

A Hybrid Teaching Mode of Algorithm Design & Analysis

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Abstract—Algorithm Design & Analysis is a compulsory course for computer majors, with many contents and strong theory. Traditional lecturing teaching is difficult to stimulate students' learning initiative, and the teaching effect is not ideal. This paper puts forward a hybrid teaching mode — the traditional lecturing teaching is adopted to enable students to master the algorithmic theories, and the case teaching is adopted to cultivate students' ability to solve practical problems using the theories they have learned. Teaching practice shows that the hybrid teaching mode can effectively improve students' learning enthusiasm and achieve good teaching results.

Keywords—algorithm design & analysis, lecturing teaching, case teaching, hybrid teaching

I. INTRODUCTION

Algorithm Design and Analysis is a compulsory course for computer majors. Through the study of this course, students should master the theories of several kinds of classical algorithms, and have the ability to design algorithms for practical problems and analyze the complexity of algorithms. The teaching of each kind of algorithm can be divided into two phases in chronological order, i.e., the theoretical learning phase and the problem solving phase. In the first phase (theory learning phase) students learn the theories of the algorithms; and in the second phase (problem solving phase) they solve practical problems using the learned theories. If the lecturing teaching is used throughout the whole teaching process, the students' learning enthusiasm can not be mobilized. Therefore, the teaching effect is very poor. Through the reflection on many years of teaching, this paper puts forward a hybrid teaching mode by incorporating the case teaching. That is, in the first phase, the lecturing teaching is adopted to enable students to master the algorithmic theories; and in the second phase, the case teaching is adopted to cultivate students' ability to solve problems by using the theoretical knowledge learned in the previous phase.

This paper is organized as follows. The first part starts by briefly introducing the case teaching. The second part covers the necessity and feasibility of the hybrid teaching in the course of Algorithm Design & Analysis. The third part covers several key points in the hybrid teaching. The fourth part covers the effect and existing problems of the hybrid teaching. The last part is the conclusion of the article.

II. CASE TEACHING

A. Background

Harvard Business School Professor C. Roland Christensen was one of the world's leading authority on case method teaching. He described the case teaching as "the art of managing uncertainty"—a process in which the instructor serves as "planner, host, moderator, devil's advocate, fellow-student, and judge," all in search of solutions to real-world problems and challenges [1].

The case teaching was proposed by C. C. Langdell, former dean of Harvard Law School in 1870 [2]. He believed that law was a science based on cases. To this end, he stressed that the curriculum in legal education should be mainly composed of cases, and the cases constituting students' learning materials should mainly come from legal practice and judgments of courts at all levels [3].

The development of the case teaching in China has only been more than 40 years. However, the effectiveness of the case teaching is becoming more and more obvious, which has won the recognition of our country's educational circle.

B. Characteristics of the Case Teaching

Compared with the traditional lecturing teaching, the case teaching has the following features [4].

a) Purpose

Through some typical cases, the case teaching enables students to master relevant knowledge and improve their skill to analyze and solve problems in case reading, thinking, analyzing and discussing. In the case teaching, it is necessary to consciously impart relevant knowledge and cultivate relevant abilities through cases. Therefore, the purpose of the case teaching is very strong.

b) Comprehensiveness

Compared with general examples, cases are richer in connotation. Therefore, case solving is more difficult, involving more knowledge and ability. As a result, the case teaching is conducive to improving students' comprehensive ability to solve practical problems.

c) Subjectivity

In the case teaching, through the guidance of teachers, students analyze the cases and put forward solutions to the

cases, so as to obtain relevant knowledge and improve their ability to deal with practical problems. The main body of the case teaching is students. Without the participation of students, the case teaching would be meaningless.

d) Guidance

The key to the case teaching is teachers. Teachers should not only prepare cases, but also guide students to think, discuss and solve problems. Although the main body of the case teaching is students, the quality of teaching depends largely on teachers' design and control of the teaching process.

III. THE NECESSITY AND FEASIBILITY OF THE HYBRID TEACHING

The very nature of algorithmics renders it particularly applicable to those disciplines that benefit from the use of computers, and these are fast becoming an overwhelming majority[5]. Algorithm Design and Analysis provides an indispensable knowledge reserve for the research and development of computer system structure, system software and application software. Through years of teaching, it is found that although students can realize the importance of the course, the learning effect is not ideal. The reasons are as follows.

On the one hand, there are too many contents, great difficulties and few class hours. First, this course covers many kinds of classical algorithms, each of which contains a variety of applications. Secondly, the course requires students not only to have certain programming ability, but also to have a solid mathematical foundation. The algorithm is abstract, theoretical, difficult to understand. Finally, although the course has many contents and great difficulties, the class hours are very limited.

On the other hand, the teaching method is backward. Due to the many contents of the course, in order to complete the teaching task, the full-course lecturing teaching has become the mainstream teaching method. The practice shows that it is feasible to use the lecturing teaching method in the theory learning phase, which can give full play to the characteristics of less teaching time, high efficiency and large capacity, so that students can master the theories of algorithm comprehensively and systematically in a short time. However, in the problem solving phase, the effect is not ideal if the lecturing teaching is still used. In the past teaching, almost each application in the teaching material is taught to the students. Due to limited class hours, the students gulp down dates in learning and don't have a deep understanding of the applications, resulting in fear of difficulties, which leads to low learning enthusiasm. This in turn leads to learning difficulties, which in turn leads to a vicious circle.

By incorporating the case teaching, this paper proposes a hybrid teaching, which gives enough consideration to the characteristics of the two teaching phases of Algorithm Design & Analysis. In the hybrid teaching, the lecturing teaching is still used in the theory learning phase. This gives full play to the characteristics of efficiency, comprehensiveness and systematicness of the lecturing teaching. In the problem solving phase, for each kind of algorithm, one or more representative applications are selected as the case. In this way, students' enthusiasm can be fully mobilized, the ability of

solving problems can be improved and the expected teaching effect can be realized.

IV. SOME KEY POINTS IN THE HYBRID TEACHING

According to the characteristics of the two teaching phases of the course of Algorithm Design & Analysis, the hybrid teaching method adopts different teaching methods to take full advantage of their strengths. In the hybrid teaching, more attention should be paid to the relationship between the two stages. In addition, a proper case base should be constructed and the case teaching skills should be improved constantly.

A. *The Relationship Between the Lecturing Teaching and the Case Teaching*

In the concrete implementation of the hybrid teaching, it is necessary to properly handle the relationship between the lecturing teaching and the case teaching. The time for the two phases should be allocated reasonably, and their teaching contents should be designed as a whole to ensure that they are an organic whole and serve the same teaching purpose.

Generally speaking, the theory behind each kind of algorithm is introduced from a specific application. Popular to say, in the theory learning phase, teachers "dissect sparrows" in the classroom. In the problem solving phase, students "dissect sparrows" by themselves. In order to make students have the ability of "dissecting sparrows", teachers must abstract relevant knowledge from specific problems when introducing algorithmic theories. Whether students master algorithmic theories in the first stage will directly determine the success or failure of the case teaching in the second stage.

B. *Case Base Construction*

Case is the core of the case teaching. Without case, the case teaching is impossible[6]. When designing a case, knowledge points should be hidden in the case, and the teaching purpose should be integrated into the whole process of case solving[7]. The construction of case base can not be achieved overnight, and it needs to be improved in the teaching process. It is necessary to adjust the difficulty of cases in time according to the teaching feedback.

a) Source of Cases

The cases mainly come from the classical applications of various algorithms. Firstly, some of these applications have been learned in the precursor course of Data Structure such as Huffman coding, shortest path, binary tree, etc. Students are familiar with these problems, so they can focus on the solution of the problems. Secondly, these problems have been studied for a long time with a variety of solutions, for which students can compare the pros and cons. Finally, it is easier for students to find relevant learning materials after class and deepen their understanding of the knowledge. Of course, the problems encountered by students and the interview questions of IT companies will be supplemented in the near future to increase students' interest in the course.

b) Case Selection Principles

The first principle is typicality. Due to the limited class hours, the selection of cases should highlight the characteristics of less and better, and try to select those typical

cases that can serve multiple knowledge points. The 0-1 knapsack problem is such a typical case. The problem is simple and easy to understand. It can be solved by brute-force method, dynamic programming, backtracking and branch-and-bound method. Through this case, students can master the characteristics of these algorithms, compare their advantages and disadvantages, and clarify the scope of application of these algorithms. The 0-1 knapsack problem can also be connected with the knapsack problem. Students are usually confused by these two problems. Although the two problems are very similar in description, the methods for solving them are completely different. The knapsack problem can only be solved by greedy algorithm. In the course of Algorithm Design & Analysis, there are many such typical cases, such as traveling salesman problem and loading problem, which can be solved by both backtracking and branch-and-bound methods.

The second principle is to simplify the description of the problems, so that students can spend more time on solving problems. Take the maximum clique problem as an example, it is essentially the same problem as the maximum independent set problem. In order to illustrate the equivalence of these two problems, the concepts of subgraph, complete subgraph, complement graph, empty subgraph, clique, maximum clique, independent set and maximum independent set should be introduced. In addition, it is necessary to prove the equivalence between complete subgraph and empty subgraph, clique and independent set, maximum clique and maximum independent set. After being exposed to these concepts, many students have lost their patience and confidence to continue learning. According to the learning level of the students, when learning the maximum clique problem, just make clear that the maximum clique problem is essentially a subset tree problem. That is, the maximum independent set problem could be bypassed, leading the students to quickly shift their attention to problem solving rather than problem understanding.

The third principle is to adjust the difficulty of the cases according to the actual level of students. If the case is too difficult, students will lose confidence; if the case is too easy, it will not help students to improve the abilities of problem solving. Taking Huffman coding as an example, the execution process is easy to understand. However, it is difficult for students to understand the theory behind the algorithm. Students also find it difficult to program and implement the Huffman algorithm without the minimum heap. Therefore, teachers should adjust the difficulty of the case according to the students' actual level.

C. The Skills of the Case Teaching

The case teaching is new to both students and teachers. By summarizing the teaching practice of many years, the following skills should be paid attention to in the case teaching.

a) Organization of the Class

The case teaching is generally carried out in the following steps — stating problems, analyzing problems, proposing solutions, comparing the pros and cons of schemes, and summarizing. The class of the case teaching should not be too large, too many students will affect the discussion. Sometimes, the class needs to be divided into groups, and the random

group is usually adopted. The number of people in each group and the gender proportion should be paid attention to. Usually, 6-8 people are suitable. The grouping can be adjusted regularly to facilitate communication. Each group shall elect their leader, who shall organize group discussion. The group shall arrange the presentation or report of the group after the discussion, and make a brief comment.

b) Preparation for the Class

In the case teaching, preparation before class is particularly important. Teachers will send the case to be discussed to students in advance, so that students can prepare before class. After students get the case, they should be familiar with the case, actively consult relevant materials and propose their own solutions. Only when students are fully prepared can they participate in problem analysis and discussion effectively.

In addition to preparing cases, teachers must also design the whole process of the case teaching. They should reasonably allocate the time for each teaching step and take the opportunities to transfer from one step to another. In the case teaching, students should be inspired and encouraged timely. Taking into account all kinds of possible situations in the case teaching, teachers should guide students' discussion towards problem solving[8].

c) Encouragement for Students

In the case teaching, each student must think by himself, come up with his own solutions, and express his opinions on his own and others' solutions. Students have different levels, therefore, teachers should encourage them to think independently and to express their own opinions.

d) Two-Way Communication

The traditional lecturing teaching is one-way. Teachers teach students knowledge. On the contrary, the case teaching is two-way. From a student's perspective, he gets the case from his teacher, digests it, and then looks up the relevant material. By doing so, his understanding of algorithmic knowledge has been deepened. After collecting the relevant information, he must think carefully and propose solutions to the problem. From a teacher's perspective, he should provide students with cases, and guide students' discussion toward problem solving. In the process of guiding, he may meet many problems, which makes him think deeply and add new teaching content. The two-way teaching is more demanding on teachers.

V. THE EFFECT AND PROBLEMS OF THE HYBRID TEACHING

A. The Effect of the Hybrid Teaching

Through several years of practice, the hybrid teaching has achieved the expected effect in the course of Algorithm Design & Analysis.

a) *The class attendance has improved significantly.* In the previous teaching, some students would not be able to keep up with the rhythm of the teaching as the course progressed. Then they felt that there was no gain and began to skip classes. After incorporating the case teaching, the phenomenon of absenteeism is basically eliminated. Students also take classes

more seriously in the theory learning phase than before, because they know that these theoretical knowledge is the basis of the case teaching.

b) Students' enthusiasm for learning has been greatly improved. In order to solve the problems in the case, students will think independently and participate in the classroom discussion actively. In conclusion, students are focused on learning from beginning to end.

c) The hybrid teaching helps to improve the research and programming ability of some students. They participate in the college programming competition and achieve good scores.

B. Problems in the Hybrid Teaching

By integrating the advantages of the lecturing teaching and the case teaching, the hybrid teaching improves the teaching effect, but also faces some problems. The problems of the lecturing teaching have been covered in many literatures and will not be repeated here. This paper focuses on the problems existing in the implementation of the case teaching.

a) Higher Requirements for Teachers

The traditional teaching is one-way and controllable, that is, teachers can carry out teaching activities according to the designed scheme. But the case teaching is two-way, and there is a lot of unpredictability in the teaching process. Unlike lectures, case method classes unfold without a detailed script. Successful instructors simultaneously manage content and process, and they must prepare rigorously for both. Case method teachers learn to balance planning and spontaneity. In practice, they pursue opportunities and "teachable moments" that emerge throughout the discussion, and deftly guide students toward discovery and learning on multiple levels[1]. In conclusion, the case teaching puts forward higher requirements for teachers' classroom design and guidance ability.

b) Active Participation of Students

In the traditional lecturing teaching, students are passive recipients and rely more on teachers. In the case teaching, students are the main body and need to adapt to this new teaching method. Therefore, teachers need to strive to guide students to participate actively in classroom discussion.

VI. CONCLUSION

On account of the characteristics of the two teaching phases of the course of Algorithm Design & Analysis, this paper proposes a hybrid teaching mode, which adopts different teaching methods in different phases. This mode ensures students to master algorithmic theory systematically, cultivates students' problem solving ability, and increases students' interest. Its effect has been manifested by our teaching practice. In the future, this mode will be further improved by absorbing new teaching philosophy at home and abroad.

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