THE IMPLEMENTATION OF THE CDIO INITIATIVE IN CUIT

Luqiao Zhang, Juan Wang, Fei Li and Lei Shi
Department of Network Engineering, Chengdu University of Information Technology, Chengdu, China

ABSTRACT

Due to the scale and complexity, the real world WEB applications, mainly websites, can only be developed by a team of engineers, who have different expertise. More specifically, team members must have the ability to create, tune and maintain the database by using Structured Query Language, the ability to retrieve data from database by using dynamic webpage programming, and the ability to create human friendly user interface by using Hyper Text Marking Language and Cascade Style Sheet. Above requirements must be considered for the bachelor program, Network Engineering, whose goal is to train qualified developer who can fulfill such WEB application development task.

In this study, we would like to present some highlights in our Network Engineering program, which adopts the spirits of the CDIO initiative. The details of our practice will be illustrated with emphasis on the implementation of integrated curriculum planning, active learning, learning assessment and program evaluation. Proved by both self-collected data and third party report, our effort is an effective method for the training of qualified engineers. Our work has been done in the Department of Network Engineering, Chengdu University of Information Technology.

KEYWORDS

Engineering Education; Network Engineering; WEB Application Developer; CDIO Standard: 3, 8, 11 and 12

INTRODUCTION

In this study, we will discuss our implementation of the CDIO initiative[1], mainly standard 3-Integrated Curriculum, standard 8-Active Learning, standard 11-Learning Assessment and standard 12-Program Evaluation (for completeness, details of those four standards are listed in Table 1), in our bachelor program of Network Engineering (NE), which aims to train students to be qualified WEB Application developers, who can handle various development tasks (from system design, programming to project management) of web applications, such as website.

Table 1 CDIO Standard 3, 8, 11, 12

Standard 3 -- Integrated Curriculum	A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills

Standard 8 -- Active Learning	Teaching and learning based on active experiential learning methods
Standard 11 -- Learning Assessment	Assessment of student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge
Standard 12 -- Program Evaluation	A system that evaluates programs against these twelve standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement

Before we get to any detail about our work, there are some background information should be given so that it would be easier to understand our practice.

First, Chengdu University of Information Technology (CUIT) is a Chinese University, who has over 20,000 undergraduates and 1,600 graduates. Among 53 provided bachelor programs, 30 of them are engineering programs. Obviously, CUIT is dedicated to the development and implementation of engineering educational programs in bachelor level.

Another thing is that Chinese universities usually have more specific major settings (or bachelor programs) than western universities. Take Computer Science and Engineering (CSE) for example, in China we have Network Engineering, Software Engineering, Computer Science and Engineering, Internet of Things Engineering, Digital Media Technology, and even Information Security. On the contrary, it is common that western universities only have Computer Science or Computer Engineering or Computer Science and Engineering.

The rest of the paper is organized as following. In section 2, we first address the problem we are facing. Right after that, we describe our solution, i.e. our practice of the CDIO initiative. Then evidence is provided to prove our work is meaningful and effective. Conclusion and summary will be given in Section 4.

PROBLEM

In China, the pressure of getting a job for bachelor students, especially a well-paid job, has increased a lot in past several years, and is about to increase in the foreseeable future. Thereafter, many students try to get interns during the fourth year with a hoping that such experiences can add on the bargaining chip for their job seeking effort. Above situation makes it more difficult for the curriculum planning, which means it is not appropriate to arrange classes for the fourth year. And thus we have very limited time to prepare our students ready for future challenges.

Meanwhile, the Information Technology (IT) industry has evolved so fast, which makes the situation even more complicated. In order to meet the challenge, engineers need to master various up-to-date development skills. It is even true for start-up companies, in which one person always plays several different roles, for example the system designer, the programmer and even the project manager. So it is our responsibility to make sure that what students were taught in college is what employers really want[5].

To sum up, so much has to be done in such a short time. Extra effort is need for the curriculum scheduling.

What makes things worse is that the new generation of college students has become more and more self-centred. Many of them may not be easily convinced to do what professors told them to do. Moreover, it is common that they have very different and diversified interests, and it is not a surprise that some of they are not interested in computer science at all. How to inspire them to be self-motivated and active learners should be taken into account.

It is our opinion that the solution to the above problem has to meet following requirements.

First, the curriculum schedule has to be decided by real world job requirements. In our context, what we need is an integrated course design, which contains only necessary courses and covers all skills needed for NE students, who are meant to be WEB Application developers after their graduation.

Second, as a complementary, proper assessment methods should be selected to test whether students are prepared to meet future challenges. To be more specific, it is better to assess the system design ability by reports, evaluate communication skills by presentations, test the programming skills by computer-based exams, rather than use paper-based exams as the 'one size fits all' solution. In addition, the assessment system should keep students in track and give them a push even they are sloppy or not interested in those topics.

At last, an evaluation system has to be applied, so that we know how current methods work and what improvements should be taken.

METHODOLOGY

In this section, how the CDIO initiative is applied in NE undergraduates training by following the above mentioned principles will be discussed.

Related Position Survey

To decide what is necessary for a qualified WEB Application engineers, we conduct a survey by collecting job responsibilities or requirements for related positions on the Internet. Our survey covers several popular human resource and job hunting websites in China, including 51job, ChinaHR and ZhaoPin. The requirements among different employers are similar, besides basics of computer science, the frontend script language, the backend dynamic webpage programming skill and the ability to handle a database are popularly demanded abilities. The survey result will later be used in our curriculum planning. Combined with common criteria of computer science programs, the requirement matrix can be formed, which is listed in Table 2.

Table 2 Ability Matrix for a WEB Application Developer

WEB Application Developer	Mathematics
	Disciplinary Knowledge of Computer Science
	Development Skills
	Interpersonal Skills and Communication Skills

Integrated Curriculum Design

The compulsory courses for the NE program are listed in Figure 1, which is consistent with the previous survey result (For the ease of description, some courses, like physics and

English, are excluded from the figure). At the same time, individual demands are not ignored, for instance, in Object-Oriented Programming, both C++ and Java are available; in Database, two most popular database products, Microsoft's SQLServer and Oracle's MySQL are provided; and in dynamic webpage programming, J2EE and .NET are available options. For consistence, if one chooses Java for Object-Oriented Programming, it is highly recommended that he should choose MySQL for Database, and the like.

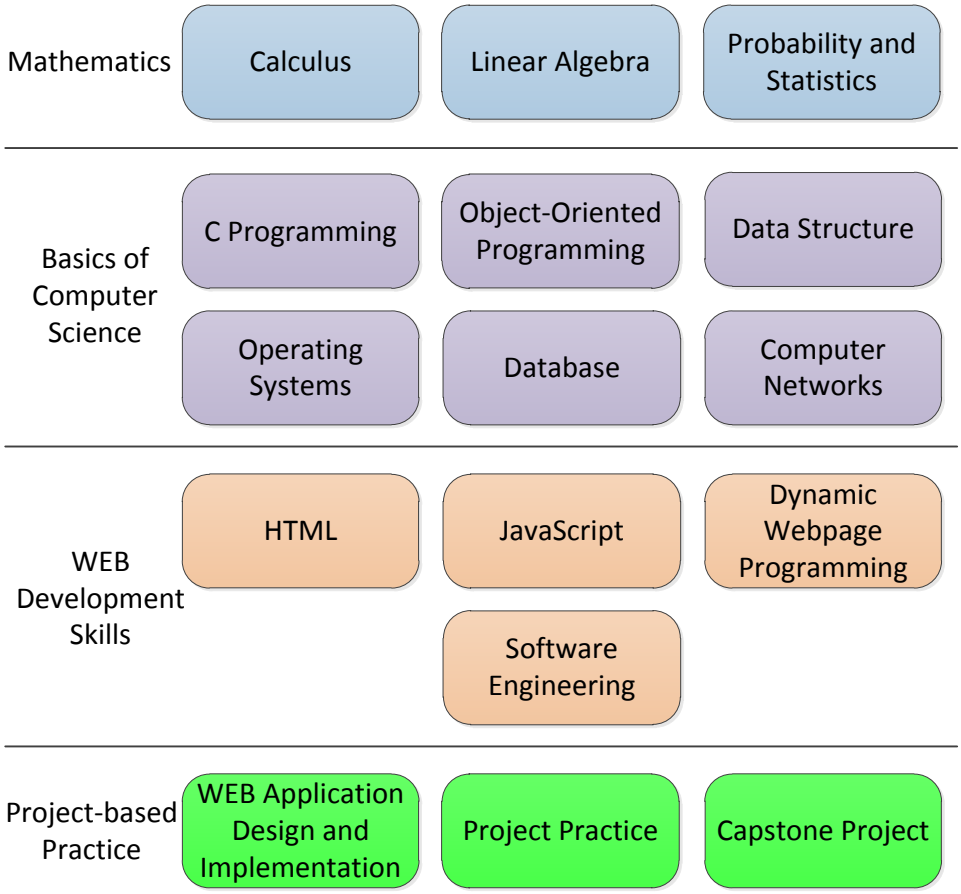

Figure 1 Part of the Curriculum Schedule for NE

At the top of the curriculum, there are mathematics courses. After that, we have courses for basics of computer sciences, such as Computer Networks, Operating Systems, and etc... Then there are courses for development skills, from the frontend programming, HTML and JavaScript, to the backend programming, Dynamic Webpage Programming. Moreover, it is necessary for a qualified software engineer to know the lifecycle of software development, the organization of software development process, and the modelling or management tools for software development. All of those are included in Software Engineering.

Needless to say, just theory is not enough for future IT engineers, hands-on experiences are essential[2]. Then there comes the WEB Application Design and Implementation, Project Practice and Capstone Project. In all of the above project-based courses, what students have learned from WEB Development Skills module will be combined and be put into practice. By doing so, students can have a holistic view of the WEB application development task and a deeper understanding for the connection between those development skills. A further illustration for the content of project-based courses is given below.

In WEB Application Design and Implementation (as the design - implement experience at basic level), students are asked to develop a simple Information Management System individually, such as human resource information management system, student information management system and customer information management system. And it is required that the system has a backend database and several frontend webpages.

In Project Practice (as the design - implement experience at advanced level), students work in teams to develop a more sophisticated WEB application, namely a more complicated website, like online bookstore and online hotel booking website. Working together as one team, students will play different roles, like the project manager, who is in the charge of task assignment and process control, the frontend developer, who uses his HTML and JavaScript programming skills to shape webpages, and the backend developer, who is responsible for data modelling, database create and data retrieval. It is also believed that they can learn interpersonal skills, communication skills rather than just programming skills through such settings. Furthermore, it mimics the lifecycle of the real world software development scenario, in which students can have hands-on experience of the whole development process including the requirement analysis, system architecture design, source code programming, system test and even maintenance.

Last but not least, the capstone project gives an over-all test of how well they grasp those knowledge and skills. As a matter of fact that many students spend their fourth year in IT industry companies, for students' interests, the projects they participated during their internship can be used as their capstone projects. It not only saves them a lot of time, but also improves the quality of capstone projects.

Extracurricular Activities

Though it is supposed that graduates of NE program will seek for WEB application developer positions, they should be allowed to develop their own interests as well. Those demands can be quite diversified and thus hard to fulfil in just classroom studies. Moreover, a well-known rule for a successful college life is that you cannot be satisfied with what you learn in classrooms, you have to work hard after classes. Thereafter, it is necessary to provide an engineering workspace where students can develop their own interests in after-class time[3].

Figure 2 A Four-Axis Unmanned Aerial Vehicle

In our department, there is a lab for student clubs, in which students are allowed to do whatever they want. Proven by facts, it is very useful for inspiring active learning. Several teams are formed for software design competition and innovative contest. Besides that, they can find guidance or financial support if necessary.

Moreover, there is a campus-wide policy that students can receive credits by participation for related competitions. And they can receive even more credits if they can win an award in contests. Many students are encouraged by such policy, lots of eye-opening applications and devices are developed by these talented young men and women. Figure 2 gives a glance for their innovative works.

Assessment System

As aforementioned reasons, it is not appropriate to use just paper-based test for all courses. Depending on contents and characteristics of courses, different assessment methods should be used, for example computer-based tests for programming courses, presentations or defenses for project-based courses.

In HTML programming, students take their final exam in a computer lab. At the beginning of the test, they are given randomly chosen questions, to create a static web page by using HTML and CSS. At the end of the test, the professor will go through students' source code and challenge them, and they have to answer those questions. At last, based on the quality of the source code and whether they answer questions correctly, final grades will be given.

Figure 3 The Login Page of Our Online Test System for C Programming

In C programming, an online test system is developed to replace the traditional paper-based exam (Figure 3 is a snapshot of its login page). And it is not only used in the final exam, but also in regular tests or quizzes. Furthermore, a stage-based test mechanism is adopted for regular tests, which means student has to pass one test in order to move on to the next stage. For instance, to move on to the chapter loop structure, students need to pass the test for chapter selective structure. Such a mechanism guarantees students achieve all setting objectives and forces them to be active participants, otherwise they fail the entire course.

Another highlight of the online test system should be mention is that students can type real source code in webpages rather than write 'fake' code on test papers, and the correctness and completeness of their code will be tested by an imbedded compiler and test cases. Such design has several advantages, to name a few, students can know their scores immediately after they finish the test, teachers can save precious time for manual checking the source

code by naked eyes, mistakes can easily be ignored by manual code inspections, like missing terminators or brackets, will never be missed, and students can practice for tests whenever they have time and wherever they can access the Internet.

As shown in Figure 4, due to the introduction of the online test system, the average final grade for C Programming has continuously increased since 2010. What is not shown in Figure 4 is that there was a sudden drop in the average final grade in 2010 compared to 2009, which we believe is caused by students were not yet used to the new testing method and the more strict assessment criteria. It is also worth mentioning that the online test system is kept in update, now it supports four courses, C Programming, Object Oriented Programming, Data Structure, and Database. Not a surprise, final grades for those courses show similar trend as the C Programming. In the future, more courses will be added.

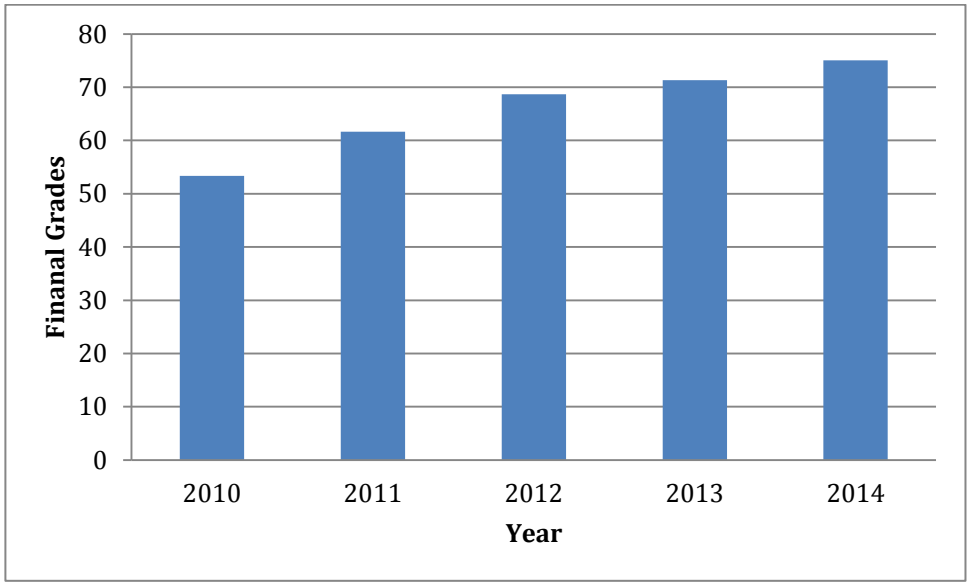

Figure 4 Annual Average Final Grades for C Programming

For those project-based courses, instead of a test, a report has to be submitted other than the source code. Then students have to give a presentation which introduces their works and explains details of their design and implementation. It is certain that they have to take professor's questions after they finish the presentation.

Program Evaluation and Continuous Improvement

The program evaluation is carried out from several different perspectives and by corresponding means, which are listed as following.

Self-evaluation

Every year, the commission of senior professors will randomly pick several courses for inspection. During the inspection, course materials including slides, assignments, test papers and lab reports are reviewed. After the inspection, a report covering three parts is formed. Those parts are the course content, effectiveness of assessment, and student's performance.

For the course content, the commission checks whether the content is update-to-date and gives suggestions for what should be added to the course and whether some topics should

be renewed. Take the course HTML for example, HTML5 and CSS3 was added in 2013 after the inspection. For the effectiveness of assessments, professors go through assignments, exam papers and lab reports, to see whether those assessments have covered the course syllabus and whether the teacher has given students enough practice. For the performance, students' grades comparison between this year and last year is conducted to determine what kinds of methods are necessary to inspire their interests and improve their performance.

Informal Meeting

It is a routine that informal meeting is hold between professors and undergraduates after they finish their capstone project defenses. During the meeting, they can complain whatever they are not satisfied, especially about what kind training they needed to find a job is missing from the current program. The fact that those complaints are made based on their very own job seeking experiences makes such suggestions are extremely valuable for the future curriculum adjustments. A very good example is that the Android Mobile Application Development has already been added to our curriculum in 2015 based on feedbacks.

Third Party Survey

Every year, a consulting company named MyCOS (MyCOS is a leading consulting company with a focus on education industry in China) is hired to track all graduates and provide an employment status report. Generally, the survey gives an overview for payments, degrees of stratification for the training they received during college life, and some other aspects. Among those statistics, what we care most is whether graduates really benefit from our efforts, or simply speaking whether they can get well-paid jobs or not. As we can see from Figure 5, the average annual income for bachelors of NE program keeps increasing, from 2010's ¥3142 to 2014's ¥4430. And the employment rate keeps above 90%, which is demonstrated in Figure 6. Both of the income and employment rate are extracted from MyCOS annual graduates reports. Above data could be more persuasive if the average income for all bachelors of NE program across the country can be found. Unfortunately, such data is not available at the time. At least, we can conclude that our effort has positive influence on the employment quality.

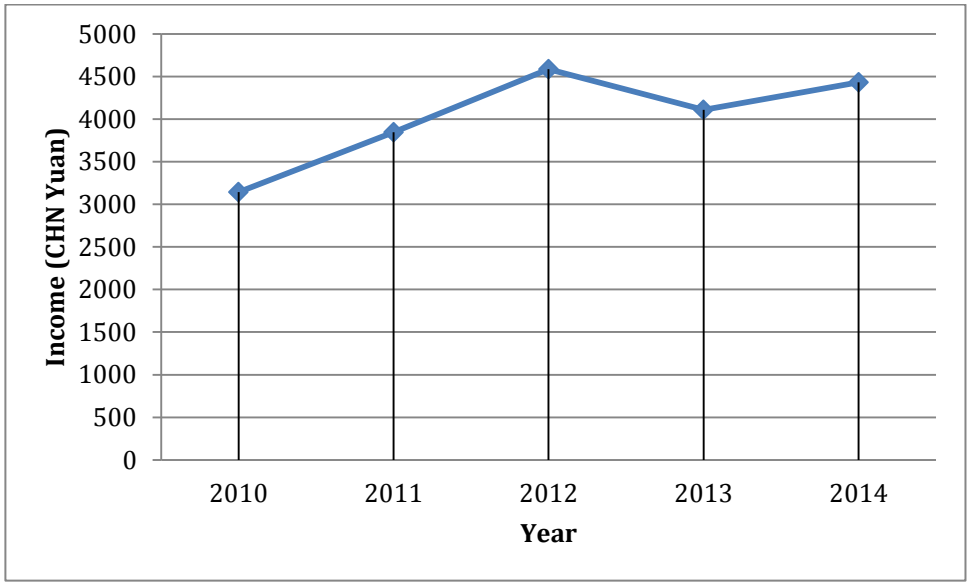

Figure 5 Annual Average Incomes for the Bachelor of NE Program

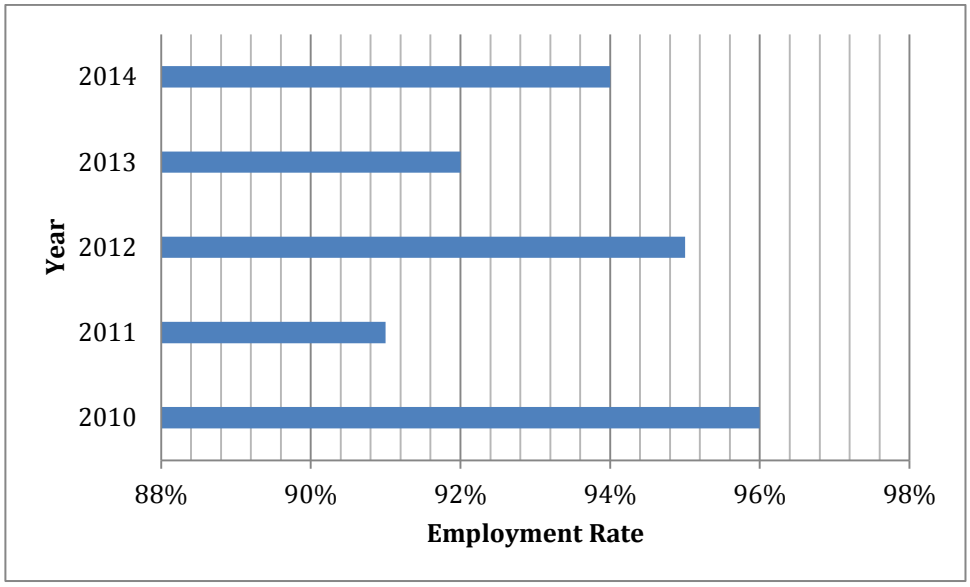

Figure 6 Annual Average Employment Rate for the Bachelor of NE Program

CONCLUSION

Gather from the above, it is safe to say that the adoption of the CDIO initiative and our effort has finally paid off. Both our self-evaluation data and the third-party job market report prove that our practice has positive effect on students' performance. And we believe the application of our experiences is not just limited to NE program, and it can also be used in other CSE related programs.

For future work, there are still possible enhancements can be made, to list a few, a closer collaboration with industry companies for project-based training[4], more engineering workspaces and laboratories can be provided, and a full-scale evaluation system for all twelve standards should be established.

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BIOGRAPHY

Luqiao Zhang, Ph. D. is an Associate Professor in Department of Network Engineering at University of Chengdu University of Information Technology, Chengdu, China. His current research focuses on bachelor program design.

Juan Wang, Ph. D. is an Associate Professor in Department of Network Engineering at University of Chengdu University of Information Technology, Chengdu, China. His current research focuses on curriculum development.

Fei Li, is a Professor in Department of Network Engineering at University of Chengdu University of Information Technology, Chengdu, China. leads the strategic directions and implementations of various academic development and educational research at the school.

Lei Shi, Ph. D. is an Assistant Professor in Department of Network Engineering at University of Chengdu University of Information Technology, Chengdu, China. His current research focuses on students' club management.

Corresponding author

Dr. Luqiao Zhang
Chengdu University of Information Technology
No.24 Block 1, Xuefu Road, Chengdu, China, 610225
zhanglq@cuit.edu.cn