' interest in the material. Consequently, I will employ an 'interest-driven approach' that will be constructed by introducing the teaching strategies described above into the 'teaching' mix and balancing them with traditional lectures.

### Concept mapping

An excellent tool to organise information about a problem or subject is to organise it using a 'concept map.' Construction of concept maps helps to build up a clear relationship between the information we already know with new information we need to learn. Concept maps can provide a springboard for classroom discussions of systems and to establish relationships between major and sub-concepts. Concept maps consist of nodes and labelled lines: nodes being the important terms or concepts and the lines between nodes indicating which concepts are related. The label on the line tells how or in what way the concepts are related. In general, we use concept maps to introduce new material and to stimulate discussion during learning activities.

Figure 1 is an example of a concept map that could be used to clarify the relationships of the components and basic aspects required of a program written in the language *C*. It can help students understand the content and concepts of the subject more clearly and in greater depth.

I hope to put the concept map shown in Figure 1 up on the wall of our classroom at the beginning of the course and leave it up for the whole semester. While I give lectures, I will use it to help students recall the concepts and ideas that we have already considered, and then refer to it as I introduce new topics. It should help both the students and me clarify the relationship between the old concepts and the new ones. At the same time, I think it will also provide the students with a good example of how to develop and draw their own schemas.

### Case study and brainstorm

Case study methodology has been widely used in Western schools for many years. Some teachers prefer to use 'made up' cases, others prefer to use specific, real incidents. In my opinion, no matter what kind of cases is chosen, it should be interesting or meaningful. I will endeavour to build a library of sample cases comprising interesting problems taken from real life. These cases will not only be

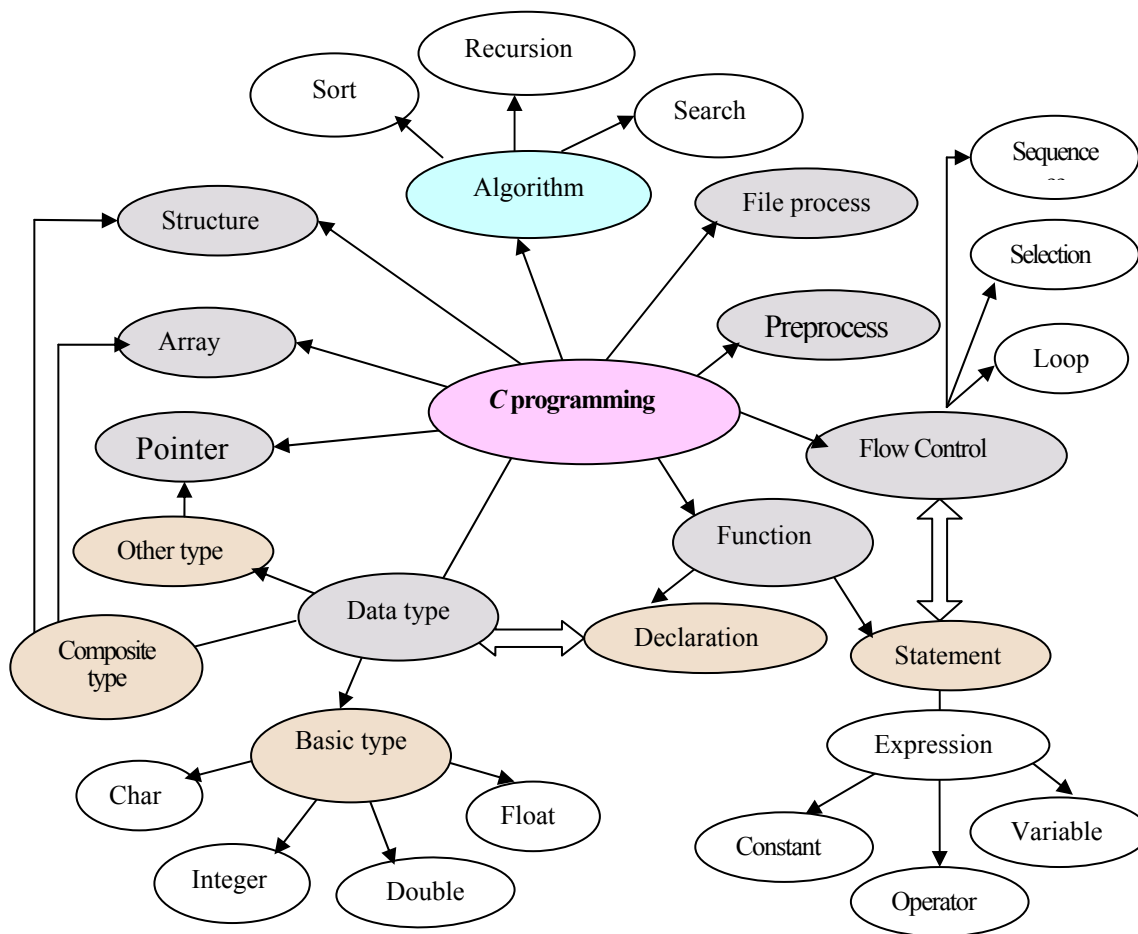


Figure 1. Basic concept map of C programming

collected by me, the teacher, but also by my students who I will ask to gather suitable material from the experiences of their friends and families. The more cases acquired, the better the case library would be. By choosing the entertaining, everyday examples from the library and presenting them in class I hope to increase students' interest in the content and enhance their learning.

**Example: 'Fox searching rabbit' problem**

*There were ten caves located near the top of a mountain. A fox and a rabbit moved around from cave to cave, staying for a time in each cave, one after the other. The fox wanted to catch the rabbit so that he could eat him. So he started to search for the rabbit. The first time, he searched in every cave one after the other. The second time he searched in every second hole, then in every third hole. In total he searched 1000 times, but...*

At the beginning of the lecture about arrays, I will first describe this case by telling my students. While students are absorbed in the plot, I will continue the story and provide key questions, for example, but even though the fox was terribly tired and almost felt dizzy, he could not find the rabbit. Do you know which cave was safe for the rabbit to hide in? At this point I will require the students to start working on the question with a brainstorming session. In order to solve the problem, they will need to be active participants and think independently. I hope to encourage them, whatever solution or ideas they come up with to solve the problem. Maybe some of them will decide to use arrays

to solve this problem (those students who read up on the subject before class). At that point, I will tell students the topic of lecture is 'Arrays'. Further, the students are required to read the relevant content that appear in the textbook and then try to write down the code.

Through this case, students will learn the following knowledge:

1. declare and use of array;
2. recall the usage of 'for' statement; and
3. learn to set labels appropriately.

The purpose of using a case study together with a brainstorming session is to foster a self-directed learning approach in students and to encourage them to be creative. However, if we just learn to solve one case, it will only result in surface learning. Therefore, I will provide follow-up to the case study aiming at developing students' lifelong skills.

**Case study follow-up**

*If you are asked to design a simple interface to deal with this problem, how will you do this?*

*Input data: the fox's search pattern (the number of caves)*

*Output data: the number of caves where the rabbit can stay safely.*

## Group project work

Researchers report that students working in small groups tend to learn more and retain the knowledge that they have learned longer. So, I plan to employ a group project work strategy in my course. Project work usually takes place at the end of a course of study. Consequently, I will give lectures for 10 weeks, and will then move on to supervised project work. I will offer three or four projects to students which have similar difficulty but different areas. Each group will be required to choose one project and finish the task in five weeks. Each week there will be a group meeting run by the group leader. At these weekly meetings, everyone will be encouraged to talk about their ideas or give proposals. As a good way to help the progress of project work, keeping a record of the meeting will be recommended. One week before the deadline, a prototype should be formed and examined. Subsequently students should submit a final project report. In the report, students may describe their individual work, what they have learned in group work and what they have contributed to the whole project. Finally, in the following week, every group will give an oral presentation to demonstrate their achievements. It is anticipated that students will develop useful skills as follows:

- independent learning skill (since each person will be allocated different tasks within the project, every group member will be responsible for their own part and have to work independently);
- collaborative skill (in order to integrate the various parts of the project and produce a successful product, everyone in the group should have a close collaboration during the project work);
- communication skill;
- time management skill;
- data collection skill (acquiring enough raw data is the first step in the process of project work, electronic libraries and online databases should enable students to find out what they need to know in a particular area);
- problem solving and analytical skill, and
- report writing skill.

As class supervisor, the role of the teachers is to:

1. help students to form groups;
2. clarify the individual tasks required to complete the project;
3. help students to choose a project topic;
4. give some advice for students;
5. share personal experience of project work with students; and
6. give regular and frequent feedback.

## Interest-driven approach

Someone once said, 'interest can be the power that drives study'. So, the course should be interesting and fun! I will emphasise fostering students' interest in learning *C* programming. For example, in the first lecture, I intend to demonstrate a program which students can sing 'Two little tigers' and a little game about 'A hungry snake'. With the music playing, students' interest may be captured strongly. At that point, it will be a good time to tell them both the programs were written and compiled in *C*. What does the *C* code look like? I will show them some detailed code in *C*.

Then I will ask the students if 'they would like to able to compile their favourite song or game?' Furthermore, I will present many examples that demonstrate the wide variety of uses for programs written in *C*. Meanwhile, I hope to develop students' own motivation to study. 'Do you know why you should complete this course?' A good teacher is also a good navigator, particularly when the students are at a loss. To help students develop clear motivation is one of the teacher's responsibilities. Of course, 'interest driven strategies' should be used throughout the entire process of teaching and learning. In the past four months, I participated actively in nearly all of the lectures and seminars at The University of Sydney. I found the active classroom atmosphere to be very positive. So, I will try my best to make my lectures more involving and therefore more interesting. First of all, as a teacher, I should be passionate about teaching. Secondly, I should introduce a few jokes or historical events and stories to break up the potential monotony of a lecture and refocus the students' attention every now and again. 'Don't present the same face everyday!' Finally, I should give students space and opportunities to express themselves and their ideas on the material we are dealing with. Group discussions, workshop, brainstorming, students-as-teachers: I could adopt any number of effective approaches in order to cultivate more active learners.

## Teacher supervisor and student tutor

As mentioned above, it is really very difficult for a single teacher to provide worthwhile guidance to students when working alone with a large practical class. The strategy that I plan to solve this problem is to enlist the help of some senior students to act as tutors. For instance, I could select four student tutors to help me in the practical classes. I should choose students who are competent computer programmers and good communicators. These attributes should be enough to make good teaching assistants. Their duties will include:

1. recording attendance;
2. answering questions;
3. 'trouble shooting' the 'sudden' problems encountered by students; and
4. reporting the common questions asked by the students to me.

This will free up my time to deal with the difficulties students experience in a more global sense. I will be able to: summarise the common and typical errors that students make in their programming and indicate how to avoid them; encourage and interact with individual students rather than be worried about the administrative aspects of class attendance; and foster better learning habits, such as self-directed learning e.g. taking responsibility for revision. At the same time, I will be able to focus on those students who are weaker and give them more help.

## Assessment

Whatever strategy is used, students will be powerfully influenced by the assessment system they are working within (Gibbs 1992). 'But, assessment is a necessary aspect of university teaching' (King 2006). So we must identify our requirements of assessment. These should include:

- certification: assessment provides an accepted way of determining the quality of students' learning and understanding; and
- encourage deep learning and lifelong learning: we should use assessment to modify students' behaviour and encourage them to be lifelong learners.

Assessment should be seen as an important way to establish lifelong learning habits.

In general, the basic types of assessment are formative and summative. Formative assessment implies a series of actions conducted by the teacher and students during the learning processes undertaken for the purpose of improving student learning which may lead to curriculum modifications (Berry 2004). Summative assessment is used to determine the relative performance of students, to grade and sort the students according to the quality of each student's understanding of the content and concepts presented to them. Commonly this takes the form of an end-of-subject examination. No matter what form the assessment takes, the most important aim for us as educators is to equip our students well and give them lifelong learning skills. I have decided to construct a comprehensive assessment system as shown in Table 1.

**Table1.** Comprehensive assessment

Assessment	Details	Marks	Type
Online assessment	Give assessment to teacher and self-assessment	5	Formative Continual Assessment
Quizzes	Two or three quizzes	10	
Project report	Summit final project program (20) and Individual report (10)	30	
Oral presentation	Individual oral presentation	10	
Final examination	Closed book	40	Summative Final Assessment

During the process of teaching and learning, students are required to access the course web site and undertake online assessment. In the web-based assessment system, students may give me feedback about my teaching, as well as assess their own study quality. On the other hand, I will collect the assessment data, analyse and summarise the analysis results. According to these results, I will make some modification to my future teaching as they are necessary. In fact, it is not easy to be absolutely fair in the process of assessment. What we can do is to make the process fairer. I hope to invite one or several colleagues to be second markers to help to assess the students' final products and mark their oral presentations (Lewis and Habeshaw 1997).

## Conclusion

There is no single, right way of teaching; and teaching is by its very nature, a great individual challenge for every teacher. I hope to employ the teaching approaches mentioned above and make changes in the way I teach my course when I return to China. Through these changes, I expect to achieve the following objectives:

- help students to be able to establish clear goals, become more creative, and develop positive attitudes to lifelong learning; and
- improve my teaching performance; use a wider variety of teaching styles, and enhance my professional abilities.

However, there are some barriers to making all these changes and innovations. First of all, the practicalities of change; it will require a large and time-consuming effort to make so many changes to the process of teaching. Preparing the case studies and project topics and so forth will not be a small or easy thing to do. Secondly, the attitudinal change: the transition from teacher-centred model to student-centred model is a big change – and not just for the teacher. For students who have been accustomed, we could even say conditioned, to 'spoon feeding' teaching methods it will be very difficult, perhaps confronting to accept the changes I have proposed here. In addition, the more comprehensive continual assessment I have proposed will place an increased workload on me as a teacher. Finally, a smooth transition to this new teaching plan will require my efforts to persuade my senior administrators about the feasibility of and the need for these innovations.

## Acknowledgements

I would like to thank to the China Scholarship Council and The University of Sydney for supporting my study. At the same time, I really appreciate the support from the School of Information Technologies. I also want to present my sincere thanks to Associate Professor Mike King, Associate Professor Mary Peat, Dr Tom Hubble, Dr Geoffrey Kennedy, Dr Zhou Bing Bing, Dr Josiah Poon, and Dr Simon Poon. I have learned a great deal about the teaching methods in all the lecturers and seminars delivered by them. Finally, I would like to express my gratitude to all the English teachers from the Centre for English Teaching especially Asher, Louise, Cecilia, Cathy and Sophie.

## References

- Berry, R. (2004) *Teachers' perceptions of their roles and their students' roles in the formative assessment process*. AARE Conference.
- Chuxiong, L. (2003) The use of student-centred learning strategies in the course of Data Structures and Algorithms. *The China Papers*, 2, 90–93.
- Gibbs, G. (1992) *Improving the quality of student learning*, Bristol [England]: Technical and Education Services Ltd, 12–18.

- Gross Davis, B. (1993) *Collaborative Learning: Group Work and Study Teams*. [online], <http://teaching.berkeley.edu/bgd/collaborative.html>.
- Hong, X. (2004) A plan for student-centred learning in a Computer Programming course. *The China Papers*, 3,111–114.
- Hubble, T. (2006) Seminar Notes: Unit of Study Evaluation in the Faculty of Science-Past and Present Practice, The University of Sydney.
- King, M. (2006) Lecture Notes: Teaching Science in English, The University of Sydney.
- Lewis, V. and Habeshaw, S. (1997) *53 Interesting Ways to Supervise Student Projects, Dissertations and Theses*. Technical and Educational Services Ltd.
- Middendorf, J. and Kalish, A. (1996) *The “Change-Up” in Lectures*. [Online], Available: <http://www.nflf.com/html/pi/9601/article1.htm>.
- Robinson, A. and Udall, M. (2006) Using formative assessment to improve student learning through critical reflection In C. Bryan and K. Clegg (Eds) *Innovative assessment in higher education*, 92–94.