Study of “data structure and algorithm design” teaching reform based on CDIO model

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ABSTRACT

CDIO is a new and innovative engineering education model. This model emphasizes that engineering education should focus on practice and training high-level engineers as a goal. “Data structure and algorithm design” is an important theory and technology course for computer-related professionals. However, traditional teaching only focuses on the theory, and the scores are just determined by the final examination papers. In this mode, students have no interest and can not apply their knowledge to solve practical problems, thus the teaching effectiveness is very poor. This paper applies the CDIO concept to “Data structure and algorithm design”, and then shows the innovative achievements. In this paper, teaching reform based on CDIO approach is performed from three aspects: firstly, reform the course syllabus of “Data structure and algorithm design”, increase the proportion of practice from 20% to 30%, in order to strengthen the students’ practical ability. Secondly, reform the curriculum contents. Join some projects to the process of teaching, and introduce this combining idea to both the teaching process and practice process. For instance, the chapter “tree” is a key section of this course, here we design a project of “association rules mining in telecommunication networks” to practice how to build a tree structure and use this structure to resolve everyday life problems. This idea of reform can not only help the students consolidate knowledge learning, but also can train the students’ hands-on innovation and practice ability. Thirdly, reform the assessment methods. In this paper, the AHP situation assessment is proposed to calculate scores scientifically. In the AHP model, student's initiative, innovation and other factors such as final exam scores should be considered as assessment criteria of analytic hierarchy process established. With the AHP model, scientific and reasonable scores can finally be given. Teaching experiments prove that the method of combining teaching and project, using AHP model to test results can effectively mobilize the enthusiasm of students, finally achieve good effectiveness of teaching.

KEYWORDS

CDIO; Data structure and algorithm design; Course syllabus reform; Project practice; AHP

1. INTRODUCTION

CDIO is a new concept and engineering education implementation system, which is jointly developed by the MIT, the Massachusetts Institute of Technology in Sweden, Linkoping University and the Royal Institute of technology etc. CDIO is abbreviated by four words “Conceive, Design, Implement and Operate”, which summarize the whole process of engineering education. “Conceive” includes the analysis of customer’s needs, the develop idea for development of the whole project, and procedures of technical program and plan; “Design” mainly includes the project design, drawing design and project implementation plan

design; “Implement” means the process of how to transform the design scheme into products or achievements; “Operate” is mainly on that the design is evaluated through the implementation of products, including revisions, improvement and eliminates of system (**Berggren K (2003), Crawley E (2007), Mbanguta Z (2004), Crawley. & Edward (2011)**) In summary, CDIO engineering education model focus on how to train students to master the basic theory of engineering knowledge and professional knowledge, more important is how to train students’ ability in engineering practice. In this training model, students can cultivate team spirit and the ability of practice and innovation, for further to become an high-level engineer.

Our university is one of the key pilot CDIO Colleges in China from the year 2008. In recent years, we have a lot of achievements in the CDIO reform. “Data structure and algorithm design” is a core course which participates in the CDIO reform in my college. The characteristics of this course are abstract and high flexibility, and its basic course is an advanced programming language design, such as C language. As an important basic course for many courses like the operating system, software engineering, databases and algorithm design etc, “Data structure and algorithm design” plays a connecting role in the computer system. Thus the course is not only the basis for general programming, but also an important foundation to achieve large-scale applications in future. Through the study of this course, students can improve their programming skills and master the ability of algorithm design. However, in actual teaching process, many problems reflected in this course are that the teaching effect is not good and the algorithm design is very difficult for students to master well.

The reasons are mainly the following aspects. First, many students can’t master the previous year’s C language learning very well, especially about the three parts of C language: function, structure and pointer. These three parts are most difficult to master for the vast majority of students. However, they are the most widely used and very important in “data structure and algorithm design”, for both function and structure can be applied to most algorithms, and pointer can be used to improve the efficiency of algorithms. In actual study, many student feel data structure is very boring and difficult, even unable to start when they meet programming. Second, the number of conceptions involved in this course is very large, especially in the two chapters “tree” and “graph”. Many students have no interested in the theoretical knowledge learning. Third, theory and practice is not closely related. Although most concepts and theories students have mastered very well, they are not able to practice with their knowledge when they participate in the actual design and do the experiments, for they can’t link the experiments to the knowledge and feel no clue to the algorithm design. Fourth, the traditional experiment design is not vey reasonable. Many experiments are too stylized to mobilize the students’ thinking and initiative. Many students just take some ready-made programs to deal with the experimental examination, thus it is not the real purpose of experimental training. Fifth, the final evaluation method is not reasonable, previous method is too simple to fully take into account the differences in students’ practical ability. Finally lead to the fact that the scores can not reflect students’ real abilities.

Due to above problems involved in “data structure and algorithm design”, this paper proposes some novel reform methods. Reform is mainly in three aspects: the syllabus reform, the curriculum content reform and the assessment reform. Through the implementation of CDIO concept indoctrination and the reform measures, not only enable the students to better master this important subject, but also make them to become interested in data structure, programming ideas and programming concept. These reforms can improve students’ practice ability which lay a good foundation for engineering practice in the future.

The rest of this paper is shown as follows: part 2 introduces the Course syllabus reform, and then the curriculum content reform methods are proposed in part 3, part 4 provides a new method for assessment reform, and finally a conclusion is made in part 5.

2. COURSE SYLLABUS REFORM

CDIO mode has great emphasis on training students' practical ability. The original part of practice is only 20% in the course syllabus. Obviously, it is not enough to make students fully be trained in practice. Therefore, we must adjust the ratio of the practical teaching in the whole teaching. We first increase this ratio to 30%, and then to gradually increase the proportion of practice according to the teaching feedback. We also adjust the content in specific sections, for example, we take some actual practical examples instead of some pure theory teaching in the section of "tree". Meanwhile, students are mainly self-study for some conceptual theory. For teaching design, we increase the proportion of examples and interactive exercises in the classroom. The goal of these reforms is to improve the learning initiative of students, change from passive acceptance of knowledge to active learning.

3. CURRICULUM CONTENT REFORM

"Data structure and algorithm design" is highly abstract, thus theoretical knowledge teaching is not able to express data structure algorithms very clearly. Although some students feel they have mastered the conceptual knowledge well, they usually can't solve the practical problems. So the experimental aspect of this course is very important. Scientific experimental design and training can make student better understand the data structure algorithms, and increase students' practical ability and program design capabilities. To focus on training of practical talented person as a goal, this curriculum has increased the proportion of practice teaching, and introduced specific projects into experiments. In this mode, students can participate in some project development. During the process of practice, they can strengthen and consolidate the theoretical knowledge learning, and then initially form the team consciousness at the same time. Here we take the chapter "Tree" for example to illustrate the implementation process of project boot model.

"Tree" is a core chapter in "data structure and algorithm design"; meanwhile it is also the first non-linear data structure that students expose. Compared to a few chapters teaching before, program algorithm design of this chapter is more difficult and abstract, so the original teaching of this chapter often focus on teaching the theory of several traversal algorithms. Obviously, only teaching these algorithms is not enough. Although applications of tree data structure are the most extensive, students and teachers both feel it is very difficult to fully connect the theory with practice. How to orient students towards the learning is urgent. This paper provides a new method to resolve it. The reform method is to introduce projects in the teaching process. Taking a specific project as an example, we have a "big data mining" team with a project "data mining based alarm correlation analysis in telecommunication networks". This project is to find the correlation between alarms with data mining method, then to locate the root cause of the failure in the networks. During the use of data mining algorithm, a frequent pattern tree may be constructed with tree data structure (shown in figure 1), and then to find all the frequent patterns of alarms using the traversal methods, finally to generate association rules with these frequent patterns. During the whole process of this project, we can see that it is actually a tree structure applied process. Student can participate in the development of this project as a team and complete it together. After this project experience, students can not only master the skills to construct tree data structure and traversal theories,

but also exercise capacity to solve the real-life problems in the specific engineering practice. Through experiments we found that this “project introduced” mode can not only stimulate students’ interest in learning, but also train their team cooperation ability. In this way, a difficult chapter can be easily resolved by doing project. In the same way, we can design the experiment of “map” chapter with introducing “Network optimization” project, and the experiments of “linear table, list” with the project “Queuing theory to solve the problem of network packet optimization transfer”.

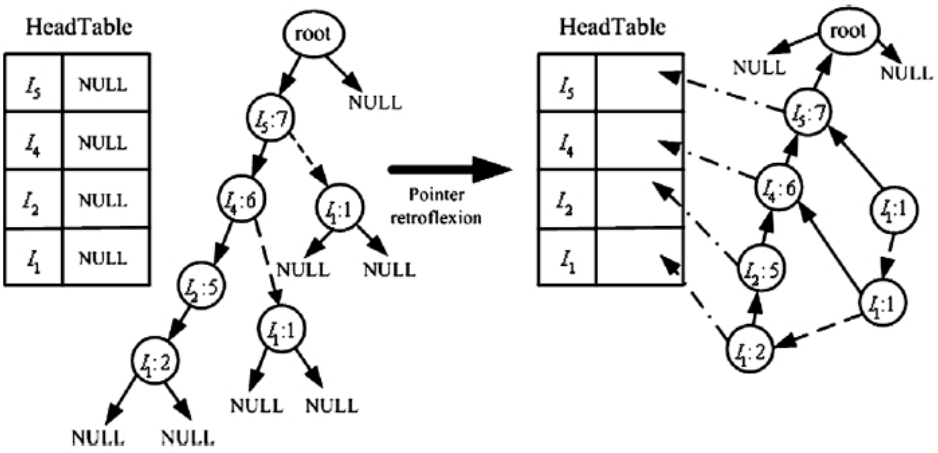

Figure1 frequent pattern tree constructed

4. ASSESSMENT METHOD REFORM

Assessment method is an important tool for assessing students’ learning and teachers’ teaching achievements. Rely solely on the score of the final exam is obviously unreasonable. This assessment method can not fully take into account the factors of students’ subjective initiative and creativity, and also easy to cause students to cope with the test and learning phenomenon. Since the factors which affect students’ achievements are manifold. It contains not only objective factors like the exam scores but also subjective factors like teacher’s mark. Therefore, this paper introduces a method of using AHP (analytic hierarchy process) model (**Saaty, T. L. (1980)**) to assess students’ achievements. AHP model can combine subjective factors with objective factors to reasonably evaluate learning performance. Specific evaluation factors are initiative of project participants, rationality and creativity of project design, experimental scores and final exam scores. We can see that these four factors are correlated. Using AHP method, the hierarchical model can be constructed according to the assessment of the relationship between these indicators. The model is shown in figure 2. From this figure we can see that, the comprehensive test results is at the highest level of this model, and it is affected by the factors of both subjective assessment and objective assessment. The last level is the main index including initiative, creativity, practical results and examination results in the assessment model.

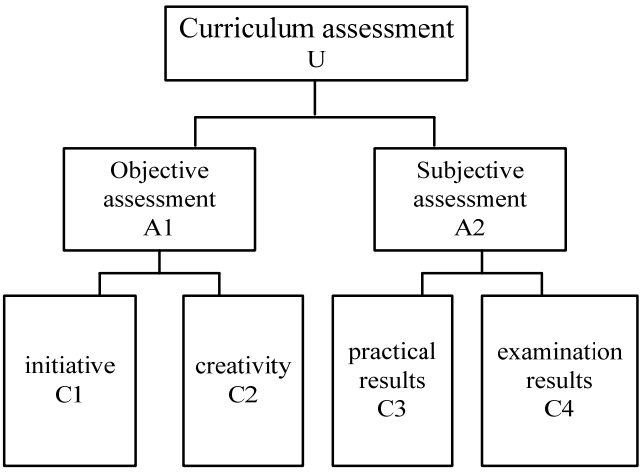

Figure 2 the AHP model

According to reference (**Jingxue R. (2006)**), get the following relative advantage matrix M from the pairwise comparison of elements on each layer of the AHP model.

$$M = \begin{bmatrix} M_{11} & M_{12} \ldots M_{1n} \\ M_{21} & M_{22} \ldots M_{2n} \\ \vdots & \vdots \ \ldots \ \vdots \\ M_{n1} & M_{n2} \ldots M_{nn} \end{bmatrix}$$

Where M_{ij} describes the relative advantage of the interval i compared to the interval j. according to the row sum of M, we get $R_i = \sum_{j=1}^{n} M_{ij}, i = 1, 2, \ldots, n$, take the following change:

$$R_{ij} = \frac{R_i - R_j}{2(\mathrm{n}-1)} + 0.5 \qquad (1)$$

From formula (1) we get the relative advantage matrix. Then rank the index according to the formula (2) as following:

$$W_i = \frac{1}{n(\mathrm{n}-1)} \left(\sum_{j=1}^{n} R_{ij} + \frac{n}{2} - 1 \right) \qquad (2)$$

Judgment matrix takes 0.1-0.9 scale structure (**Decai H & Lin X (2002)**). After using the interval number to represent the pair wise comparison of indicators, the interval judgment matrix of the second and third levels in AHP model can be taken by both the analysis of the whole course and teacher's experience. Taking "data structure and algorithm design" as an example, the construction of judgment matrix is shown in table 1 and table 2.

Table 1 judgment matrix on the second level

U	A1	A2
A1	[0.5 0.5]	[0.75 0.85]
A2	[0.15 0.25]	[0.5 0.5]

Table 2 judgment matrix on the third level

judgment matrix under objective assessment

A1	C1	C2	C3	C4
C1	[0.5 0.5]	[0.65 0.75]	[0.55 0.65]	[0.75 0.85]
C2	[0.25 035]	[0.5 0.5]	[0.55 0.65]	[0.55 0.75]
C3	[0.35 0.45]	[0.35 0.45]	[0.5 0.5]	[0.75 0.85]
C4	[0.15 0.25]	[0.25 0.45]	[0.15 0.25]	[0.5 0.5]

judgment matrix under subjective assessment

A1	C1	C2	C3	C4
C1	[0.5 0.5]	[0.75 0.85]	[0.75 0.95]	[0.85 0.95]
C2	[0.15 0.25]	[0.5 0.5]	[0.55 0.95]	[0.65 0.85]
C3	[0.05 0.25]	[0.05 0.45]	[0.5 0.5]	[0.75 0.85]
C4	[0.05 0.15]	[0.15 0.35]	[0.15 0.25]	[0.5 0.5]

Finally, according to a comprehensive assessment results, students' achievement will be made as a distributed map. If it meets the normal distribution, this is a successful assessment. If it not required, teacher must return to the model to modify the matrix until eventually meet the demand.

This AHP method can be used to determine the students' achievements scientifically. As we can see that it contains both subjective evaluation and objective evaluation. Therefore, this evaluation method can be widely applied to the assessment of any subjects, especially the occasions with more subjective assessment, such as the courses that have more experiments. This model can effectively avoid the subjective bias by human subjective evaluation. Matrix in this model can be fixed by the students' final scores, and it finally can guide the future assessments as an experience value.

5. CONCLUSION

This paper provides some CDIO based reform methods for the curriculum "data structure and algorithm design", which focuses on the curriculum content reform and the assessment method reform. With the method of introducing projects in the curriculum teaching, students and teachers' initiative can be fully stimulated. With AHP model, students' achievements can be reasonably reflected. Through the experiments in a pilot class for communication engineering students, it verifies that the methods proposed above are scientific and effective. In the future, these reform methods can be gradually extended to all classes and various majors.

6. ACKNOWLEDGEMENTS

This work is supported by the Project of Sichuan Provincial Department of Science and Technology, China (No. 2015JY0047, 2015z039), Fund Project of Sichuan Provincial Department of Education (No.13Z215) and the Foundation of Scientific Research of Chengdu University of Information Technology, China (No. J201405)

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BIOGRAPHICAL INFORMATION

Li Tongyan, Ph. D. is a lecturer in Department of computer communication in the university of information technology. She is now a member of the institute of communications in China. Her studies are mainly on the aspects of computer network, the communication and its management. In recent years, she mainly teaches “data structure and algorithm design” and participates the CDIO based reform of this curriculum. She has already completed two articles on topics related to curriculum design and the improvement of teaching and assessment.

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