CONTINUING EDUCATION COURSES EMPHASIZING HANDS-ON DSP EXPERIMENTS FOR NIGHT-SCHOOL STUDENTS

Hsien-Tsai Wu and Sen M. Kuo[*]
Department of Computer Science and Information Engineering
Southern Taiwan University of Technology
Yung Kung City, Tainan County, TAIWAN

*Department of Electronical Engineering
Northern Illinois University
DeKalb, IL 60115 USA

ABSTRACT

The recent rapid increase in digital signal processing (DSP) applications has generated a need for electrical engineers with DSP backgrounds; however, a university-industry gap still exists. At Southern Taiwan University of Technology (STUT), a sequence of innovative DSP courses, which emphasize hands-on experiments and practical applications, was developed for continuing education in electrical and computer engineering. These courses are taught in the evening for night-school students, and are separated from traditional classes for regular full-time students. This program requires the participators to have at least three years of working experience before enrolling in the program. It enables the night-school students to experiment with sophisticated DSP applications to augment the theoretical, conceptual and analytical material provided in DSP courses. The inclusion of both software and hardware developments permits students to undertake a wide range of real-time DSP projects in the field. Analysis of assessment data suggests that the introduction of Digital Signal Processors Fundamentals course can increase learning interests and overcome the prerequisite problem of DSP Laboratory Experiments course.

1. INTRODUCTION

DSP technology has been used in many electronic products from household equipment, industrial machinery, medical equipment, and computer peripherals to communication systems and devices. DSP has consistently derived its vitality from the interplay between theory and applications. Correspondingly, DSP courses in universities have increasingly incorporated computer exercises and laboratory experiments to assist students for better understanding the principles of DSP [1], and experience the excitement of applying abstract mathematical concepts to the processing of real-world signals. Digital signal processors are the most popular processors for DSP applications. These devices are also widely used in university classrooms for introducing real-time DSP to the students. Many educators developed and presented undergraduate courses that emphasize real-time DSP applications [2-5].

In Taiwan, most DSP courses were only taught in the graduate curricula and many practicing engineers have never been exposed to DSP. Many of these engineers now find themselves working on products that use digital signal processors. Although the DSP semiconductor industry is training engineers on the practical aspects of DSP through workshops and seminars, it focuses on processes itself. It may also disrupt engineer's work schedule, add inconvenience and increase cost of travel since the course is often offered in a remote location. On the other hand, many universities have already developed very good courses in DSP theory, implementation, and applications [2-5], but are designed for regular, full-time students. This paper presents DSP courses at universities that are specifically designed for the schedule and circumstance of practicing engineers at night school in Taiwan.

There are two major educational programs, a regular daytime program and a supplementary night-time program, for universities in Taiwan. Night school programs are designed for people who have been employed for more than one year, and the period of study is five years. In these supplementary programs, students take evening classes that are separated from day-time programs. In order to support the government policy of promoting the senior professionals to return to school for updating their knowledge and skills, the supplementary programs were started at STUT in 1998. It is required that the participators have at least three years of working experience before enrolling in the program.

STUT received the donation of DSP tools from Texas Instruments (TI) through the University Program, and established the TI DSP Laboratory. Recently, new

MSP430 and TRF69xx labs have also been established through the donations from TI and Morrihan incorporation to the Computer Science and Information Engineering (CSIE) and Electronic Engineering (EE) departments. We integrated those labs into our curriculum to support real-time signal processing for our students in the classes.

We believe that in addition to understanding the general theory of DSP, it is very important for night-school students to design projects based on digital signal processors in order to learn both the hardware interface techniques and the software programming skills. This paper describes the integration of DSP technology, applications and laboratory experiments into the undergraduate courses offered at STUT for the night-school programs.

2. THE NIGHT-SCHOOL DSP EDUCATION at STUT

In order to promote continuing education, the Ministry of Education in Taiwan allowed the technical colleges to have night-school for part-time students in 1981. STUT is located at the southern part of Taiwan, and the College of Engineering was established in July of 1996. There are many industrial companies near campus; so many engineers need continuing education at night.

Our night school has outstanding faculty members, and the relationship between students and teachers is very harmonious. Our teaching aims at balance between theory and practice. The curricula focus on molding students to meet the needs of Southern Taiwan Science-based Industrial Park, the Science Area in Southern Taiwan, and the Taiwan Technical City. Because of its solid foundation and good teaching, our night school has developed rapidly. In addition to the full-time faculty members, we also hire experienced experts as part-time teachers. In this way, our teaching meets the needs of modern learners for continuing education.

STUT awares that narrowing the university-industry gap is very important. This goal can be achieved by:

1. Revising the courses and degree plans to meet different industry requirements.
2. Inviting industry to participate in the planning and reviewing of undergraduate and graduate curricula.
3. Improving the experimental capabilities of graduates through better laboratory training.

The main focus and strength of CSIE Department is applied digital signal processing. Companies in STUT's service area are almost involved with DSP. In addition to hardware knowledge such as digital signal processors, strong software background such as real-time DSP algorithms and programming skills are also required. It is important to southern Taiwan industrial activities that we offer strong real-time DSP application courses. With this in mind, a real-time application course, DSP Laboratory Experiments, was introduced into the undergraduate curriculum for night-school students. This course introduces TMS320C6x, TMS320C54x and TMS320C55x digital signal processors and uses their development systems for experiments. Through a sequence of lab experiments, students will learn the concepts and skills of DSP programming to design and develop advanced DSP applications. Because this course emphasizes practical DSP aspects is well received by undergraduate students.

Enabling night-school students to experiment with sophisticated DSP applications to augment the theoretical, conceptual and analytical material provided in their three DSP courses is major goal of DSP courses in STUT.

2.1 Digital Signal Processing

Basic DSP concepts are introduced in Digital Signal Processing (CSIE312). This theoretical-oriented course introduces the basic principles of sampling technique, discrete-time signals and systems, and digital filter design. It also includes fast computations of discrete Fourier transform and discrete-time system structures. Topics covered in this course are divided into following eight areas:

1. Discrete-Time Signals and Systems
2. *z*-Transform
3. Sampling
4. Transform Analysis of Linear Time-Invariant Systems
5. Structures for Discrete-Time Systems
6. Digital Filter Design
7. Discrete Fourier Transform
8. Computation of Discrete Fourier Transform

2.2 Digital Signal Processors Fundamentals

Due to daytime work, it is necessary for night-school students to study digital signal processors before conducting DSP laboratory experiments. As suggested by course assessment (will be introduced in Section IV), there is a gap between CSIE312 and CSIE566. As a remedy, a new Digital Signal Processors Fundamentals (CSIE433) course was added to introduce fundamental concepts of digital signal processors. This course presents architectures, programming skills, block FIR filter implementations, on-chip peripherals, and DSP/BIOS of fixed-point digital signal processors: TMS320C54xx and TMS320C55xx. Therefore CSIE433 is a processor-oriented design course. Topics covered in the course are divided into following fourteen areas:

1. Architecture Overview

2. Software Development and Code Composer Studio (CCS)
3. Addressing Mode
4. Internal Memory and EMIF
5. Solving a Sum of Products
6. Numerical Issues
7. Solving a Block FIR Filter
8. Memory Transfers Using the DMA
9. Serial Transfers Using the McBSP
10. Application Specific Instructions
11. Using the C Compiler
12. Managing Interrupts
13. Other Peripherals
14. DSP/BIOS (optional: C54x/C55x Migration)

2.3 DSP Laboratory Experiments

In addition to understanding the theory of DSP, it is important for night-school students to conduct design projects based on digital signal processors in order to learn hardware, interface skills, and software programming. This section describes the integration of DSP applications and laboratory experiments into the undergraduate DSP courses for continuing education.

This class implements DSP algorithms on digital signal processors and introduces following five applications:

1. Self-Developed DSP Platform
2. Active Noise Control using the Self-Developed DSP Platform
3. Multi-channel DTMF Detection using the Self-Developed DSP Platform
4. Multifunctional Automatic Pulse Wave Analyzer using the Self-Developed DSP Platform
5. Image Catching & Processing System using the TMS320C6711 DSK

3. EVALUATION AND ASSESSMENT

Before the end of semester, the students are requested to complete a survey for teaching assessment and evaluation. This will help teachers to improve teaching skills and assist students in enhancing the learning progress, and also build up better interaction between instructors and students. The survey statistics is processed by the Office of Academic Affairs, and the result is used as a reference for the faculty to arrange and design courses. This survey is divided into two sections with 11 questions. The first section has eight questions that focus on students' satisfaction with the courses and lecturers. The second section has three questions, which are students' self-evaluations. Students make the following six choices for each question in the first section: highly agree, agree, average, disagree, extremely disagree, and unable to answer. For statistics purpose, the first five choices are giving the scores of 5, 4, 3, 2, 1, and no score is given for the last choice. The second section has questions on students' self-evaluation, which can be used as references. The teaching survey form is shown in Table 1.

Table 1 The teaching survey form

The Evaluation of Lecturers	1	The contents of courses are well prepared, fruitful, and appropriate.
	2	The teaching attitudes were serious, responsible, and regular.
	3	The expressions and explanations of the course contents were very clear.
	4	The quantities and progress of the teaching were well controlled.
	5	Appropriate adjustments were taken upon receiving students' feedback.
	6	Clear explanations and willing to discuss with students were occurred inside and outside the classroom.
	7	There were fair and reasonable grading criterions.
	8	Teaching materials assist learning.
Students' Self Evaluations	1	The percentage of your participations was: a) over 95% b)80~95% c) 60~80% d) 40%~60% e) under 40%
	2	When in class, you: a) really concentrated b) concentrated c) had average concentration d) didn't really concentrate e) did not listen.
	3	My feeling after completing this course was very helpful: a) highly agree b) agree c) neutral d) disagree e) extremely disagree

Tables 2, 3, and 4 summarize the survey results of DSP courses at STUT during 1998~2002 for night-school students. The number of students was around 40~50 per class. The statistics of DSP courses, as shown in Tables 2 to 4, indicate that:

1. In 1998 ~ 2002, the Digital Signal Processing course was popular for night-school students at STUT.
2. In 1999 and 2000, before the course Digital Signal Processors Fundamentals was offered, the feedback of DSP Laboratory Experiments course was not able to exceed a score of 4. This showed that the DSP Laboratory Experiment course did not meet anticipations because there is a gap between the

Digital Signal Processing and DSP Laboratory Experiments.

3. After offering the new Digital Signal Processors Fundamentals, the feedback of DSP Laboratory Experiments courses reached 4.25. In 2002, the average score climbed up to 4.45. It obviously showed that Digital Signal Processors Fundamentals course really assists in connecting courses of Digital Signal Processing and DSP Laboratory Experiments.
4. In 2000 ~ 2002, after offering the Digital Signal Processors Fundamentals course, it had been popular to night-school students, and the popularity continue growing. This is because this course focuses on implementing DSP algorithms and software applications, which overcomes the problems of the insufficient time for self-study processor architectures and increases learning interests.
5. The 3rd question in the evaluation form shows that after offering Digital Signal Processors Fundamentals, the students who agree with DSP Laboratory Experiments and Digital Signal Processors Fundamental courses are also increased. Most students who took DSP Laboratory Experiments and Digital Signal Processors Fundamentals felt these courses were helpful for assisting students to familiar with DSP, self-developed platforms, and real-time DSP applications. This flow is similar to the R&D procedures of industries, which greatly assists night-school students with their works.

Table 2. Digital Signal Processing - Teaching feedback survey, the average marks for the first section

Year	Class A	Class B
2002	4.1	4.1
2001	3.9	4.1
2000	4.1	4.2
1999	4.0	4.0
1998	4.1	4.0

Table 3. Digital Signal Processors Fundamentals – Teaching feedback survey, the average marks for the first section

Year	Class A	Class B
2002	4.2	4.3
2001	4.4	4.2
2000	4.1	4.0
1999	N/A	N/A
1998	N/A	N/A

Table 4. DSP Laboratory Experiments – Teaching feedback survey, the average marks for the first section

Year	Class A	Class B
2002	4.4	4.5
2001	4.3	4.2
2000	3.7	3.8
1999	3.4	3.6

4. CONCLUSIONS

The new Digital Signal Processors Fundamentals course focuses on DSP concepts and algorithms was introduced in night-school curriculum so that the DSP Laboratory Experiments course can teach students to use DSP chips for designing different real-time DSP applications. Several real-time DSP applications presented in DSP Laboratory Experiments also prepare night-school students for practical DSP system design and developments. The DSP courses presented in this paper met the needs of night-school students and assisted them significantly in their works.

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