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SPOC-Based Exploration of Teaching Model in Data Structure and Algorithm Course

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ABSTRACT

The traditional teaching model for data structure and algorithm course has exposed a lot of problems and needs to be innovated. In this paper, given the desirable advantages of small private online course (SPOC), we dedicate to integrate SPOC into data structure and algorithm course teaching so as to develop a SPOC-based online and offline combined teaching model. For this, we will firstly analyze the problems of conventional teaching model. Then, the specific method will be designed to enable SPOC-based teaching model, and thereby easing the problems. Finally, an online teaching platform will be introduced to support the explored SPOC-based teaching model. It can be expected that the teaching effectiveness of data structure and algorithm course can be significantly improved by adopting the proposed SPOC-based teaching model.

Keywords: *data structure and algorithm course, SPOC, teaching model, online platform*

I. INTRODUCTION

Nowadays, with the rapid development of computer and communication technologies, online education has been attracted extensive attentions[1], [2]. On the basis of online education, people can easily access massive resources for autonomous learning, furthermore, various learning community can be flexibly established for exchanges and discussions among autonomous learners[3], [4]. Under this background, colleges and universities, which undertake a large number of diverse courses, show a great interest in carrying out various forms of online education[5]. Among which, massive open online course (MOOC) is a popular mode used in early stage[6], [7], [8]. However, there exists some problems that hinder to integrate MOOC into curriculum of higher education[9], [10]. The first problem is that the contents of MOOC are generally lack of specificity given that MOOC is designed for wide audience rather than a particular group. Secondly, it is hard to control the teaching process for teachers since that MOOC mainly depend on the autonomous learning of students. Finally, it is difficult to evaluate teaching effect due to that a few of online assessment methods are provided in MOOC. These problems indicate that online courses can not completely replace traditional classroom teaching in colleges and universities.

Small private online course (SPOC), as a hybrid online and offline teaching model, is viewing as a desirable candidate to overcome the shortcomings of MOOC in reforming teaching mode in colleges and universities [11], [12], [13]. Comparing with MOOC, SPOC can focus on one major or one grade in a/an college/university, and then design specific study resources and methods that used for controlling teaching process and evaluating teaching effect based on characteristics of students. In practice, Harvard University has carried out SPOC for three courses in 2013, and Tsinghua University in China also designed SPOC for cloud computing and software engineering course in the same year. Therefore, to develop SPOC for different curriculums of higher education on the basis of characteristics of courses and learners, will become a hot teaching research direction.

Data structure and algorithm course is an important and professional foundation lesson of IT-related major in colleges and universities[14]. The objective of the course is to enable students to understand the logical structures of problems, and then solve the problems by choosing appropriate storage structures and designing effective algorithms. Nevertheless, it is hard to achieve such objective in practical teaching. Fortunately, based on SPOC, the difficulties in teaching data structure and algorithm course can be eased through integrating online teaching with conventional classroom teaching, and then the teaching objective is expected to be achieved. Thus, in this paper, we will explore SPOC-based teaching model for data structure and algorithm course, so as to improve the teaching effectiveness.

The rest of the paper is organized as follows. In section II, the major difficulties in traditional classroom teaching for data structure and algorithm course are analyzed, which is followed by the specific method for

enabling SPOC-based teaching model. Section III introduces an online teaching platform which can efficiently support the proposed SPOC-based teaching model. The conclusion of the paper is presented in section IV.

II. METHODS FOR IMPLEMENTING SPOC-BASED TEACHING MODEL

In this section, we firstly analyze the major difficulties in traditional classroom teaching of data structure and algorithm course, and then propose a method to enable SPOC-based teaching model so as to alleviate the difficulties.

A. Major difficulties in conventional classroom teaching

In colleges and universities, it is hard to achieve desirable results if only classroom teaching is adopted for data structure and algorithm course. The reason is that there are some difficulties while carrying out traditional classroom teaching.

- Given the strong theoretical of data structure and algorithm course, it is difficult for students to understand the key knowledge points of the course in the short term. Data structure and algorithm course contains many abstract concepts (e.g., abstract data type, logical structure and storage structure, etc.), pseudo-code-based algorithm description, analysis of time and space complexities, such knowledge can not be easily understood and grasped only through classroom teaching with limited teaching time.
- It is difficult to apply the studied theoretical knowledge into practical problems. For the data structure and algorithm course, the ultimate objective is to enable students can design algorithm to solve various practical problems by using the studied theoretical knowledge. Although correlative experimental course is generally offered, but the real effect is not satisfactory due to limited experiment class and guidance.
- The variant preliminary knowledge levels of students are another difficulty in classroom teaching of data structure and algorithm course. In most colleges and universities, before offering data structure and algorithm course, some other courses, such as introduce to computer course and programming language course, are usually carried out as forerunners, which inevitably results in a knowledge gap among students at the beginning of the course. Under such circumstance, it is hard to successfully complete teaching tasks of data structure and algorithm course by following classroom teaching.
- The insufficiency of communication between teachers and students also brings difficulty in classroom teaching of data structure and algorithm course. In real classroom teaching, due to limited class hour and a large number of students, teachers can not discuss with students about their specific study, furthermore, students have little chance to directly talk with teachers. Then, teachers can not regulate teaching content, adjust teaching process and improve teaching approach in time, thus it is conceivable that classroom teaching effect will be discounted.
- The monotony and hysteresis of course assessment will result in difficulty on effective evaluation and timely improvement of data structure and algorithm course. In traditional teaching model, the assessment of the course generally uses paper examination, such single writing examination is hard to reflect the achievements of students, furthermore, the examination is usually conducted at the end of the course, which leads to that the feedback of the assessment can not be used to improve the current teaching.

In view of the above difficulties, we then explore SPOC-based teaching model for data structure and algorithm course to effectively improve the teaching effect of the course.

B. The method to enable SPOC-based teaching model

Although conventional classroom teaching model has many deficiencies, it still can not be completely replaced. Thus, our considered SPOC-based teaching model dedicates to sufficiently take the advantages of both online teaching and offline teaching. The specific method to realize such model for data structure and algorithm course will be introduced from the following respects.

1) The organization and arrangement of teaching content: There are many knowledge points in data structure and algorithm course, some of them are adapted to be learned in class, while another of them are suitable for online teaching. Thus, it is important to classify the teaching content while enabling SPOC-based teaching model. To be specific, the basic category rules envisioned in this paper are: (a) the illustration of concept and terminology, the design and analysis of algorithms are arranged in the traditional class; (b) the description of specific examples and the completion of some exercises are taken via online teaching; (c) the above division is not absolute, it can be adjusted according to real-time feedback. On the

basis of the envisioned criterias and the main teaching content, we then give an overview of the organization and arrangement of teaching content of data structure and algorithm course in "Table I". It is worth noting that the classification listed in "Table I" can be appropriately adjusted in the actual teaching process.

TABLE I. ORGNIZATION AND ARRANGEMENT OF TEACHING CONTENT

Teaching content	**Teaching model**	
	Classroom teaching	***Online teaching***
Preliminary knowledge	✧ Concepts of data structure, abstract data type and algorithm. ✧ Analysis of time and space complexities of algorithms.	✧ Examples for analyzing time and space complexities of algorithms. ✧ Practices about using pseudo language to describe algorithms.
Linear data structure	✧ Concepts and storage structures of list, stack and queue. ✧ Realizations and analysis of the basic operations of list, stack and queue.	✧ Application examples of list, stack and queue. ✧ Practices about using linear data structure to model and solve some engineering problems.
Non-linear data structure	✧ Concepts, properties and storage structures of tree, forest and graph. ✧ Illustration and analysis of the traversal of non-linear data structure, and some classical algorithms which are based on non-linear data structure.	✧ Application examples of tree and graph. ✧ Practices about using non-linear data structure to model and solve some engineering problems.
Searching and sorting	✧ Concepts and storage structures of search table. ✧ Illustration and analysis of static searching, dynamic searching, hash searching, insert sorting, exchange sorting, select sorting, merge sorting and radix sorting.	✧ Application examples of searching and sorting. ✧ Practices about using searching and sorting to solve some systemic problems.

2) The active expansion of teaching practice: For data structure and algorithm course, it is very important to integrate theory knowledge into practice, which is hard to be realized through traditional classroom teaching. With the integration of online teaching, the teaching practice can be largely expanded. In this paper, on the basis of online teaching, we would like to introduce the concept of CDIO to realize "Learning-by-Doing" [15,16]. CDIO, in which C, D, I, O, respectively means conceive, design, implementation and operate, dedicates to let students learn professional knowledge via doing engineering projects. In view of this, the first thing is to design targeted projects, then to abstract mathematic models of the problems that incurred in implementing the projects so as to reduce to specific data structures. The designed projects and their illustrations can be posted to online platform, so students can conveniently complete the projects. Meanwhile, teachers can monitor students' progress and then provide guidance accordingly. It can be foreseen that such SPOC-based teaching practice can significantly enhance teaching effectiveness of data structure and algorithm course.

3) The innovation of teaching approach: Under traditional classroom teaching, teachers generally dominate the whole teaching process, and students are passive in the acceptance of knowledge, which will result in inefficient teaching. Based on SPOC, teaching approach can be innovated to improve the learning autonomy of students, i.e., to guide students to actively study online and thus to adjust classroom teaching content.

4) The reestablishment of curriculum assessment approach: Traditional assessment approach for data structure and algorithm course is monotonic and lagging. Against SPOC background, phased and diversified course assessment approach should be established. In this paper, we would like to propose a three-stage assessment approach. The first phase evaluation will be taken at the beginning of the course, and the purpose is to know students' study foundation. The second phase exam will be irregularly taken during the process of the course and the forms can be varied. The third phase assessment will be taken at the end of the course, certainly, the specific form is not limited to traditional paper-based exam.

III. ONLINE TEACHING PLATFORM

The above description and illustration indicate advantages and methods of enabling SPOC-based teaching model for data structure and algorithm course. Among which, the construction of online teaching platform plays an important role. Thus, in this section, we will give a brief introduction of our designed SPOC-based online teaching platform.

For the designed platform, the users can be classified into two kinds, i.e., teachers and students.

Each kind of users have well-defined functions which are listed as follows:

- Teachers: register and then log into the platform; upload learning materials; publish learning tasks; download files submitted by students; communicate online with students.
- Students: register and then log into the platform; collect and download learning materials; test online; upload homework; communicate online with teachers.

Fig. 1. Function demonstration of teachers.

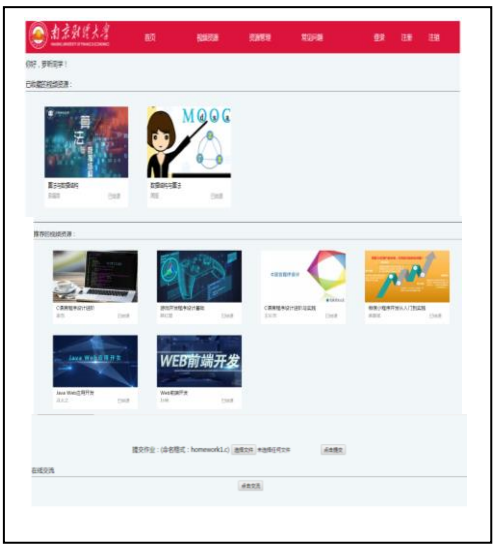

Fig. 2. Function demonstration of students.

Based on the above classification, we then show the main functioning interfaces of the platform. For teachers, after logging into the system, their managed classes will be firstly presented as shown in "Fig. 1", then the teacher can select a particular class for management, and the specific function buttons are also displayed in "Fig. 1". For students, after logging into the platform, then can find the learning materials recommended by their teachers and then save or download such resources, the other specific functions which listed before are also presented in "Fig. 2".

IV. CONCLUSION

In this paper, we explored SPOC-based teaching model for data structure and algorithm course. The difficulties incurred in traditional classroom teaching of data structure and algorithm course was firstly analyzed, which provides guidance on designing method for enabling SPOC-based teaching model. Then, the specific SPOC implementation method was designed from aspects of teaching content, teaching practice, teaching and assessment approaches. Finally, an online teaching platform for supporting SPOC-based data structure and algorithm course teaching was introduced. In the future, an important study issue is to evaluate the explored SPOC-based teaching model, which will be conducted in our future practical teaching for data structure and algorithm course.

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