The Teaching of Data Structures Course for Computer Specialty

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Abstract **- *Data Structures* is a core curriculum of computer specialty, which aims to cultivate undergraduates' abilities of selecting appropriate data structures to develop high quality application programs. Its contents include principles of programming, stack, queue, recursion, list, string, search, sort, table, information retrieving, tree, graph, etc. This paper presents our teaching of *Data Structures* course for computer specialty in Soochow University. We developed multimedia coursewares and designed a dynamic demonstration software to help students understand complicated procedures of algorithms easily. We also developed an online teaching platform on which students can submit their schoolworks, teachers can correct students' schoolworks, and teachers can answer students' questions on line. Because we use the bilingual teaching mode and the textbook is in English version, some students have reading and understanding difficulties. These people can download the Chinese materials from the platform, which help them understand the English materials well. To enhance the undergraduates' practice and innovation capabilities, three types of projects have been designed, which include testing project, designing project and comprehensive project. This paper also gives the good effects we have obtained.**

Index Terms - Coursewares development, Dynamic demonstration, Online teaching platform, Course projects

INTRODUCTION

Data Structure is not only a core course in computer majors but also a hot selective course for other science and engineering majors. It is currently a required testing topic for graduate student enrollment in many Chinese universities. This course introduces how to solve a series of problems with computer, especially different kinds of data organization when dealing with non-numeric data information processing problems, and algorithms on various structures. Its contents include principles of programming, stack, queue, recursion, list, string, search, sort, table, information retrieving, tree, graph, etc. The course aims to help students master the characteristics of data structures, storage, algorithms and their basic applications in computer, to cultivate students' abilities of selecting appropriate data structure, and to program high quality applications. Since the course is full of concepts, abstract definitions, principles, models and algorithms, it is often difficult for students to understand and learn it. Many students have difficulties in understanding the algorithms and applying them into projects. Therefore, they are lack of study interest, application capability, and innovation ability in this course.

To improve this situation, we improved our work in the organization of teaching contents, projects, etc. Also we developed multimedia coursewares, dynamic demonstration software and online teaching platform. It is believed that the improvement and perfection of the multimedia network application will bring significant changes in teaching this course.

THE ORGANIZATION OF TEACHING CONTENTS

The original English version book[1] is chosen as the textbook for *Data Structures* course. The highlights of the text book are:

- The contents are new and practical. The objective language C++ is used as a coding language through the whole book. The advantages of C++ fits it well to build secure, effective and simple implementations of data structures.
- The construction of the book is clear and easy to understand for students. The questions and advanced reading material are listed at the end of each chapter for students to review and improve.
- The design style is rigorous. The textbook has taken full consideration in the overall design thought and the programming detail. It is advantageous to cultivate students' rigorous programming style and the abilities of practice.
- The textbook explains concepts of data structures through interesting and the concrete examples carefully designed, which can interest students to study correlative subjects.

In the textbook, by working through the first large project (CONWAY's game of Life), Chapter 1 expounds principles of object-oriented program design, top-down refinement, review, and testing. Chapter 2 applies stacks to the development of programs for reversing input, for modeling a desk calculator, and for checking the nesting of brackets. Chapter 3 expounds several different implementations of the abstract data type and develops a large application program showing the relative advantages of different implementations. Chapter 4 presents linked implementations of stacks and queues. Chapter 5 continues to elucidate stacks by studying their relationship to problem solving and programming with recursion. More general lists with their linked and contiguous implementations provide the theme for Chapter 6. The chapter also includes an encapsulated string implementation. Chapter 7, Chapter 8, and Chapter 9 present algorithms for searching, sorting, and table access (including hashing), respectively. Chapter 10 presents binary trees, ties together concepts from lists, searching. Chapter 11 continues

the study of more sophisticated data structures, including tries, B-trees, and red-black trees. Chapter 12 introduces graphs as more general structures useful for problem graphs solving, and introduces some of the classical algorithms for shortest paths and minimal spanning trees in graphs.

We arranged the course contents and teaching outline which is shown in TABLE I.

TABLE I
THE ORGANIZATION OF CONTENTS

contents		periods
Chapter 1	Programming Principles	2
Chapter 2	Stacks	6
Chapter 3	Queues	4
Chapter 4	Linked Stacks and Queues	6
Chapter 5	Recursion	4
Chapter 6	Lists and Strings	6
Chapter 7	Searching	8
Chapter 8	Sorting	8
Chapter 9	Tables And Information Retrieval	6
Chapter 10	Binary Trees	8
Chapter 11	Multiway Tree	6
Chapter 12	Graphics	8
Total		**72**

DESIGN OF MULTIMEDIA COURSEWARES AND DYNAMIC DEMONSTRATION SOFTWARE

Algorithms in *Data Structures* course are very abstract and dynamic. They are hard to be explained by traditional class board writings and demonstrations. The result is that more time was spent and less success was achieved with the traditional teaching method. To improve this situation, multimedia coursewares have been prepared and dynamic demonstration software have been designed to help students understand complicated algorithms and procedures easily. It is well known that multimedia teaching is vivid, straightforward, and full of information. It will help students in understanding abstract concepts and algorithms, improve their study interests. Many techniques such as combination of sound and word, picture demonstration, cartoon show, and their interactions are applied with careful selection of teaching materials. This is totally different from simply putting contents in the textbook into slides. For example, dynamic demonstrations are applied in explaining algorithms in node insertion and deletion of linked list, visiting and searching of binary tree, graph traversal and depth-first, breadth-first search, etc. This kind of dynamic demonstration helps students in understanding abstract algorithms.

Dynamic demonstrations are implemented by Flash MX[2], which is a very popular software in cartoon design. Flash MX has been widely used in networks, multimedia teaching and game production since it is easy to learn and convenient to apply. In order to simultaneously position the current execution code with dynamic demonstration in an algorithm, cartoons and codes have been all made into film editing elements with their frames corresponding each other.

PROJECTS

A lot of practice is required in studying *Data Structures* course[3]. Some typical algorithms and basic techniques in the course need to be applied in the projects. This requires more time in designing projects. Based on the purpose of the projects and students' studying procedure, three types of projects have been designed, which include testing project, designing project and comprehensive project. Testing project requires students test algorithm efficiency and feasibility based on the pre-existing algorithm, such as *minimal spanning tree* with Prim algorithm. Designing project requires students propose algorithm and implement it in certain date structures, such as detecting if there is a circle in a directed graph, graph traversals for visiting every sighting (node) in a park (graph). Comprehensive project covers more comprehensive course materials and more focuses on combined application of algorithms and data structures. With the appropriate design of these three kinds of projects, students are trained for strong application skills, innovation capabilities, and comprehensive abilities.

The detailed implementation procedures in designing and comprehensive projects are listed below.

(1) Problem Analysis

Based on the project requirement, students are required to analyze and understand the problem. They are also required to understand how to solve the problem and what system functions to be implemented.

(2) Integrated Logic Design

For each object described in the project, data types and classes need to be defined. Main program module and data structures are therefore designed based on the data structure design principle. In this integrated logic design step, it is required that each data type declaration, data structure collection, and operation function are described in detail. Algorithms in each major module and their calling relationships are also required to be shown in the flow chart.

(3) Detailed Design

In this step, the corresponding data structure is defined and algorithms in the modules are written. System functions need to be considered as a whole for clear system structure and easy testing. The specification for each operation should be explained in detail. The objective in this step is to add details in the design of data structure and its operations. Type of data structure and algorithms in the modules are also declared.

(4) Writing Codes

Based on the detailed design in step 3, codes are written with some necessary comments and clear logic.

(5) Program Testing

Bottom up method is usually used in program testing for each module. Students are required to be familiar with all debug functions. They are also required to designate testing data, set break point and verify the function with personal programming. After program testing, the source codes and comments should be cleaned with structured format and results.

(6) Result Analysis

Results are analyzed to see whether project requirements are met. If some requirements are not met, the program are required to be tested again and some appropriate changes are to be made until all project requirements are met.

(7) Project Conclusion

It covers project conclusions, report written, and project grading.

ONLINE TEACHING PLATFORM

We developed an online teaching platform. The structure of the platform is shown in Figure 1.

Through this platform, the teacher of *Data Structures* can accomplish the following tasks:

- Build the online course

Online classroom provides teachers and students a stable learning environment of powerful functionality, user-friendly interface, abundant resources. The main menu includes: my courses, public courses, history courses, my file folder, learning material, online answers, online audio and vidio.

At the beginning of the semester, the manager loads the list of students, schedule of the course and the list of the teachers into the database. Before using the online course, the teacher need to build the online course according to the manual. The detail includes following steps. First, select the name of the course, the type of the course, start time, end time, etc. Then, key in the information of the course, course schedule, information of the teacher, automatically load the list of students into the system. Finally, finish the creation of the course.

- Upload and download the coursewares, learning material

Some students' English background are not so strong, and it is hard for them to read the original textbook. Both English and Chinese coursewares are available so that students can have abundant learning materials.

- Allocate and review the assignment online

Upon the finish of building the online course, the teacher posts the information of the course and the schedule arrangement, assign the homework, review the homework, collect the grade and evaluate the students on line. The teacher can monitor the students' working progress clearly, such as submitting the homework, the number of missing assignment and grade. After he assigns the homework, he can make sure if the students have finished the work on time through the system.

- Teacher-student real time communication

Teachers and students can exchange the opinion and feedback online. And teachers can answer students' question online.

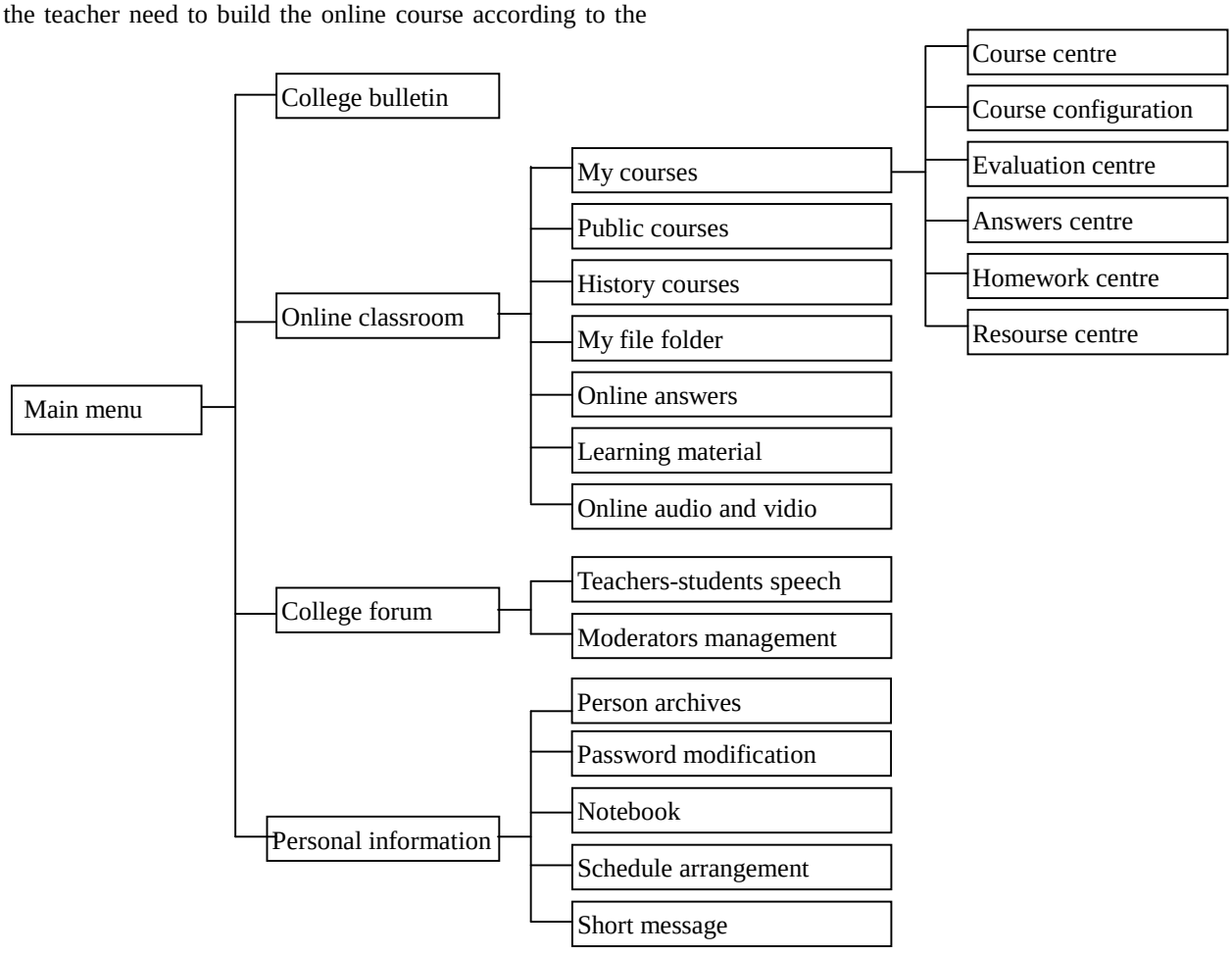

FIGURE 1
THE STRUCTURE OF THE ONLINE TEACHING PLATFORM

CONCLUTIONS

It has been considered that *Data Structures* is quite difficult to study. Students are often afraid of the difficulties and this causes the result of passive study. With our endeavor, the students discover gladly that the originally abstract concepts become concrete, the originally dull algorithms become vivid. This arouses the students' enthusiasm of study enormously, strengthens their self-confidence. The students read the learning materials consciously. Their capabilities of analyzing questions using data structures knowledge and programming to solve questions have been enhanced. This builds the solid foundation for the following curriculum study. In recent three years, more than 30 students got the awards in all kinds of national or provincial programming competitions. The course *Data Structures* was awarded the excellent prize by Jiangsu education department.

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REFERENCES

[1] Robert L.Kruse,Alexander J.Ryba, *Data Structudres and Program Design in C++*,Higher Education Press,Pearson Education, 2002.

[2] Gang Wang, FenHan, "Design and Development of Network Multi—Media Courseware Based on Flash MX and ASP", *Journal of Sichuan University of Science & Engineering (Natural Science Edition)*, Vol.18, No. 3, 2005, pp.49-53.

[3] Jing Jiang, "Practice on the Experiment in Data Structure", *Experiment Science & Technology*, No 12, 2006, pp.64-66.