Multidisciplinary Integrative Learning and Assessment in Engineering Education (Case Study)

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Index Terms: Multidisciplinary, Learning, Assessment

Introduction

Rapidly changing technology along with increasing industry expectations provide escalating challenges for engineering graduates. In addition to excellent technical skills, industry expects vocational engineering graduates to demonstrate good communication and learning skills, and the ability to integrate knowledge from various sources [1]. "Work-ready" engineering and technology graduates need to be confident in applying their skills and knowledge to modern technological systems [2]. However, it is proven that connecting knowledge from multiple sources is difficult and requires a proper and thorough understanding [3].

There are various approaches adopted for integrative learning. A number of institutes offer workshops on classroom approaches that promote connection making, such as collaborative learning, service learning, and others. Particularly in engineering and technology, industry seminars and training sessions are normally conducted to give a valuable exposure to the students on the current industry standards. However, in general, the engineering curricula are focused on technical subjects without sufficiently integrating them into industry practice. Most tertiary students, in their first two years, find difficulty in integrating theoretical knowledge and practical experience gained in two or more subjects and apply them to a real-life engineering problem [3, 4].

A contributing factor could be a somewhat artificial demarcation between engineering subjects along theoretical and practical lines, for example, in tertiary electronics programs Digital Signal Processing (DSP), traditionally taught as a theoretical subject, and the Microprocessor Applications (MA), traditionally a practical, laboratory based subject [2]. Most of the students are unable to relate the theoretical knowledge gained in DSP, to practical platforms and are unable to implement the DSP algorithms using a microprocessor. Hence, integrative learning should be considered as an essential means of delivery [3], especially within the framework of Vocational Education and Training (VET). In VET, the employability of graduates is directly related to their competence in both the practical and theoretical aspects of modern engineering systems and applications.

This paper is based on action research in teaching and learning and researches the potential in teaching and integrative learning by introducing a common project for the two courses of DSP and Microprocessor Applications. It was undertaken by electronics teachers in the School of Engineering (TAFE) at RMIT University. The project was funded by the Science, Engineering and Technology portfolio, RMIT University. This research project received ethics approval from RMIT University Ethics Committee. Based on the proposed methodology, the research outcomes of implementing a common project were evaluated and reviewed to establish directions for further improvement.

Objectives

The main aim of this research was to enhance integrative learning by specifying a common project for the theoretical subject (DSP) and the practical subject (MA) that were taught in the second (final) year of the Advanced Diploma of Electronics Engineering. The other expected outcomes included the following:

- use teaching time across the two subjects effectively
- improve students' learning experience
- enhance work integrated learning
- improve quality of teaching
- strengthen industry links

Methodology

The collaborative action research method was used to conduct the study as it has the potential to improve teaching and learning, action and reflection, and to link theory and practice [5]. Collaborative work has been found to benefit both staff and students [6]. It is essential in engineering education to design courses with integrative learning in mind. As the project work focused on the application of knowledge [1], it was decided by the researchers to specify a common project as a tool for integrative learning. As per the curricula, the learning outcomes for both the courses, DSP and Microprocessor Applications were listed, and a series of consultations were held with industry experts to gain an understanding of the relevance of the learning outcomes to the current industry projects. As suggested by the industry experts, after completion of the project the students were expected to have a better understanding of mathematical algorithms, hardware and software and the flow from algorithm level to implementation level. General attributes such as logical thinking, an analytic approach, quick learning for rapidly changing technology were some of the essential characteristics expected from students [1].

Based on the learning outcomes of the two subjects (Appendix 1), plus industry feedback, a suitable industry related project was developed in which the students were required to design, develop, test and document. This project covered most of the learning outcomes for the DSP and MA subjects (Appendix 2). The project included problem solving as a part of the design and hence had a mixed-mode approach of problem solving and project-based learning. Other factors, such as students' underpinning knowledge, complexity of the project, time duration for completion of the project, and efficient use of the allocated time were also considered.

Implementation

The students in the final year of the Advanced Diploma of Electronics Engineering were divided into two groups. One group included ten students who volunteered to undertake the experimental project with the control group made up of the rest of the students. The control group was taught the two subjects in the traditional way. The students in the experimental group had to use the theoretical knowledge of DSP and the practical knowledge and skills in Microprocessor Applications to successfully complete the specified project. Before commencing work on the project, a pre-project survey (Appendix 3) was conducted to measure the capabilities and underpinning knowledge of the students in the two subject areas.

The students were asked to start working on the project when it was considered that they had sufficient theoretical knowledge for both subjects. They had 6 weeks (8hrs/week) in the final semester to complete the project. Based on the specifications given, the students designed, built and tested the project, within the specified timeframe. After completion of the project, a post-project survey (Appendix 3) was conducted to re-assess the knowledge gained and capabilities developed by the students in the two subjects. At the same time the control group was taught and assessed in the established method of assignments and a written examination for DSP, and laboratory exercises and a written examination for Microprocessor Applications. The written examination was common for both groups.

Results

The results of this research project were evaluated by collecting and analysing data based on students' written examinations; feedback received from the students, industry partners, and the teaching team; researchers' observations and reflections. Qualitative and quantitative analysis was conducted using student pre- and post-survey forms. The project outcomes were finally assessed based on the results of the analysis. The participating students' learning experience, achieved learning outcomes and their performances in the written examinations were compared to those in the control group.

The following results were obtained:

- The concept of Work Integrated Learning was successfully implemented in a traditionally theoretical subject. Industry Advisory group commended the real-life application of the project and high industry standards of the student work (Appendix 4).

- Normally the DSP subject is taught for 4 hrs/week whereas Microprocessor Application is taught for 6hrs/week during the final semester. However, the project was designed in such a way that the students implemented DSP algorithms using microprocessors during the MA class time and hence the effective teaching and learning time for the DSP course increased from 4hrs to 6hrs per week as seen in Fig. 1.

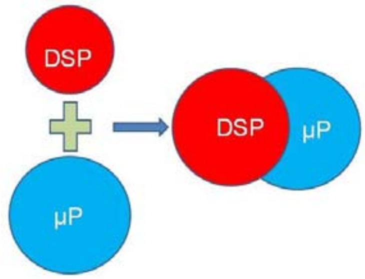

Figure 1

- The results of the pre-project survey indicated that 70% of the participating students agreed that DSP was taught as a purely theoretical subject and they found it difficult to understand the mathematical DSP algorithms. In spite of having been taught the subject of Microprocessor Applications, 83% of the participating students were not confident in implementing the mathematical algorithms learned in DSP.

- The post-project survey demonstrated that 100% of the participating students "strongly agreed" that working on the project had improved their understanding of DSP and made them confident in implementing the mathematical DSP algorithms. All the students were highly satisfied with the project.

- It was found that 30% of the control group were not successful in completing either or both subjects while 100% of the students in the experimental group successfully completed both subjects with good results.

Conclusion

This case demonstrated that multidisciplinary learning and assessment based on an integrated project increased the confidence of the participating students in both subject areas. The students were enthusiastic, focused and participated actively in the project work. They were better able to apply theoretical knowledge in practice. The student learning experience in both subject areas improved significantly. The teaching time allocated for the two subjects was effectively utilized as the project was completed in the specified time frame and with a better understanding of the two subjects. It facilitated the process of continuous improvement of teaching and learning quality, and benefited both the teachers and the students. Hence, this study supports the concept that through project based integrative learning and by applying collaborative action research, the quality of engineering education can be improved.

Discussion

A similar approach can be applied to a number of engineering disciplines. Australian vocational (TAFE) courses are competency-based, which means that the students have to demonstrate competence in performing specific tasks. Multidisciplinary learning and assessment method allows us to combine several competencies in a meaningful cluster and use an industry-related project to enhance the students' learning in each competency, and provide a common assessment tool.

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Appendix 1. Learning outcomes

EEET6628C Microprocessor Applications

On completion of this subject students will be able to:

- Understand, distinguish, and describe various architectures of Microprocessors/microcontrollers with special reference to Harvard architecture
- Use 16 bit fixed point processor/microcontroller to
  - Process data digitally(DSP operations)
  - Develop hardware and software interfaces to receive, process and transmit DSP data.
  - Use real time interrupts and other software driven interrupts.
- Link assembly language modules with high level language modules (using C)
- Design and construct signal conditioning circuits.
- Use Microcontroller for timing operations.
- Interface microprocessors/microcontrollers to A/D and D/A converters

EEET6630C Digital Signal Processing

On completion of this subject students will be able to understand and implement the following DSP concepts:

- Sampling, aliasing, reconstruction and quantisation
- Time domain processing- correlation, convolution and modulation
- Spectral analysis
- Filtering

Students will use software tools to produce real life applications. They will be exposed to software simulations and appropriate hardware platform for implementation.

Appendix 2.

Project: Design, implementation and testing of a FIR filter using DSP56803 processor.

EEET6628C Microprocessor Applications
EEET6630C Digital Signal Processing

Introduction:

The aim of this project is to provide students an opportunity to apply DSP techniques that they have learnt in their DSP theory classes. They will do this while achieving the learning outcomes of Microprocessor applications course. This project will therefore cover the competencies of both the courses.

Students are required to complete this project in groups with no more than two students in a group. Students are encouraged to choose their group members themselves. However, if needed, teacher's help can be sought to solve grouping issues.

Students will be provided with all the software and hardware tools viz. DSP evaluation boards, oscilloscopes, signal generators, power supplies, MATLAB, electronic components and other consumables like OPAMPS, DACs, and wires.

The project is to be completed in two stages; stage 1 must be completed before proceeding on to stage 2.

Project Time Lines:

Stage 1	October 1, 2007
Stage 2	October 29, 2007

Project Description:

Stage 1: Implement A/D and D/A conversions using DSP56803 and a suitable D/A converter

Students will:

- Construct an analogue Low Pass filter with a cut off frequency of 1.2 KHz.
- Use A/D subsystem of the DSP56803 processor to implement an interrupt driven 12 bit A/D conversion to sample the analogue signal output of the low pass filter designed in the previous step. Sampling to be done at 10 KHz.
- Use SPI subsystem to transmit this data out at the same frequency (10 KHz)
- Use a suitable D/A converter to convert the digital signal back into analogue signal.
- Use a Low pass filter to filter out undesired high frequency signals.
- Compare the input signal and output signal on the oscilloscope.
- Implement the following into the input signal and observe the resultant signal on the oscilloscope.
    - delay
    - echo

Stage 2: Design and implement an FIR filter. The specifications for this filter are given below.

Filter Implementation	FIR
Pass band ripple	0.5dB
Stop band attenuation	25dB
Pass band	990Hz – 1010Hz
Stop band edge frequencies	900 Hz, 1100Hz
Sampling frequency	10 KHz

Students will:

- Use MATLAB to calculate the coefficients and plot the frequency response for the above filter.

- Investigate the effects of coefficient quantisation on frequency response
- Implement this filter using DSP56803 processor.
- Test and demonstrate real-time filtering

Project report:

Students to submit a project report with the detailed description of each aspect of the project.

Appendix 3.

PRE- STUDENT FEEDBACK SURVEY

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I am able to relate the theory learnt in Digital Signal Processing (DSP) to real life/practical applications.					
2	I am good in applying micro-controller skills learnt in the course to areas of DSP/Control/Communications or related engineering field.					
3	Based on the current DSP curriculum, I have understood the DSP course very well					
4	I am confident in implementing mathematical algorithms using the micro-controller					
5	The DSP algorithms are easy to understand based on the background knowledge					
6	There is a good balance between theory and practice in the DSP course					
7	There is a good balance between theory and practice in the Micro-controller course					
8	I did have previous knowledge in using micro-controllers					

POST- STUDENT FEEDBACK SURVEY

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I am able to relate the theory learnt in Digital Signal Processing (DSP) to real life/practical applications.					
2	Working on the Project made me more confident in DSP area					
3	Working on the Project made me more confident in Micro-controller area					
4	The time allocated for the Project was sufficient to complete it					
5	My overall skills have improved and I have gained a better understanding of DSP and Micro-controller applications through this Project					
6	There is a good balance between theory and practice in the DSP and Micro-controller courses					
7	My previous background in micro-controller helped me to learn faster with the Project					
8	Overall, I am quite satisfied with the project					

Appendix 4. Student Project

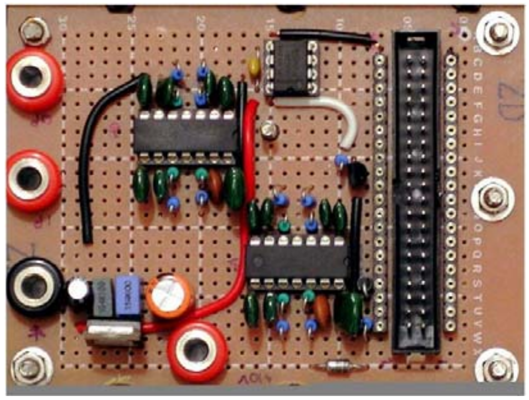

Figure 2. Hardware Design

Figure 3. Filter Output