Full Paper

Abstract: ‘

signals and systems’, ’digital signal processing’ and ‘random signal processing’ are three important fundamental courses for electrical engineering bachelor degree students. Aiming at the problems encountered in teaching process of three courses, a comprehensive innovation and practice in teaching and learning is presented in this paper. Its main idea is that instructional activities are conducted based on a project, in which students gain knowledge by ‘learning in doing’ and ‘doing in learning’. In order to implement the instructional objectives, three courses are integrated into a new course named ‘signal analysis and processing’. Based on the new course, teaching contents are organized with a new sequence, and a project frame is constructed, teacher’s teaching and students’ learning are all based on project. Three years’ teaching practice show students’ self-directed skills, communication skills and team-working ability are improved obviously. Most importantly, their learning interests and subjective initiative of learning changed greatly which means their learning attitude is transformed from passiveness to activeness.

Keywords

project-based teaching and learning , course innovation , signal analysis and processing, learning in doing, doing in learning,

Introduction

Normally, three fundamental courses which are ‘signals and system, digital signal processing and random signal processing’ are very important for the electrical engineering bachelor degree students in their four years course curriculum. These three courses have similar features which are both strong theoretical and practical. The contents of these subjects are tightly related each other. Main problems students in their learning process are that they feel very difficult to learn with conventional teaching approach, They can not understand the meaning of some mathematical concepts and properties, such as the concept of spectrum, system group delay and so on. All of these problems in their learning process will induce them concentrate their efforts only on calculations with mathematical formula such as calculating Fourier Transform (FT), Laplace Transform(LT) and Z-Transform(ZT). In addition, most students don’t know how to analyze and solve the problems in real world especially for Chinese students who are used to doing mathematic exercises after class . In the conventional teaching approach, students listen to teacher’s lectures in the class, then do homework and test few laboratory work after class. This teaching method makes students feel very boring in their study activities and feel more difficult to accept the knowledge, which results in engaging a low level of learning as students gain information from lecture and memorize facts and procedures in order to pass exams. The desired teaching goal can’t be achieved in fact. So, it is necessary to modify the traditional style of instructional methods both for teachers and students in order to improve their learning outcome and enable students to better retrieve the pertinent theoretical knowledge when faced with real world engineering problems.

Project-based Learning (PBL) refers to either project-based learning or problem-based learning, which is defined as “a learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem”(J.R, Savery,2006). It is a self-directed mode of course delivery and students gain knowledge of the course material through designing, investigating and decision making at each step of the project (e.g,Eliathamby Ambikairajah, Tharmarajah Thiruvaran, and Ray Eaton， 2013). In project-based learning, students begin with an assignment to carry out one or more tasks that lead to the production of a final product-a design, a model, a device or a computer simulation(e.g, Prince, M. and R. Felder， 2006 and

2007). The main advantages of PBL is that it can improve the understanding of basic concepts, to stimulate the students' self-learning ,to encourage deep and creative learning, and to develop team work and communication skills. So, PBL gained world-wide interest as one of instructional methods, which is normally applied under the concept of CDIO (conceive, design, implement, operation,CDIO) engineering education curriculum. Many instructors in different universities of the world have practiced PBL in order to improve quality of personnel training of higher education and meet growing needs of modern industry and related engineering fields(e.g , Eliathamby Ambikairajah and Julien Epps,2011; Hudson Jackson,Kassim Tarhini,Brian Maggi,Nathan Rumsey,2012; Agüera, F., Barcala-Montejano, M.A,2012; Nasser Hosseinzadeh, Mohammad Reza Hesamzadeh,2012; Kazuya, Akiyuki Minamide,2013).

Based on PBL, this paper presents an innovative method of teaching and learning in three courses as mentioned in paragraph1 from the viewpoint of teaching contents organizing and instructional approach. In the following sections of this paper, we will first introduce how to organize the three courses together to form a new course. Then we will describe the project design and how to implement teaching and learning based on project. Assessment to the students is introduced in the fourth part and conclusions in the end.

Teaching Contents Organizing of the New Course

In traditional electronic engineering teaching curriculum , the course of 'signals and systems' is normally set in the fourth semester which is the spring semester of second academic year, and the course of 'digital signal processing' ,'random signal processing' are set in fifth semester. The teaching hours of the three courses in classroom and laboratory are listed in the table1.

Table 1 Teaching hours of the three courses

Course name	Teaching semester	Theoretical hours	Laboratory work hours
Signals and systems	4th	46	8
Digital signal processing	5th	36	0
Random signal processing	5th	36	0

From table1, we can see students spend most of time in learning theories and only a little time is spent in laboratory. It is noted that the contents of laboratory work only acquire students to do several independent experiments in order to test and verify some theories or principles. This is not beneficial for students to establish and understand a whole concept of 'signal analysis and processing from the viewpoint of a system' . Also, it is not fit for the idea of engineering education and can not meet the needs of modern industry. So, the teachers of the courses' group proposed to innovate the courses both from teaching contents and instructional approach.

One of the main reform idea is to integrate the three courses listed in table1 into a new course named 'signal analysis and processing'. New knowledge system is constructed according to signal analysis, system analysis, signal processing, system design and implementation. The advantage of it is more systematic and logical. It is easy to be accepted by students along central thread from signal to system. Also, the repetition of same knowledge in the three courses are avoided, which means we can save a lot of theoretical teaching time for practice. The new course only need 72 theoretical teaching hours and 46 hours is saved comparing with that of previous three courses. The saved teaching time are arranged for project. Teaching and practical work are finished within 3th and 4th semester. Figure.1 shows the Theoretical framework of the new course.

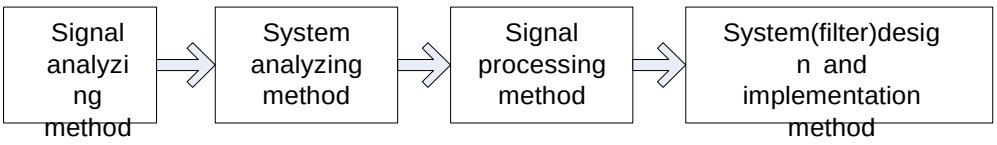


Figure.1 Theoretical framework of the new course

In the signal analyzing part of Figure1, continuous and discrete signal definition, classification and analyzing method in time domain, frequency domain and complex frequency domain are lectured to the students. These signals include both determinate signal and random signals. Statistic properties for random signal are also imparted. In system analyzing block, linear time invariant (LTI) continuous and discrete systems analyzing method and system properties are presented in different domain. Some typical systems are demonstrated such as ideal low-pass filter and distortionless transmission system and so on. In the signal processing part, the main contents are solutions of LTI system response to any input signals in different domain, which can be considered as the relationship between input and output of system. In the final part , we delivery some typical filters, including analogue and digital filter, design methods and their structure implementation.

Project Description

According to teaching contents of the new course, the instructors acquire the students to design and implement a project in Matlab or Labview during their learning. The project is about a signal processing system with computer simulation. It contains signal input, spectrum analysis and denoising. Figure.2 shows the frame of the project.

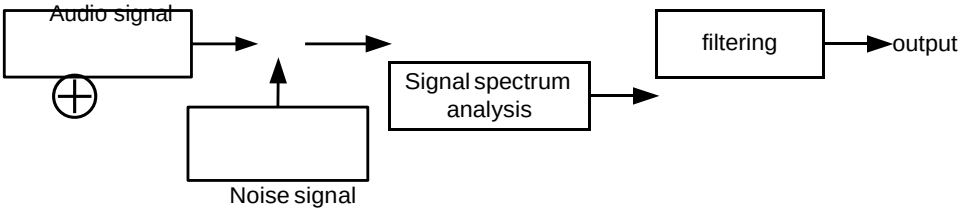
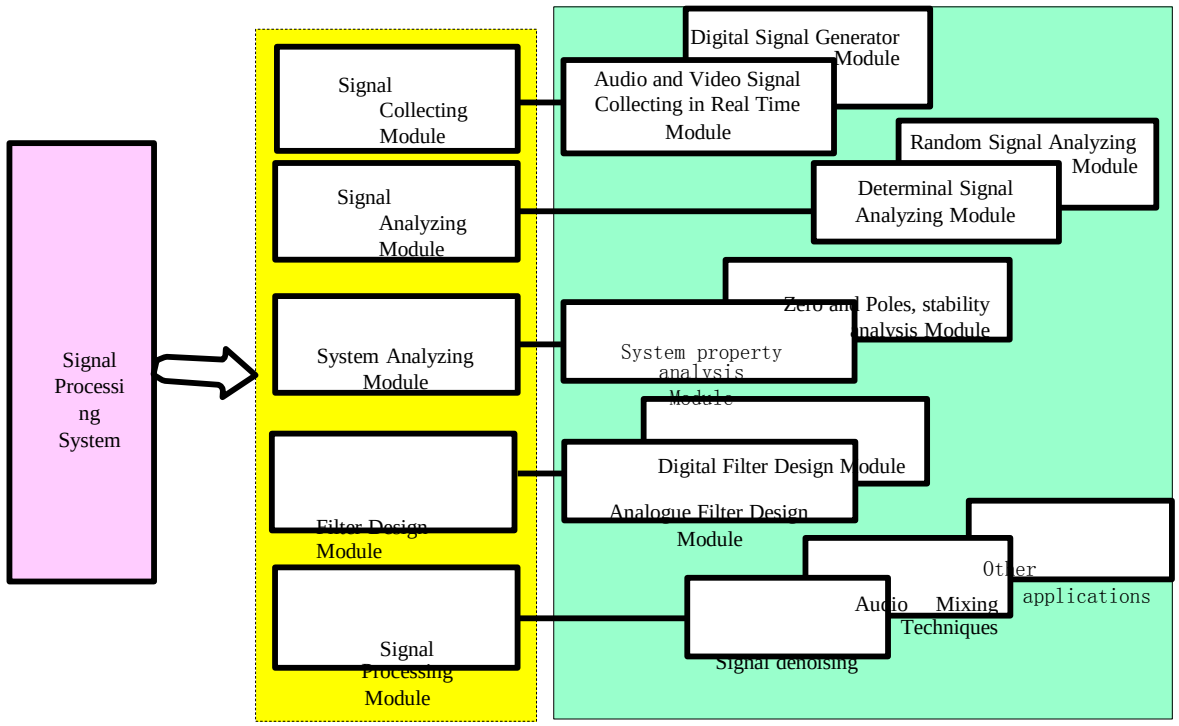


Figure.2 System block diagram

Students are a required to design each module and implement the corresponding functions. Then, connect each module together to form a whole signal processing system under the frame of Matlab GUI or Labview GUI. Figure.3 is further decomposition map of Figure2, which explains what students should do for each part of the signal processing system. This diagram is the modification of that in literature (e.g. Han Ping, He Weikun, Shi Qingyan, Han Yan 2014) Table 2 lists the detail tasks of each module. If students can finish the system design and run it smoothly by themselves, the purpose of project-based teaching and learning should be achieved successfully.



Main Module Sub-Modules

Figure.3 Decomposition map of the signal processing system

Table2 Main tasks of each module

Module	tasks	note
Signal Collecting	1) Collect audio signal(such as speech) from outside with multimedia recorder or read audio signal file already saved inside the local computer 2) Generate some standard signals such as rectangular pulse, Triangular pulse, exponential signal ,sinusoidal signal and typical window function. 3) Generate sinusoidal signal with different single frequency, then mix with signals from 1) to form noisy signals where the sinusoidal signal is assumed to be noise. 4) Building a signal database to save the signals from 1),2) and3) for later use	● Students need to decide the sampling rate when they collect the speech or other audio signal from outside ● Students can plot each signal and observe their features in time domain.
Signal Analyzing	5) Use DFT or FFT to analyze the signal's spectrum and describe the magnitude and phase response with figures 6) Use DFT or FFT to analyze power spectrum of noise signal	● Student need to understand some of DFT(FFT)properties, especially the zero padding, in order to help students understand the signal frequency property
System Analyzing	This part needs to be combined with filter design to assign task. See the next section.	
Filer Design	7) Aim at the noisy signal generated from 3), design different type of filter to filter the noise. 8) Analyze the designed filter magnitude and phase response, zeros/poles and stability. 9) Decide if the designed filter meets the filtering needs. 10) Compare filter's properties with different design methods	● Filter can be designed as low-pass, hi-pass, band-pass or band-stop depends on the noise frequency. ● Filters designed include FIR DF and IIR DF. ● Design methods include windowing method, frequency sampling method for FIR DF, and impulse invariant , bilinear transform for IIR DF..

Signal Processing	11) Input the noisy signal to the designed filter to calculate and observe the filter output 12) Compare the filtered signal with the raw signal without noise to check the filtering quality 13) Students can design and implement other systems like audio mixer.	● Student need to think what is damaged for the filered signal after filtering ● Student also need to think how to design a good filter

Approach of project-based teaching and learning

The instructor's teaching and students learning activities are all based on the project. At the beginning of the new course, students are first presented an audio or speech signal filtering demo system developed by the course teachers and assigned the project task. In the following teaching activities, instructor teaches their lectures according to the new courses syllabus sequence which are in accordance with the flowchart of project design (Figure.2). Students start to learn with the assignment to carry out their project tasks that lead to the production of a final product----signal processing system in Matlab or Labview. When they finished a teaching unit learning, they will start to do the project on teams. Each team has 3-4 students(students' number in each team depends on the whole students' number of the class). For example, when they learned signal analysis method, they are asked to design the signal collection and spectrum analysis module, build the signal database by themselves. During the project design process, they must think and answer some questions asked by teachers such as what is the signal sampling rate you select when collecting audio or speech signals? Why does the spectrum of sinusoidal signal with single frequency not appear as a single line spectrum? How to make a signal spectrum more clear without changing its spectrum's structure?..... To finish the project and answer each question, students will read text book, do experiments and verify some theories actively except for listening to lessons. This project-based learning approach is called 'learning in doing' and 'doing in learning'. And the teaching process is also based on the project. When students implement a module, instructors require each team to give a presentation which we call 'stage reporting'.
Instructors should give them some suggestions to improve the design quality or help them solving problems occurred in their designing.

Assessment

To check the students learning outcome and other skills, students are required to finish the following work at the end of the course: 1) write a technical report in each team 2) project presentation to instructors and students. 3) attend final writing exam with close book within a specified time. The course mark each student obtain finally is consist of three elements: homework (5%)+project (30%)+final writing exam(65%).
The grades of homework and writing exam are decided by the students' personal learning level . For the project grade, students are evaluated individually by teachers. Each student is asked to demonstrate what he had done in the project by individual, answer questions about the project, explain some concepts, theories related to the course and design decision he made. In addition, students are required to operate live show for the teachers.
With above check points, instructors know each student's contribution to the project and the understanding level to the course knowledge. So, they can give more correct assessment to each student.

Conclusion

In this paper, the author demonstrate the innovation and practice of three courses related to' signals' in electrical engineering curriculum----signals and systems, digital signal processing and random signal process. The innovation includes not only teaching contents integration of three courses but also the teaching and learning approach reform. A new course named 'signal analysis and processing 'is formed by compressing and integrating contents of the three courses. Teaching procedure is laid out according to the sequence of signal analysis, system analysis, system design and signal processing. This arrangement can save much theoretical teaching time in classroom and leave more time to the students for practice. Based on the new course syllabus, project-based teaching and learning is conducted throughout the teaching process which needs two semesters (in 3th and 4th semester, second year) to be finished.

Although no quantitative assessment has been carried out yet, we are certain from the students' learning attitude, the feedback of most students and other instructors who teach them in later courses that the capability to communicate with others, working in teams, knowledge mastering of the course, self-learning and active learning have all been increased largely. Especially, the ability to design and implement a product with technical tools by themselves is enhanced obviously. Students' learning interests are easy to be stimulated by 'doing in learning' and 'learning in doing'. They are very proud of their products. Some students also designed and supplement more complex digital signal processing applications in their project. So, we think the project-based teaching and learning activity has achieved the purpose of the course innovation. Most importantly, the innovation can better meet the needs of engineering profession.

Just as one coin has two sides, apart from the advantages we have achieved, there are still several problems we encountered in the course innovation. The main problem is that 4 extra teachers or tutors are required to join the course in order to supervise students finishing project, attend their stage reporting and final presentation. Because there are about eighty students (20 work teams) in a class, each teacher (tutor) is responsible for 4 teams and holds team meetings every two weeks. So, compared with traditional delivery mode in which 2 teachers are required normally, it is difficult to operate if all courses adopt the innovation mode because too much teachers are needed. In addition, there are still a few of students who have little contribution on project. They often ask their team member for help in the project instead. Finally, as students spend much time on the project, it could have influence on other courses learning. Future work will be focused on improving the assessment and supervision method to motivate each student making more contribution to project.

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