ISSN: 2664-9640

Exploration on the Reform of Data Structure and Algorithm Course in the Emerging Engineering Education

Erli Wang [1, a], Qi Zhang [2], Xingjian Liang[1], Wenzhong Zhu[1], Yani Hou[1]

[1] School of Computer Science and Engineering, Sichuan University of Science and Engineering, China

[2] School of Fine Arts, Sichuan University of Science and Engineering, Zigong 643000, China

[a]welsuse@163.com

Abstract

The data structure and algorithms course is one of the core and compulsory units for the major of Internet of Things (IoT). Combining with practical teaching experience, surveys and questionnaires regarding this course were conveyed to a large quantity of students. It indicates that there are quite a few problems in the process of teaching, such as inadequate foundation knowledge from the prerequisite courses, lack of interest and self-discipline from students, outdated teaching methods and techniques, as well as the monotonous mode of assessments. To cultivate more new talents to meet the standard of Emerging Engineering Education, this paper introduces the concept of "flipped classroom" teaching method to the theory teaching of this course. The new teaching experiment will be driven by competitions to stimulate students' interest. It will also encourage students to conduct scientific researches in order to exercise learning practicality at different levels of the study. Furthermore, a comprehensive evaluation system will be established in order to evaluate students' overall ability and understanding of the course during the learning process. All of these methods can be used as reference for the follow-up reform of the course.

Keywords

Emerging Engineering Education; Data Structure and Algorithm; Teaching Reform; IoT.

1. Introduction

In order to proactively respond to the challenges of the new scientific and technological revolution, the Ministry of Education of China issued a notice on launching Emerging Engineering Education(3E) research and practice in 2017 to promote the reform and innovation of engineering education. The 3E is characterized by innovation and iteration, and pays attention to the reform of the discipline system and evaluation. Moreover, strengthening the cultivation of training talents related to big data and Internet of Things (IoT) is clearly proposed [1]. As a multi-disciplinary specialty, IoT is inseparable from artificial intelligence technology. Cultivating talents who adapt to social development has become one of the important goals of the major of IoT in universities. However, the training goals of professional talents in college are far from the needs of industrial talents [2]. Most students are not strong in practice, and their innovative thinking and abilities need to be further improved. The data structure and algorithm course, which is an important basis for learning other courses, has always been the core course of computer majors [3]. As a key development of cross industry under the background of 3E, IoT puts forward higher requirements on the quality of talents than the traditional computer industry [4]. How to reform the data structure and algorithm course and deal with the new challenges of talent training under the new situation is particularly urgent. The research takes the data structure and algorithm course of the IoT major

of Sichuan University of Science and Engineering as an example to explore the problems in the teaching process. Furthermore, the methods expected to solve the problems are also proposed to lay a good foundation for the reform of this course.

2. Analysis of the current situation of data structure and algorithm teaching

The data structure and algorithm course is the basis for leaning embedded development, mobile development and other core courses of IoT. It has high requirements for logical thinking ability and programming foundation. Students generally feel that the course is difficult to learning, and they also reflect that the knowledge has not been absorbed. In order to further investigate the reasons, an anonymous questionnaire survey was conducted on 98 students in the sophomore classes 1-3 of the major of IoT, and the effective recovery rate reached 82%. Combining with practical teaching experience and the survey, the teaching problems of this course include three aspects as follows:

2.1. Inadequate foundation knowledge and lack of self-discipline in the students

With the expansion of college enrollment, the quality of students has undergone significant changes [5]. Discrete mathematics is the theoretical basis for learning data structure [6], however, the failure rate of discrete mathematics exams is around 30% in the past three years, which means that quite a part of students may need to spend more time and energy in learning abstract concepts and problems in the course of data structure and algorithm. Furthermore, the course requires students to master a programming language to learn the algorithm. However, in the teaching process, the teacher found that students' programming ability was weak, and some students could not solve the basic problems of compiling in practice.

In the questionnaire survey, students reported that they encountered many difficulties in their learning courses. 62.5% of students did not know where to start their studies, and 41.25% of students did not know how to solve problems when they encountered problems. What is more, 31.25% of students directly expressed the lack of relevant professional knowledge, and 27.5% of students were afraid of debugging programs. All the above prove that quite a part of the students has a weak foundation and their logical thinking has not been well cultivated. The survey also found that a relatively large proportion (42.5%) of students believed that they could understand the knowledge in class but forget it after class. But when investigating the extracurricular time spent on the course each week (as shown in Figure 1), nearly 60% of the students had less than 5 hours of extracurricular study time per week. It can reflect that some students have poor learning self-discipline, despite of knowing that their professional foundation is inadequate, and they still do not spend time and energy to review the knowledge. This is also one of the main reasons why many students generally think that the course is difficult and cannot keep up with the progress of learning.

2.2. Outdated teaching methods and techniques

2.2.1. Problems in theoretical class

The class hours of the course are set to 64 class hours, including 48 class hours of theoretical teaching and 16 class hours of experimental teaching. At present, theoretical teaching is mainly based on traditional classroom teaching. In the survey of theoretical teaching, some students believed that the lecture progress was fast and the course was not interesting. Due to the limitation of theoretical class hours, the teacher can usually only introduce the basic operations and methods of several commonly logical structures, and has to spend a certain amount of time to repeat the knowledge of pre-course. Thus, it results that the teacher is eager to introduce the

ISSN: 2664-9640

content of the course to catch up with the teaching progress, while the students passively accept knowledge.

In the survey of teaching resources (as shown in Figure 2), although most students believed that the existing curriculum resources could highlight the important and difficult points of the curriculum, there were still 32.5% of students who said that the curriculum resources were adequate and had no characteristics, and 5% of students felt that the existing teaching resources were unabundant and unattractive. For the post-95 students who grew up in the era of the rise of new media, only using textbooks and PPT with boring texts as teaching resources seems to be lack of new ideas. In addition, PPT-based classroom teaching cannot take into account the "fatigue time" and the speed of understanding the problem of each student. The teachers may only care about introducing the knowledge to the students and ignore the interaction and communication with students. The classroom atmosphere is not active enough, and it results that students are not interested in learning.

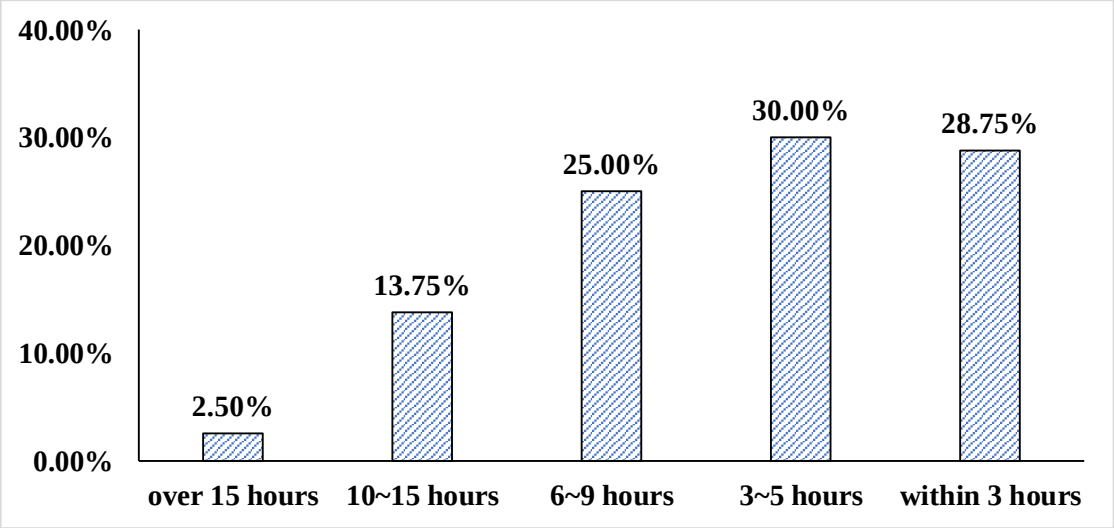

Figure1 The extracurricular time spent on data dtructure and algorithm course each week

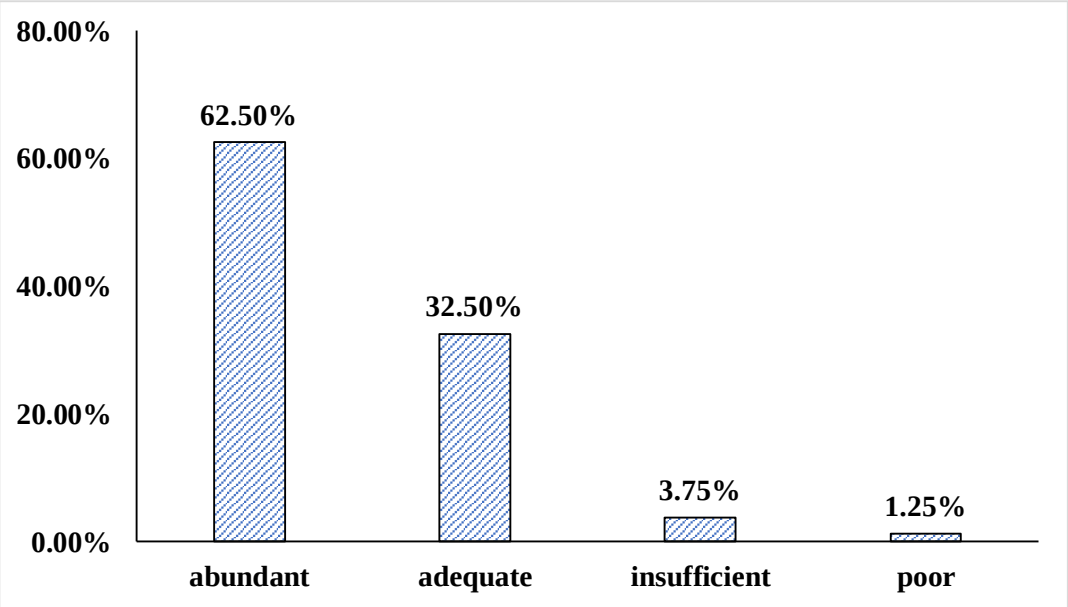

Figure2 The survey of teaching resources

ISSN: 2664-9640

2.2.2. Problems in experimental class

Experimental teaching focuses on cultivating practical abilities, enabling students to analyze the logical structure of data, and design efficient and flexible storage structures and algorithms[7]. In each experimental class, the teacher will give descriptions of the problem, the design of data structure, the analysis of the algorithm and the reference code to the students. While the reference code is not finished yet, it requires the students to analyze and fill in the blanks by themselves. The experiment is relatively simple, but some students still think that the content is hard to complete in the expermental class, and more students feel that the experiment lacks necessary guidance. As shown in Figure 3, in the experimental class, the problems of students unable to understand the content and reference code accounted for nearly 50%, and the problems of failing to master the basic code debugging accounted for about 94%. Many students just typed the given codes into the computer, and spent a lot of time in debugging grammatical errors showing in the compilation process. Therefore, the teacher had to guide the part of students who are unable to solve basic problems and could not handle the different practial problems encountered by all students. Furthermore, it is expected that the experiment coure should be designed by layer to cultivate students at different levels, and the preparations in basic and top-notch experiments are inadequate.

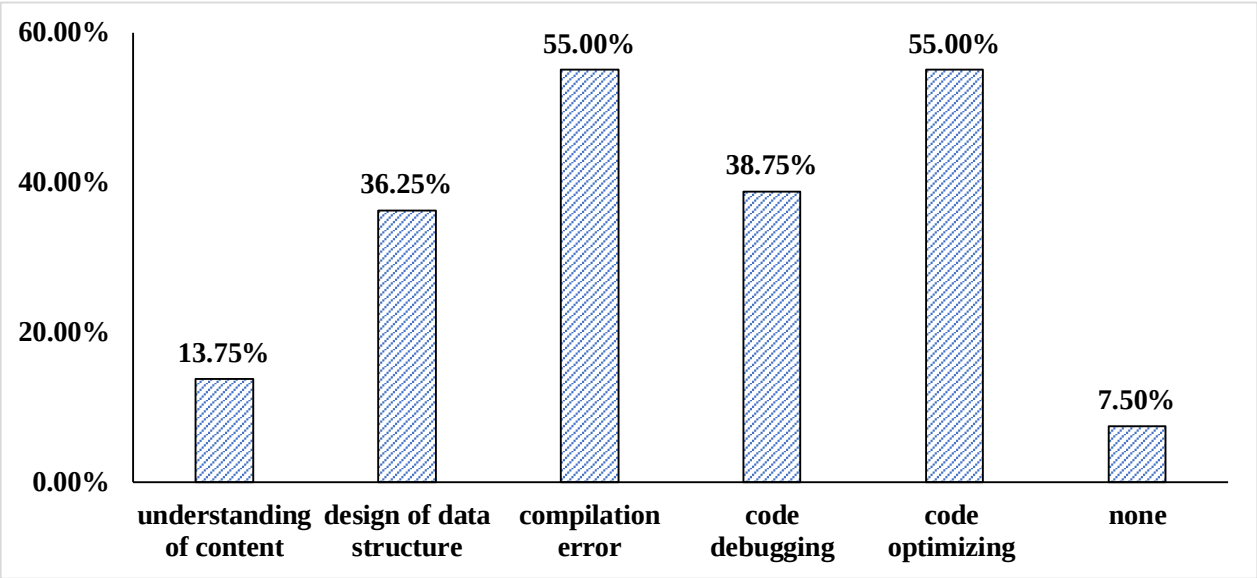

Figure 3 The problems encountered in experimental class

2.3. Monotonous mode of assessments

The current course assessment consists of final closed-book exam (60%), attendance (10%), homework (10%), experiment (10%), and mid-term exam (10%). It is generally believed that once the final exam account for a large proportion, it is easy to cause students to pay few attentions to learning in the class. In the survey on the factors affecting the grade, the proportion of students think that they don't study hard during the regular course as the main reason accounted for 60%, and 58.75% of students thought that their learning methods were improper. What is more, 42.5% of students said that they had not reviewed carefully before the exam, and some students thought they were lack of practical opportunities and interest in learning. It can be seen that in the cognition of students, the daily study has a greater impact on the grade. However, the current assessment of the course focuses more on the results and lacks effective evaluation of the learning process.

In the current assessment method, attendance score is mainly given by the method of roll call in class. The homework score is composed of two parts: in-class test homework and off-class homework. Additionally, it may take quite a few minutes to call names of all student in the class and the homework plagiarism is widespread. In the experimental class, evaluation is based on student performance and reports. However, the teacher has to face all the students in the class, and the evaluation of student experimental performance score cannot be implemented in a limited time. Students with strong hands-on ability not only completed the experiment quickly, but also can easily answered new questions raised by the teacher. While for some students with weak foundations, the teacher may always be needed to guide them, which makes it impossible for the teacher to evaluate the performance of other students. The experimental report has become a handwritten text for the assessment, and there are even students who completely copy other students' reports and summaries.

In this case, how to improve teaching methods and propose a reasonable evaluation mechanism to cultivate high-quality IoT talents who can adapt to the development of the times are very worthy of research.

3. Exploration of teaching reform of data structure and algorithm course

It is pointed out that one of the key tasks in the construction of Emerging Engineering Education is learning and teaching, and it is proposed to reconstruct the knowledge system of talents and to innovate teaching methods and technologies [1]. This paper takes the teaching reform of data structure and algorithm course as the starting point, actively responding to the requirements of Emerging Engineering Education for talents training. The following suggestions are put forward mainly from the theory, practical teaching and assessment methods in order to provide references for the curriculum reform.

3.1. Introducing mixed classroom teaching and riching the existing teaching resources

The traditional teaching model can no longer adapt to the rapid development of modern society. The survey results showed that when the students encountered problems in the learning process, they were more inclined to ask for help online and consulted other students, while only 17.5% of them consulted teachers to solve problems. It indicates that the students have a certain ability to solve problems and the dependence on teachers is not high. Teachers only need to play their own guiding role and rationally design the teaching process to transform a duck-filling classroom into a guiding classroom. In the concept of flipped classroom teaching, teachers turn from managers to instructors and organizers, and students grow from passive receivers to active learners [8-9]. In addition, the implementation of teaching models such as flipped classrooms and MOOCs is inseparable from a networked environment and digital education platform [10]. It is necessary to make full use of the diversity of Internet media to rich the existing teaching resources. The specific implementation measures are as follows:

3.1.1. Preparation before class

The teacher can make various forms of online resources, such as micro videos, and divide the knowledge points into blocks. It is recommended to use animations and videos to demonstrate the operation of the algorithm to create a vivid teaching atmosphere. The task time of platforms such as Chaoxing can be used to urge students to watch videos to complete the discussions and assignments before class. For the general and repetitive knowledge of pre-courses, students need to review it outside the class, thus the teacher can concentrate on the new knowledge in the classroom. Additionally, a student-centered learning interaction model can be constructed by adjusting the time in and out of the classroom.

3.1.2. Discussion in class

According to the discussion and completion of homework, the teacher design teaching activities, and answer common questions in the preview process or explain the abstract knowledge in the classroom. In addition, materials such as projects or cases can be added to teaching design. Examples close to life not only increase classroom interaction between teachers and students, but also stimulate students' interest in learning. Taking the design and implementation of parking lot management system as an example, IoT hardware devices can be used to show the process of car entering and exiting by swiping the card. Therefore, the students will have a better understanding of the application of professional knowledge.

3.1.3. Summary and review after class

The teacher summarizes the important and difficult points in the teaching process to form videos and document materials, then arranges the homework after class and publishes it to the network platform. While the students use the abundant teaching resources to review, and further strengthen the connection of knowledge systems.

3.2. Competitions and scientific researches to cultivate talents at different levels

Practice is a bridge between applying theoretical knowledge to solve practical problems and it also an important criterion for testing the quality of theoretical teaching. Therefore, it is necessary to fully consider the differences between individual students and train them at different levels in experimental class.

For students with weak foundation, they are guided by the reference book to understand the code and the basic process of the algorithm. While the students with better ability can be selected as experimental team leaders, who are responsible for helping the others to solve the compilation errors, and the teacher only need to answer the common questions of the students. It can enhance communication between students and achieve a truly student-centered experimental teaching. Additionally, students who have demonstrated a good foundation in practice can participate in competitions and research projects to cultivate their ability to analyze and solve practical problems. First of all, the difficulty of subject competition topics is much greater than that of normal lectures and examinations. Many competitions (such as ACM, etc.) require high quality of students' psychological thinking and team spirit. The teacher can choose some topics for students to think and practice after class, and use the ACM/ICPC online evaluation platform to solve the problems in groups. Secondly, scientific research projects can be applied to test students' innovative ability to discover, analyze, and solve problems. The teacher can select relevant research sub-projects in scientific research projects whose difficulty matches students' abilities, so as to exercise students' literature retrieval and independent thinking ability, and initially cultivate the basic qualities of conducting scientific research.

3.3. Build a comprehensive evaluation system to pay attention to the learning process

The assessment should focus on the evaluation of students' participation and completion in the learning process, instead of judging the result of learning based on final grades. It can increase the proportion of regular grades (attendance grade 10%, homework grade 20%, experiment grade 20% and midterm grade 10%), and reduce the proportion of final exam grade (40%). During the evaluation process of the experiment, the students take the initiative to participate in the evaluation, and the final experimental evaluation contitutes of three parts: student self-evaluation (30%), group member evaluation (30%) and teacher evaluation (40%), which can highlight the cooperation, mutual assistance and communication skills. For students participating in competition training and research projects, additional points will be awarded based on their performance. Combining the performance of students in and out of class, a

reasonable reward and punishment mechanism for adding or subtracting scores can be established. What's more, a computer-based test model combining theory with practice should be explored in the future.

4. Summary

Combining with practical teaching experience, surveys and questionnaires regarding the data structure and algorithm course were conveyed to the IoT students, and the result shows that teaching process problems are mainly concentrated in the followings: Students' abstract problem-solving thinking has not been well-trained, and the lack of prior knowledge and self-discipline have caused certain difficulties in learning this course; The existing teaching methods and techniques are outdated and individual differences is not well considered in the teaching process; The course assessment method is monotonous, and there is no effective evaluation of the learning process.

In response to the above problems, it is proposed to introduce mixed classroom teaching, wherein teachers can play their own guiding role and rationally design the teaching process. Teaching resources should be riched to enhance the interactive communication with students. In addition, students with weak foundations can be guided by course experiments, and those with better ability are driven by subject competitions and scientific research projects to cultivate students' practical ability at different levels. Furthurmore, a reasonable comprehensive evaluation system should be established to evaluate students' overall ability and understanding of the course. The paper provides references for the follow-up reform and the training of talents in applied-undergraduate collegue under the background of Emerging Engineering Education.

Acknowledgements

This paper was supported by the Teaching Reform Project of Sichuan University of Science and Engineering(JG-19-43, JG-19-44, JG19-72). Thanks are extended to all the people who give helpful comments.

References

[1] Denghua Zhong. Connotations and Actions for Establishing the Emerging Engineering Education[J]. Research in Higher Education of Engineering, Vol. 03(2017), p. 7-12.
[2] Chengning Huang, Shuangmei Li, Cheng Li. Exploration and Practice of Software Talents Training Mode Under the Background of Integration of Industry and Education[J]. Software Guide, Vol. 19(2020), No.04, p. 281-284.
[3] Bingtao Zhang, Xiaopeng Wang, Lvcheng Wang, et al. Research on the Teaching of Data Structure and Algorithm Based on Engineering Certification [J]. Software Guide, Vol. 18(2019), No.01, p. 201-204.
[4] Juan Li. Data Structure Course Construction Oriented to the Applied Talents Training[J]. Software Guide, Vol. 19(2020), No.02, p. 168-171.
[5] Jin Qiu, Ping Wang. Data Structure Based on Project-Oriented Teaching Research[J]. Journal of Southwest China Normal University (Natural Science Edition), Vol.44(2018), No.9, p. 167-172.
[6] Jiangjiang Wu, Chun Du, Hao Chen, et al. Discussion on the Teaching Method Of Discrete Mathematics in the Era of Artificial Intelligence[J]. Education Modernization, Vol.5(2018), No.52, p. 154-155+179.
[7] Xiong Yang. Practical Teaching Reform of Algorithm and Data Structure Course Based on Cloud Computing[J]. China Education of Light Industry, Vol.5(2019), p. 46-51.
[8] Liping Sun, Jing Cheng, Yonglong Luo. Application of flipped classroom in data structure teaching [J]. Computer Education, Vol.24 (2015), p. 71-74+77.
[9] Jie Fang. Research on Flipped Classroom Teaching Mode of Algorithm Design and Analysis[J]. Software Guide, Vol.15(2016), No.09, p.199-201.

[10] Tao Zhou, Hongyu Xie, Muzhuang Yang, et al. Microlecture Design of GIS Data Structure Course Based on FlippedClassroom Perspective[J]. Geospatial Information, Vol.16(2018), No.10, p. 11+59-62.