Thinking and Practice of Online Teaching under COVID-19 Epidemic

Zhang Ping
State Key Laboratory of Mathematical Engineering and Advanced computing
Zhengzhou, China
email:13674910726@139.com

Liu Fudong
State Key Laboratory of Mathematical Engineering and Advanced computing
Zhengzhou, China
email: lwfydy@126.com

Shan Zheng
State Key Laboratory of Mathematical Engineering and Advanced computing
Zhengzhou, China
zzzhengming@163.com

***Abstract*—Response to the outbreak of COVID-19, classes in this semester are mainly replaced by online teaching to ensure continual learning. Teachers are actively exploring effective online teaching methods to provide a good learning experience for students at home. This paper presents an online teaching model based on the idea of Problem-Based Learning (PBL) and take "Data Structure" as an example to discuss the design of teaching process and problems.**

Keywords—Online teaching, Problem-Based Learning (PBL), Autonomous learning, livestreaming, online judge

I. INTRODUCTION

At the beginning of 2020, the outbreak of COVID-19 hit majority of countries and regions on this planet. To curb the spread of the novel coronavirus outbreak, schools and universities in China are required to postpone the start of the spring semester until the epidemic is under control. A record number of children and youth cannot continue their regular study life. Under such situation, Internet and online courses become the best solution[1].

Many schools and universities are now embracing online learning as a substitute of traditional teaching[2][3]. Courses are conducted online via different platforms, including its internal online classroom system, video conferencing and open online education platforms such as XuetangX, CNMOOC, IMOOC and the China University MOOC which provides a variety of courses available to the public in China. Many professors have been livestreaming their classes, playing recorded course videos and organizing discussions using instant messaging apps such as WeChat, QQ, or conference system online.

Online education provides solutions to crisis, but the shift from physical classrooms to online ones has not been without problems[4].

There are some problems in teaching online. Teachers are not able to know if students are slacking or paying attention. Students might not be able to ask questions to gain a better understanding. Students at home need self-disciple when taking online classes, which is difficult for many students who are immersed in games and the internet. They may not know how to control themselves at home when taking online classes. The home environment lacks the learning environment that schools have. So, how to effectively implement online teaching is a topic worth studying.

This study presents an effective teaching method for online teaching. The basic idea of this method is Problem-Based Learning (PBL). During online teaching, teachers guide, check and manage student's study by different kind of problems or questions while students acquire knowledge by answering and solving problems. And the application of PBL teaching method in Data Structure, a professional basic courses of computer science, is discussed.

II. DESIGN OF TEACHING PROCESS

Problem-Based Learning (PBL) is a relatively new pedagogical system that has revolutionized the teaching-learning process in multiple different parts of the world, as well as in various fields of knowledge. It is a kind of heuristic teaching method. The main idea is that teaching process revolves around problems. That is teachers present the teaching content in the form of related questions and problems to students who study and answer these questions and to solve problems. In the process, students can master knowledge, develop intelligence, cultivate skills. The PBL teaching method regards problem-solving as the basic process of teaching. In teaching process, different ways can be adopted, such as teachers leading students to solve problems, teachers and students jointly solving problems, and students independently exploring and solving problems. Thus, teaching become a process with clear purpose and can motivate students' initiative[5].

In view of the problems existing in current online education, PBL is introduce into online teaching of Data Structure which is an important professional basic course. The process of data structure teaching is divided into three phases: autonomous learning from Internet, livestreaming and Answering questions, and online exercise. The idea of Problem-Based Learning is introduced into each teaching phase and problems become bridge between teachers and students. The teaching process is shown in figure 1.

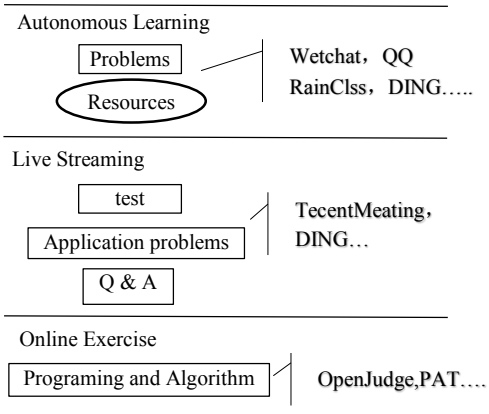

Figure1 process of DS teaching

A. Autonomous learning from Internet

The autonomous learning phase is knowledge-based learning. Teachers use web platform (here we use Rain Class of XuetangX) to publish content and requirements of this class in advance. The class content is divided into knowledge points, and publish to students in the form of MOOC, SPOC, short

videos, algorithm animation, or other reference materials. These teaching resources include those independently constructed by us and high-quality teaching resources of famous teachers, such as MOOC video of the national excellent course Data Structure of Professor Chen Yue of Zhejiang University, Data Structure and Algorithm teaching video of Professor Zhengjunhui of Tsinghua University, etc., which are selectively recommended according to the teaching content of each class.

The problem of autonomous learning is that it is difficult for students to master the points and difficulties of knowledge. Question are used to solve this problem. The questions at this stage come from knowledge points. These questions are not only the requirements for students' self-study, but also the guidance for self-study. Students study with these questions and master the knowledge through answering them. This requires each question to be clear, answerable, and operable. Therefore, the quality of questions directly affects the effect of learning. This design of question will be discussed in Section III.

B. Livestreaming and Q & A

The biggest problem with online education is the lack of interaction between teachers and students. Teachers can't keep track of the students' work. The phase livestreaming and Answering questions aim to solve the problem. This phase consists of three main activities: testing, Q & A and knowledge application.

Testing is to evaluate the result of students' autonomous learning. At the beginning of each livestreaming, we spend 15-20 minutes to take a quiz according to what students are learning. By such testing, teachers can grasp students' learning situation and it can also effectively motivate students to learn. Testing is completed using the online test of Rain Class. The online test of the rain class is a very useful tool. It can present questions in objective or subjective form. Students answer these questions on the platform, results are fed back immediately and shown in a visual form. Based on the test, teachers can further explain what students haven't understand or master.

Q & A is an important activity of interaction between teachers and student. In teaching of Data Structure, we use which the multi-person cloud conference solution of Tencent, Tencent Meeting. It can support real-time share and communication with excellent video and audio quality. Especially, Tencent Meeting provides free unlimited time conference function for 300-person to users across the country during the epidemic. With Tencent Meeting, teachers and students can communicate face to face through the Internet and discuss problems encountered in autonomous learning.

Knowledge application is the focus of the live lesson and is also based on problem. According to the teaching content, by setting application scenarios, putting forward requirements, teachers guide students to refine application problem. And then students try to analyze and solve the problem using what they have learned. Further, they can put forward new problems and make effort to study and resolve them, so that the students' thinking is always consistent with the rhythm of the classroom and in a spiraling state.

C. Online exercise

Strong practicality is an important feature of Data Structure courses and cannot be ignored either during online teaching. We use online judge platform to train students' practicality. After each class, teachers will release test or exercise problems (algorithm and program design) on OpenJudge online judge platform. The platform will test the algorithm programs submitted by the students and then give the results and scores. The platform will give the list of the class students' answers which can also stimulate the students' competition and promote their learning. We introduce the topics of ACM and mathematical modeling competition to enable students with ability to learn more and go further.

III. Design of Problems

A. Problems for autonomous learning

Problems for autonomous learning are used to guide students to study independently. These problems are guiding ones because the main purpose of this phase is to understand and master knowledges. For example, when they studying linear table, problems are raised firstly at the first level of knowledge points, linear table, such as *what kind of logical relationship between data elements in a linear table? Please describe the logical structure of linear table? Give three examples that can be described in a linear table in life, etc.* Then problems are raised at the second level of the knowledge point while studying sequence table. For example, problems like: *write the storage structure of the sequence table in C language? Explain the advantages and disadvantages of the sequence table? When would you choose to use a sequential table?* At last, problems are raised at the third level of knowledge points when they studying linked list. For example, problems like: *to implement an algorithm of insertion a node after a given one and analyze its time complexity? Implementation an algorithm of inserting a node before a given one and analyze its time complexity? How to improve the insert-after algorithm to reduce the complexity from O (n) to O (1), and write the corresponding algorithm.*

The problems of autonomous learning form a task list for students to study independently. It guides students to study teaching resources given by teachers. By answering questions and completing tasks, students understand and master course content step by step.

B. Problems of applications

The goal of application problems is to deepen students' understanding of what they are studying and learn to apply them to solve practical issues. For example, when studying circular linked-list, we will start with the story of Joseph, a Jewish scientist, and present the question of Joseph's ring: From among n people, numbered 1, 2, . . ., n, standing in circle every mth is going to be executed and only the life of the last remaining person will be saved. Joseph was smart enough to choose the position of the last remaining person, thus saving his life to give us the message about the incident. The problems is that *what the initial number of Jewish.*

To solve this problem, students will naturally consider using circular linked-list. Then *what kind of storage method will be used, static linked list or dynamic linked list?* Students will have two different choices, and we each of them will be discussed separately.

If you choose static linked list, how do you mark the person who left? How to define the data structure? How to implement the algorithm?

If you use dynamic linked list, how do you record the initial sequence number? What to do with the exited person? How to implement the algorithm?

In this way, the process of analyzing and solving problems is essentially the process of students' understanding and application of knowledge. Through this application scenario, students understand further the logical structure of linear tables, the logical structure of circular tables, and can use different storage structures for one logical structure, and the implementation of specific algorithms depends on the storage structure. students learned to define their own data elements and data structures according to the needs of specific problems.

C. *Problems of online exercises*

Problems of online exercises used to cultivate students' practicality including ability of programming and algorithm design. These problems Can be divided into two categories: basic ones and extensive ones. Basic problems are set according to knowledge points. Extensive problems are topics from ACM, programing competition and mathematical modeling competition for capable students. After programing, summitting on online judge platform, student can get running result quickly. Through online judge platform, students can compete with their classmates and stimulate their studying enthusiasm.

IV. CONCLUSION

Since the COVID-19 outbreak, the practice of teachers and students has proved the feasibility of online teaching and has realized "no suspend teaching, no suspend learning". So far, we have completed teaching the first three chapters. The questionnaire survey shows that students are very welcome to this teaching model and average scores of three unit tests even exceed those of traditional teaching in the past.

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