Teaching Methods Reform of "Algorithm Design and Analysis" Course

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ABSTRACT

In order to improve the teaching quality of *Algorithm Design and Analysis* course, we reform the teaching methods according to student characteristics and other factors about the course. This work firstly proposed the mixed teaching methods based on heuristics, inquiry, discussion, and cases, then implemented the teaching organization forms such as hierarchical experiment and group work, and finally suggested diversified assessment methods to stimulate students' interest in learning and improve their autonomous learning, innovative and problem-solving ability. The teaching results in recent years demonstrate that the reform has achieved positive learning effects, not only improving students' scores, but also increasing the participation in computer competitions and improving the application ability of algorithms.

Keywords: *Teaching Methods, Teaching Ideas and Concepts, Teaching Organization Forms, Diversified Assessment Methods*

1. INTRODUCTION

Algorithm Design and Analysis is an introductory professional course for computer science and technology and software engineering at our university. This course focuses on the basic theories, methods and applications of some algorithms, including the divide and conquer method, dynamic programming, greedy algorithms, the backtracking method, and the branch and bound method. The objective of this course is to cultivate students' ability to analyze and solve problems. It includes: master the basic methods of designing algorithms, become familiar with the basic techniques of algorithm analysis, and be proficient in using common algorithms to solve practical problems. Mastering these concepts creates a solid foundation for students to further study in more advanced courses.

There are some shortcomings with the existing teaching methods, such as difficulty understanding course contents, backwards teaching methods, a low level of student learning motivation and weak innovative ability. Therefore, we have attempted to reform the teaching methods through the modern teaching concepts while promoting the students' comprehensive application and innovative ability. The remaining structure of this paper is divided into three sections. In the second section, a brief introduction of the teaching status analysis of *Algorithm Design and Analysis* course is presented. The teaching methods utilized for the course is described in section 3, and section 4 details concluding thoughts.

2. TEACHING STATUS ANALYSIS OF "ALGORITHM DESIGN AND ANALYSIS"

Currently, there are some challenges in the teaching of *Algorithm Design and Analysis*.

2.1. Prerequisite Courses Do Not Establish a Solid Foundation

There is a multi-step design process for creating an algorithm. Firstly, establish a mathematical model by analyzing the given problem. Secondly, design the algorithm based on the data structure, and then analyse the complexity of the designed algorithm. Finally, implement the algorithm using a programming language [1,2]. Therefore, the prerequisite courses for *Algorithm Design and Analysis* are *Data Structure*, *Programming Language*, and a certain mathematical foundation. Many students have not developed the necessary basic skills in relevant prerequisite courses, which lead to the inability to understand the relevant knowledge in algorithm courses and need to review previous contents.

2.2. The Course Contents Are Abstract and Difficult to Understand

Algorithm Design and Analysis involves many knowledge points, and some knowledge points coincide with *Data Structure* [3]. But different from *Data Structure*, *Algorithm Design and Analysis* focuses on the cultivation of logical thinking ability. Moreover, this course is relatively theoretical and practical, and some theoretical knowledge is abstract and difficult to comprehend. As an example, many students do not understand the dynamic programming solution of the 0-1 knapsack problem.

2.3. Backward Teaching Methods

The pure lecture-style teaching method is generally used in traditional teaching [4], and the interaction between teachers and students is lacking. If the theoretical knowledge of algorithms is explained in a lackluster way and the case selection has no practical application value, it is difficult to maintain students' attention during instruction. Besides, this teaching method leaves students little space for active thinking or inquiry, which results in low learning enthusiasm over time.

2.4. The Experimental Results Are Not Satisfactory

Some students were only able to verify the algorithm according to the experimental contents designed by the teacher because of their inadequate prerequisite knowledge of *Data Structure* and basic programming skills during the experimental teaching. These students rarely designed an algorithm, which is not conducive to the cultivation of students' critical thinking, innovative, and problem-solving skills.

2.5. The Assessment Methods Are Not Very Reasonable

At present, the assessment methods for *Algorithm Design and Analysis* are similar to other courses; the test paper score accounts for 70% of the total score and the usual score accounts for 30%. The usual score includes homework, an experiment report, attendance, and class participation. However, the assessment methods only reflect the students' mastery of theoretical knowledge, but cannot assess the students' real application of this knowledge. Therefore, we try to improve existing assessment methods through the modern teaching concept, which promotes students' comprehensive application and innovative ability.

3. THE IMPROVED TEACHING METHODS

We reform the teaching methods combined with the actual situation of our students and the characteristics of the course. The overall architecture diagram is shown in Figure 1.
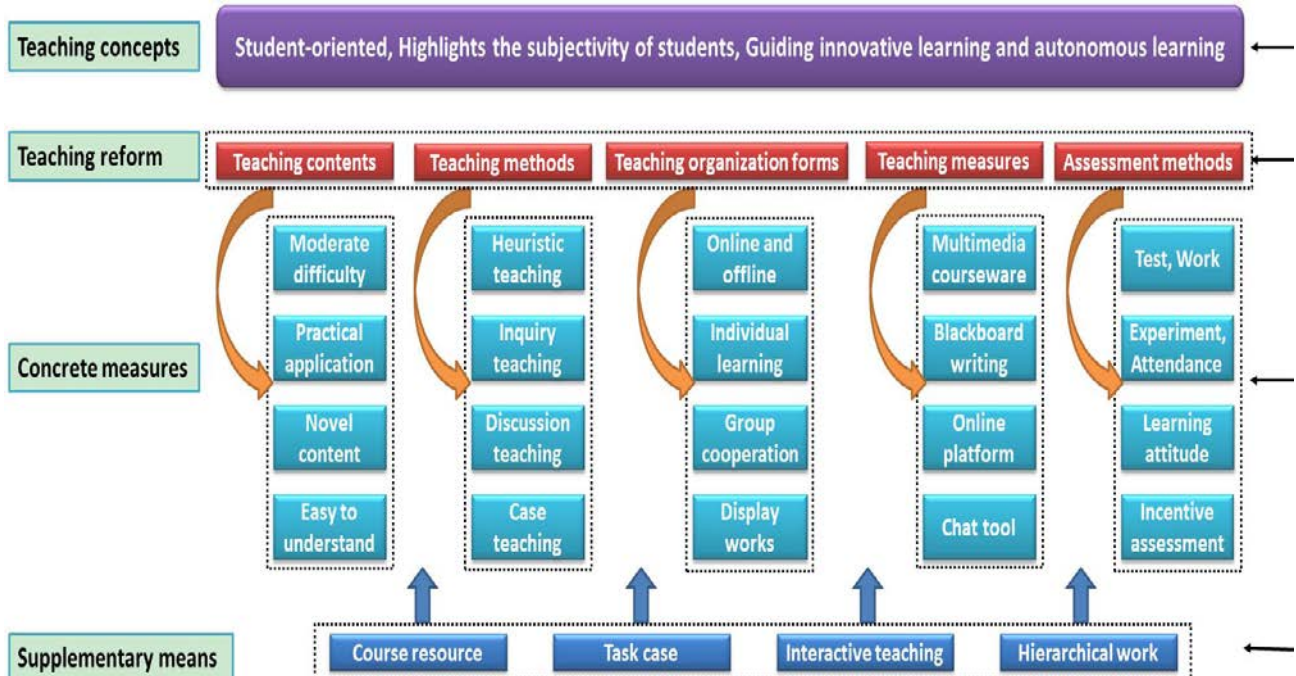

Figure 1. The Overall structure

3.1. Teaching Ideas and Concepts

The modern teaching concept focuses on "student-oriented" and highlights the subjectivity of students in the teaching process. In other words, we need to carry out teaching according to the behavior and psychological characteristics of students in order to stimulate students' potential and improve their interest in learning. Therefore, we should not only help students build the overall curriculum system, but also leave enough space for self-study and extended learning as we formulate the teaching plan and contents from the perspective of students. We should explore guiding teaching and transform the traditional teaching concept of teacher-centered, textbook-centered and classroom-centered to student-centered and practice-centered regarding teaching methods [5]. Additionally, we should adopt diversified teaching methods according to the different characteristics of students in order to create conditions that holistically develop each student.

Students come to this course with varying degrees of preparation. The modern teaching "student-oriented" concept cannot be embodied if traditional teaching ideas are employed. We will provide the method of how to utilize the modern teaching concept in our course. Initially, the first class session does not include any theoretical knowledge, and students are mainly guided to get started and cultivate their interest in learning. Students are presented with cases where they are guided to contemplate the algorithms behind them. And the students assess their own knowledge level according to these cases. Then, students are given different assignments or experiments with a degree of difficulty that corresponds to their self-assessed level of understanding, which teaches students according to their aptitude and prerequisite knowledge.

3.2. Construction of the Teaching Methods System

3.2.1. Identify the Teaching Objective and Select the Teaching Contents Appropriately

Teaching objectives should be student-centered and focus on stimulating students' enthusiasm to actively participate in learning so that they can continuously improve their problem solving and innovative abilities throughout the process of learning knowledge. The teaching contents should fully reflect the key points and difficult points of the course on the premise of clear teaching objectives. First of all, we must be grasp the difficulty of contents and continuously update our knowledge reserves. Then optimize the selected contents according to students' prerequisite knowledge, and supplement the contents appropriately with knowledge and resources beyond books. Finally, explain the algorithm design skills and analysis methods while incorporating practical problem. It's best to avoid abstract and boring teaching contents in order to make the course easier to understand, and stimulate

students' interest in learning and a strong desire to explore the principle. For example, starting with the "Tmall Double 11" shopping example that is of interest to every student, we guide students to think about how to get "You Might Like" and "Recommended for You" on the Tmall website.

3.2.2. Create Characteristic Teaching Methods

Traditional teaching methods are closed. Students are passive in the traditional teaching process, which restricts their ability to utilize personal learning preferences or personality traits in their learning. The modern teaching philosophy emphasizes students at the center of learning, and teachers should be a leader in this process. As leaders, teachers impart the contents of the course to students while focusing on students' autonomous learning in this process. This method aids students in identifying and solving problems independently, which cultivates students' innovative consciousness and creative ability.

In order to transition students' learning habits from passive to active, we adopt heuristic, inquisitive, discussion, and participatory teaching methods in the teaching process. Students are alerted at the beginning of the course that there is more theoretical knowledge in the course and needs a certain degree of mathematical knowledge. Then, teachers use experimental tasks and cases with thematic discussion that can arouse students' interest in the material throughout the teaching process. Students can examine problems by thinking about the learning materials and consulting those materials to gain a more detailed understanding of the problem. Finally, students find their own solutions to the problem under the guidance of the teacher. This enables students to take an active role early on in acquiring knowledge while cultivating their collaborative ability, which aligns with the university autonomous learning method. For example, students are guided to contemplate algorithms and underlying principles for concepts such as a "Paternity Test" and "Thesis Academic Misconduct Detection". Then several questions are posed, and students need to utilize relevant materials with questions and conduct group discussions. Finally, the longest common subsequence problem in the dynamic programming algorithm is derived from the results discussed by students.

3.3. Construction of Teaching Organization Forms

3.3.1. Combination of Online and Offline

Before class, different preview contents and learning materials are arranged by accounting for students' varying levels of computer skills. Students can learn online by watching short videos and reading learning materials. In

class, the students are guided to master relevant knowledge points through our explanation and analysis of examples.

3.3.2. Hierarchical Experiment

The implementation of experimental learning directly affects the teaching outcomes of each computer course. Experimental teaching plays an irreplaceable role in cultivating students' innovative, practical, and problem-solving abilities. Therefore, focusing on strengthening practical teaching is the key to teaching reform. A careful arrangement of experimental classroom and homework assignments as well as a planned selection of comprehensive exercises covering classroom teaching knowledge points can enable students to learn and master the essence of the algorithm.

The experimental teaching tasks are set up to carry out individualized learning by accounting for students' varying levels of computer skills. For students who are not particularly proficient in designing algorithms, we provide the screenshots of the final results and prompt operation of individual topics in the experimental contents to enhance the enthusiasm of students and improve learning efficiency. For students who are more proficient in designing algorithms, we require them to design and expand on an algorithm. For students who are particularly proficient in designing algorithms, we encourage them to participate in the algorithm competition, and their competition scores are added to the final assessment. Every student will work harder and have a stronger interest in learning as a result of this individualized learning.

3.3.3. Group Work Training and Communication

Students are divided into groups in order to foster students' teamwork skills. Each group has an assignment. Encourage students to show their homework to other groups in class, and then discuss the knowledge points in the homework to improve the students' interest in learning and participation consciousness. Students need to discuss problems in their group first if they encounter problems in the process of doing homework. Then they can search for helpful resources online in order to develop the habit of using various available resources to solve problems independently. Finally, students are encouraged to ask for our help if they are unable to solve the problem after using all their resources. This can enhance students' ability to analyze and solve problems, so that students can have a positive attitude towards learning as they enter more advanced study.

3.4. Construction of Teaching Measures

In the course preparation process, we carefully analyze our teaching materials while consulting any excellent course

materials offered by a similar course at another university, and determine our own teaching approach. We also design teaching plans according to the teaching materials and the characteristics of students, and carefully design multimedia courseware that combines the use of sounds, images, texts, and animation. We skillfully use various teaching media including blackboard writing to improve students' understanding. According to the experience in recent years, blackboard writing is much better than multimedia courseware in analyzing the complexity of an algorithm. It is best to combine multimedia courseware with blackboard writing to explain the execution process of an algorithm.

We make full use of the network teaching platform, QQ group, WeChat, email, and other teaching tools to expand knowledge, arrange homework, and release teaching materials such as handouts, courseware, and exercises to facilitate students' autonomous learning. we also strengthen post-class communication with students through modern communication methods, timely grasp each students' learning situation, and assist students who need extra help after class.

3.5. Reform of Assessment Methods

A new overall course assessment plan was designed that evaluates students' learning from multiple angles with special emphasis on the results of computer experiments and group work. The final score of the *Algorithm Design and Analysis* course is composed of the following parts: five experimental reports (12%); ten homework assignments (12%); a final examination (60%); and class attendance, learning attitude, classroom interaction, and learning initiative (16%). In addition, expansion homework, group reports, special discussion, classroom display, and participation in the competition are included as extra score points. This grading structure allows students to demonstrate their creative ability in various forms, which greatly increases their enthusiasm for learning, improves their comprehensive ability of applying computer algorithms, and achieves the goal of teaching.

4. CONCLUSION

Positive teaching results have been achieved following nearly seven years of teaching reformation. Firstly, the students' final scores have improved. Secondly, the number of students participating in the ACM-ICPC competition, software design competitions, and software service outsourcing competitions has also increased annually. Finally, the students who have graduated questionnaire indicate that students are able to apply what they have learned, model some practical problems, and design algorithms.

In the future, the teaching methods of the *Algorithm Design and Analysis* course will continue to be improved in order to elevate the level of teaching quality.

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