Teaching and Learning through Projects in the Course *DSP*

Yong-quan JIANG

Dept. of Electronic Engineering, Shantou University, P. R. China

Min-fen SHEN, Zhe-min ZHUANG, Xu-tao LI, Jun WANG, Li-sheng FAN

Dept. of Electronic Engineering, Shantou University, P. R. China

ABSTRACT

In order to improve the ability of combining theory with practice, herein we introduce an idiographic teaching and learning methodology, which has been successfully employed in the course of Digital Signal Processing (DSP). How to formulate the course syllabus is discussed, involving the motivations and details. The key point is to incorporate relevant elements of EIP-CDIO into the teaching and learning activities. Our three-year's results demonstrate that the reform of EIP-CDIO improves student's comprehensive abilities efficiently. Most students have learned more than their expectations from the course DSP.

KEYWORDS

EIP-CDIO, Course syllabus of DSP, Active and experiential learning, Teaching and Learning through Projects

INTRODUCTION

Theory learning without any assistant practice is ineffective because there are many nuances, exceptions, and subtleties to be learned in practical environments [1]. Therefore, learning from practice is the same important as acquiring knowledge and applying it into practice for engineering students. Currently, one of the shortcomings in traditional engineering education is lack of sufficient Conceive-Design-Implement-Operate (CDIO) training. The Engineering College of Shantou University has proposed EIP-CDIO education mode which further emphasizes EIP (Ethics-Integrity-Professionalism) considering the specific circumstance of China [2]. Under this education mode, theory course and seminar are fused with project practice by teams, and the humanism spirit is carried through the course. The objective of EIP-CDIO is to make students have diatheses, such as professional morality, honesty, acuity, creativity, and so on.

Since 2005, our teaching and learning reforms directed by EIP-CDIO have been firstly explored in some courses. And then, the complete reform was put in force for all the courses in 2006. The course digital signal processing (DSP) is one of the first pilot courses, and we have never intermitted our efforts to enhance the teaching and learning level. The concrete measures for teaching and learning reform of the course DSP are introduced in this article. We are greatly pleased to share the experience with other colleagues engaged in electronic engineering education.

ENACTING THE COURSE SYLLABUS ACCORDING TO EIP-CDIO

Our method to enact the syllabus is: Firstly, the kernel of the course must be grasped, and then the projects by which students perform their experiential learning are constructed according to it. The kernel contents of DSP are shown in the followings:

1. Digital processing of analog signals procedure
2. Digital spectrum analysis algorithms
3. FIR digital filter design and their realization algorithms
4. IIR digital filter design and their realization algorithms

According to the aforementioned contents, the project constructed by us is the "Designing and implementing a digital filter system to filter analog signals". The project includes the following units:

1. Generation of an arbitrary analog signal and digitization
2. Spectrum analysis of the generated analog signal by DSP algorithms
3. Designing an FIR or an IIR digital filter to satisfy the given specifications
4. Designing a block diagram to realize the digital filter
5. Writing program and performing numerical calculation according to the block diagram by sample processing methods
6. Constructing the analog signal from the digital filter output
7. Spectrum analysis of the output analog signal by DSP algorithms
8. Evaluation the filtering effect by comparing the output signal spectrum with the input signal spectrum

Evidently, the project covers the kernel contents of DSP. Five to ten students are grouped together to do the project. Cooperation and competition among groups are encouraged. Compared with the traditional course syllabus of DSP, our syllabus is more detailed and explicit in terms of teaching contents and objectives. Only the kernel contents are instructed and discussed by interactive strategies in class, and the others are completed by students' experiential learning. In this way, the total contents are covered by 42 credit hours. Students understand the knowledge and improve their practical abilities through the idiographic teaching and learning methods.

To incorporate the relevant elements of EIP-CDIO into the teaching and learning, our methodology is the followings:

1. Active teaching and learning
2. Experiential learning through projects
3. Emphasizing critical thinking
4. Complete analysis of the kernel contents in interactive pattern
5. Scientific research aided teaching
6. Cooperation and competition spirit training
7. EIP edification

Our faculty previous efforts have already set up the EIP-CDIO mode for engineering education [2]. In general, each course should play its role in developing students' ability of EIP-CDIO. Fig. 1 shows the teaching and learning methodology of the course DSP directed by EIP-CDIO education mode. To match this mode, we propose projects of three levels:

1. First-level project is the main thread, serving the education program
2. Second-level projects are of comprehensive design-implement, serving the corresponding course group
3. Third-level projects are specialized, serving the corresponding kernel courses.

Employing Bloom's Taxonomy, our syllabus of the course DSP is detailed and explicit in terms of the contents and objectives. The contents are divided into memory, understanding, practice and integration analysis, marked by four-level degree, i.e., A, B, C, D.

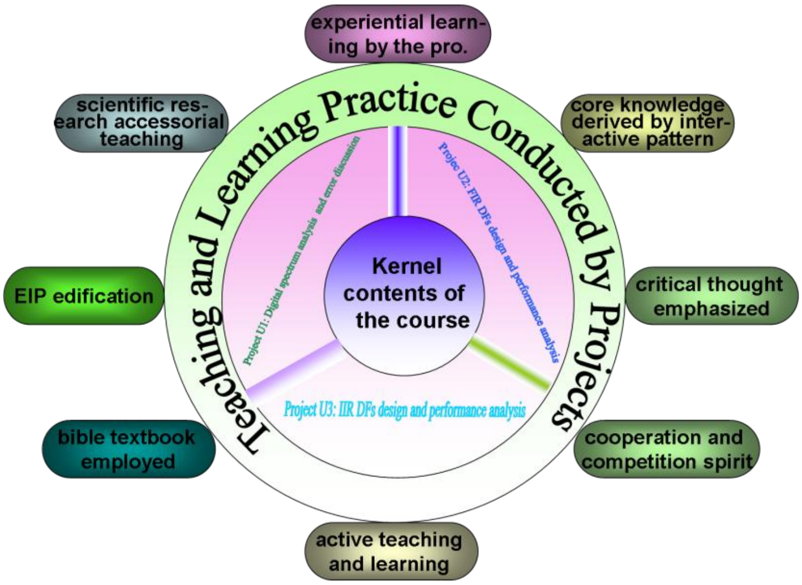

Figure 1. Teaching and learning methodology of EIP-CDIO in the course DSP

INCORPORATING THE RELEVANT ELEMENTS OF EIP-CDIO INTO TEACHING AND LEARNING

Teaching and Learning Method 1: Active Teaching and Learning

It is said that interest is the best teacher, and we try our best to inspire students' interest in the course of teaching. At the first class, we prefer to introduce some practical examples regarding the course, in order to let students understand the motivation of the course. When discussing the kernel contents, we firstly introduce what kind technical problems are met in typical application, and give the solution to increase students' desire of active learning.

For example, we show students the following observed signal in Fig. 2 when discussing "Digital spectrum analysis algorithms", and then ask students what information concealed in the signal. Most students say "Just noise, without any information", then we show students the spectral amplitude of the signal in Fig. 3 by digital spectrum analysis algorithm, and ask the same question again. Now students understand that there is a periodical signal hidden in the noise, then we explain furthermore that the signal is observed under the strong noise background, therefore it is hard to find the hidden sinusoidal signal by waveform in time-domain or by hearing. However, the hidden sinusoidal signal can be easily found by its spectral magnitude. In practice the sinusoidal signal hidden in strong noise sometimes is the behavior of device trouble. If we can find it earlier, larger loss can be avoided.

Teaching and Learning Method 2: Experiential Learning Through Projects

In order to let students learn more from practice, we design the third-level project of course DSP named "Designing and implementing a digital filter system to filter analog signals", which consists of eight units introduced in section II. Our teaching and learning program is guided by the project. Specifically, we prefer to arrange the third-level project in the first class, and let students learn the course with thinking the problems in the project. The third-level project should be as specific as possible, making students be able to apply what they have learned to solve the specific problems in the project. Fig. 4 shows one solution of the project by students.

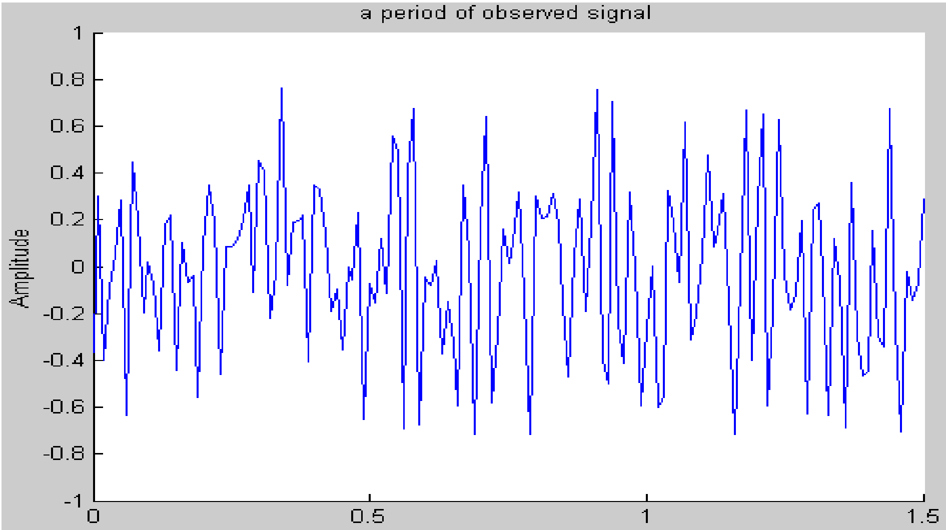

Figure 2. Observed signal

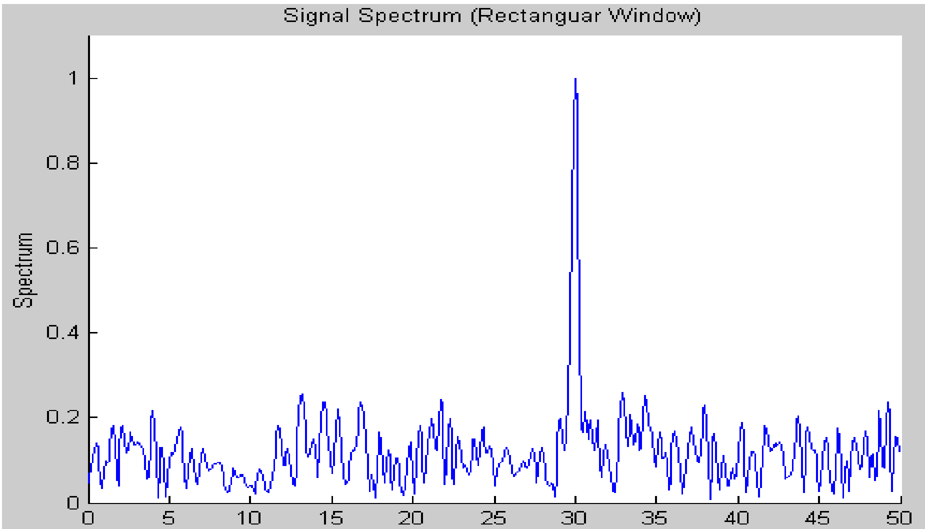

Figure 3. Spectral amplitude of the signal in Fig. 2

Teaching and Learning Method 3: Emphasizing Critical Thinking

We prefer to encourage students to ask why as frequently as possible. and tell them not to blindly follow teachers and textbooks. When discussing the algorithm of digital spectrum analysis, most textbooks directly give DTFT algorithm as

$$X_d(\omega) = \sum_{n=-\infty}^{\infty} x_d(n) e^{-j\omega n}$$

then present the relationship between digital frequency and analog frequency as

$$\omega = \Omega T = 2\pi fT$$

We ask students: “Why does the textbook hold this relationship? ”. Some students answer: “This relationship is only a regulation”. We then ask: “Why does this relationship exist? ”. With the interactive form, students recall the CTFT of an ideal sampled signal:

$$x_{is}(t) = x_a(t)\sum_{n=-\infty}^{\infty}\delta(t-nT) \xrightarrow{CTFT} X_{is}(\Omega) = \int_{-\infty}^{+\infty}\sum_{n=-\infty}^{\infty} x_a(nT)\delta(t-nT)dt = \sum_{n=-\infty}^{\infty} x(n)e^{-j\Omega Tn}$$

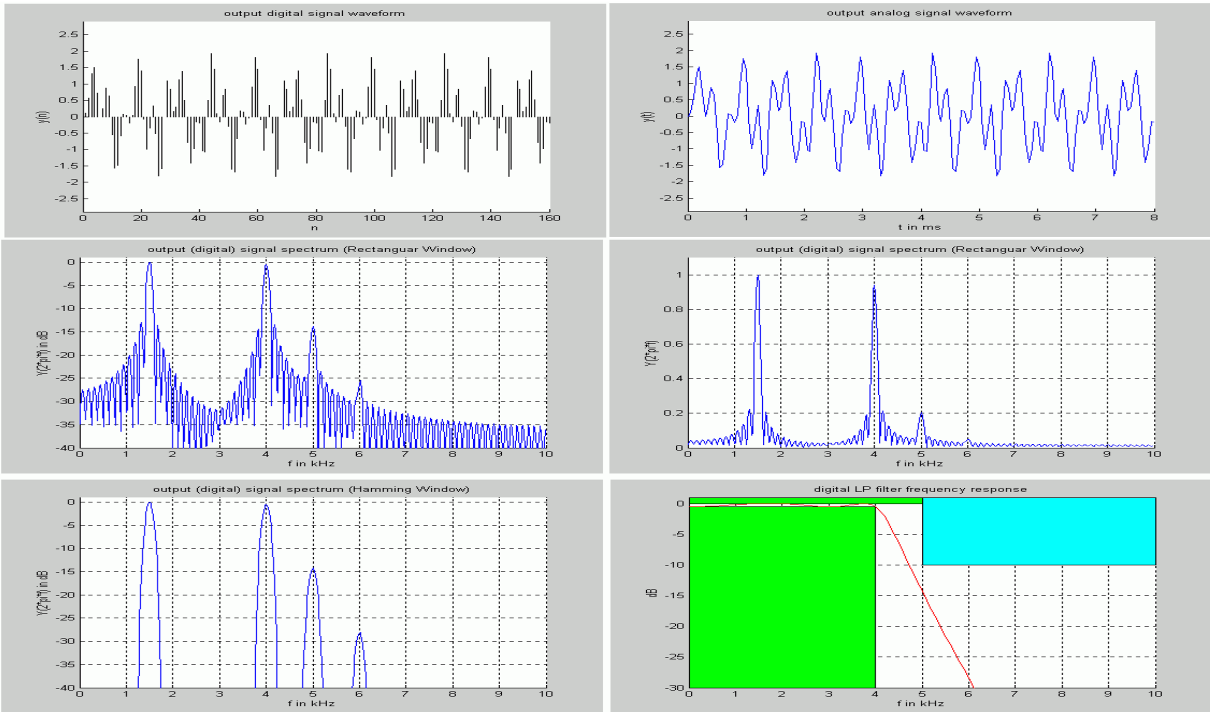

Figure 4. One solution of the project by students

Additionally, according to the sampling theorem, we get

$$X_{is}(\Omega) = \frac{1}{T}\sum_{n=-\infty}^{\infty} X_a\left(\Omega - m\frac{2\pi}{T}\right)$$

This equation indicates that there exists periodical expansion relationship between $X_{is}(\Omega)$ and $X_a(\Omega)$. When the digital frequency $\omega = \Omega T = 2\pi fT$ is defined, the spectrum of a discrete-time signal is the same as that of the ideal sampled signal. By the above interactive discussion, students not only understand why the digital frequency ω is defined as $2\pi fT$, but also master the relationship between $X_a(\Omega)$ and $X_d(\omega)$.

Teaching and Learning Method 4: Complete Analysis of the Kernel Contents in Interactive Pattern

According to the requirement of "*Course syllabus of Digital Signal Processing*", the credit hour of the course is sharply reduced. In the classroom, only the kernel contents are taught and discussed, while the others should be actively learned by students themselves through the project. The kernel contents must be deduced and analyzed completely. On the one hand, students must grasp the kernel contents. On the other hand, we impart the method of analyzing and solving problems, i.e., giving the method of fishing is better than giving fish.

CONCLUSION

According to the EIP-CDIO education mode, we have formulated "*Course syllabus of Digital Signal Processing*", and the syllabus has been performed since 2005. Three-year's teaching and learning activities indicate that the CDIO reforms enhance students' ability of combining theory with practice. Students' study enthusiasm has been aroused effectively, and they have learned more than their expectations from the course.

REFERENCES

[1] Ulrich K.T. and Eppinger S.D., Product Design and Development (3rd Ed.), McGraw-Hill, 2004.

[2] Gu P.H., Shen M.F., Li S.P., Zhuang Z.M., Lu X.H. and Xiong G.J., "From CDIO to EIP-CDIO : A Probe into the Mode of Talent Cultivation in Shantou University", China Academic Education, Jan., 2008, pp 12-20.

[3] THE CDIO™ STANDARDS, http://www.cdio.org/tools/cdio_standards.html.

[4] Maria K.W., Antal Boldizar, "Active Learning Through Group Dialogue in a Project-Based Course on Environmentally Adapted Product Development", http://www.cdio.org/papers/papers.html.

Corresponding author
Dr. Yong-quan JIANG
Department of Electronic Egineering, Shantou University
243# Daxue Road
Shantou, Guangdong, 515063, P.R. China
86-754-82902566
jyq@stu.edu.cn