Engaging International Students Through the Setting of Challenging Mini-Projects

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Abstract*: This paper reflects upon the introduction of a Co-operative Project to the Curriculum for Masters Students studying Advanced Digital Control at the University of Adelaide's School of Mechanical Engineering. The rationale for the project's structure is presented and its effectiveness is assessed through consideration of student feedback and the success of the student team in a series of national and international competitions.*

Introduction

Advanced Digital Control (ADC) is a Level 4 course undertaken by both final year undergraduate Mechatronics students, and Masters students, in the School of Mechanical Engineering at the University of Adelaide. Prior to 2009, Masters students undertaking courses at Level 4 were typically required to complete a course specific, individual, mini-project accounting for 1 unit of extra credit. In ADC the mini-projects were selected from a list presented to them and were historically of a technical and theoretical nature often encompassing computer simulations within an environment such as Matlab or Xilinx ISE, e.g. The development of a configurable filter using ΣΔ conversion. Students were required to research the topic, develop a project plan, carry out appropriate simulations, develop necessary software and conduct testing.

The learning outcomes from these mini-projects were very often less than one might hope for. International students often have little experience of practical engineering and frequently have difficulty working on projects. Too often the ADC mini-projects were not completed successfully. It seems that the students' academic and cultural background leaves them ill-prepared for such projects and a very supportive environment is necessary for them to be successful (Mahat and Hourigan, 2006).

For 2009 the mini-project was re-cast as a co-operative project in order to broaden the scope of the learning outcomes to accommodate those associated with team working. This was coupled with a desire to move beyond isolated, narrowly focused laboratory work in order to better prepare students for employment in the modern workplace. It was also expected that the need for the supervision of only one project would reduce the burden of supervision and that the team members could, to a certain extent, support each other.

Project Framework

The mini-project was developed as a team project, both in order to have the team complete an ambitious project in a relatively short timeframe, and to develop the 'soft skills' employers are demanding of engineering graduates; those that enable them to operate effectively in today's workplace: diplomacy, flexibility, leadership, communication skills, creativity, problem solving and project management.

To tackle the difficulties inherent in meeting such disparate learning outcomes the Royal Society (1998) recommended that courses should:

- integrate within them design, teamwork and inter-personal skills
- concentrate on problem based learning and its particular motivation to develop awareness of social, economic and environmental issues
- provide an adequate number of design projects and, generally make courses more motivating, stimulating and exciting

As student led knowledge acquisition was required to complete the project successfully (the necessary knowledge was not taught in the course) the project also encompassed Problem Based Learning (PBL).

Specific course learning outcomes met by the project included:

- have the skills to design digital controllers able to meet defined specifications
- be able to assess the stability and robustness of digital control systems
- understand the need to undertake lifelong learning

while developing the following, course specified, graduate attributes:

- ability to apply knowledge of basic science and engineering fundamentals
- ability to communicate effectively
- ability to undertake problem definition, formulation and solution
- ability to utilise a systems approach to design and operational performance
- ability to function effectively as an individual in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member

The project was also somewhat open-ended: a minimum specification was presented but the students were free to extend this if desired to improve aspects of performance.

Negotiated Learning Objectives

Each student was required to complete a pro-forma identifying key individual learning objectives, categorised into four broad areas:

- knowledge and understanding, e.g. principle of operation of the servo motor
- intellectual abilities, e.g. analyse and interpret data
- practical skills, e.g. use instruments or software tools
- general transferable skills, e.g. use of IT, communication, teamwork

These negotiated learning outcomes have repeatedly been found by the authors to be effective in allowing students to focus on their own development priorities and furthermore, crucially they help to change the students' focus from 'how much work is required to pass the course' to 'what would I like to learn' (Grainger et al., 2006).

Student Meeting Minutes

The student team was required to take minutes of their meetings and to post these online. These can be quite brief and a template was provided to guide the students in recording the appropriate information. They provide evidence of each individual's contribution in an ongoing manner such that the supervisor can take action in time to rectify problems that might arise during the course of the project.

Assessment

Assessment was based on the team's output and also the conduct and effectiveness of team processes such as teamwork and planning. A 4000 word report was required detailing the system's operational principles, conceptual design with a full explanation of their design choices and judgements and a critical analysis of the results. This comprised 75% of the coursework mark. The balance of 25% was for a reflective essay submitted by each student individually. This comprises a critical evaluation of the student's achievement of their learning objectives and of the learning process and recommendations for improvement.

A final element of the assessment was a weighting of the mark for individual engagement as evidenced by the team minutes and the reflective essay. This provides a mechanism for ensuring students who do not engage in the project do not unduly benefit from the work of others while also allowing for exceptional student effort to be recognised.

The ADC Project – A Robotic Concertina

Co-incidental with the reconsideration of the ADC mini-projects, an opportunity arose to develop a robotic musical instrument with sponsorship from NICTA (National ICT Australia, Australia's Information and Communications Technology (ICT) Centre of Excellence).

The ADC Masters students comprising six international students from China and Iran, undertook the design of a robotic concertina, the instrument being a 48-key Stagi 'English' Tenor Concertina (interestingly, the concertina was invented in 1829 by British Scientist, Sir Charles Wheatstone, more famously known for The Wheatstone Bridge).

The bellows are driven by a microprocessor controlled servo motor via a rack and pinion mechanism using feedback to control the air pressure. Microprocessor controlled solenoids are used to open and close valves, allowing air to flow over the sound-producing reeds. All the skills developed during the project, including the mechanical, software and electronic design, are directly applicable to the real world of mechatronics engineering and graduate students might be expected to design similar systems for hard disk drives, automotive anti-lock braking systems or manufacturing robotics.

Artemis Orchestral Contest

The Artemis Orchestral Contest is a novel mechatronic competition as the focus is on music. The mechatronic devices built for the competition are not technically robots, they do not have the required degrees of freedom or re-programmability to be classified as such, but for the general public the distinction is moot. They see a robot and instead of shooting, fighting, racing, flying or some other cliché robot activity, it is engaged in playing a musical instrument. The Artemisia Association (the body that runs the international competition) has the aim of using the contest to "to stimulate interest in young people in Embedded Systems technology and its applications". NICTA supports that aim and attempts to use participation in the contest to the same end, in Australia.

NICTA enters the Artemis Orchestral Competition (Artemisia, 2009) as part of a larger effort to motivate school children to consider ICT as a career option. Enrolments in ICT related university courses in Australia have fallen dramatically in recent years and NICTA is pursuing a number of activities to try to both increase, and maintain, interest in school children in ICT careers. These activities include sponsorship, creation and delivery of new embedded programming course content for the National Computer Science School (NCSS, 2009) and sponsorship of the 2009 Young Aus-Innovators National ICT Prize (ACS, 2009).

NICTA Candiago Challenge Cup

NICTA generates candidate entries for the international contest by hosting a local version named the "Candiago Challenge Cup" (NICTA, 2009). Part of the prize for winning the cup is an offer for NICTA to sponsor participation in the Artemis Orchestral Competition the following year. The robotic concertina developed by the students won the Candiago Challenge Cup in 2008 and subsequently two of the students, with further development of the concertina, travelled to Nice, France, to compete in the Artemis Orchestral Competition.

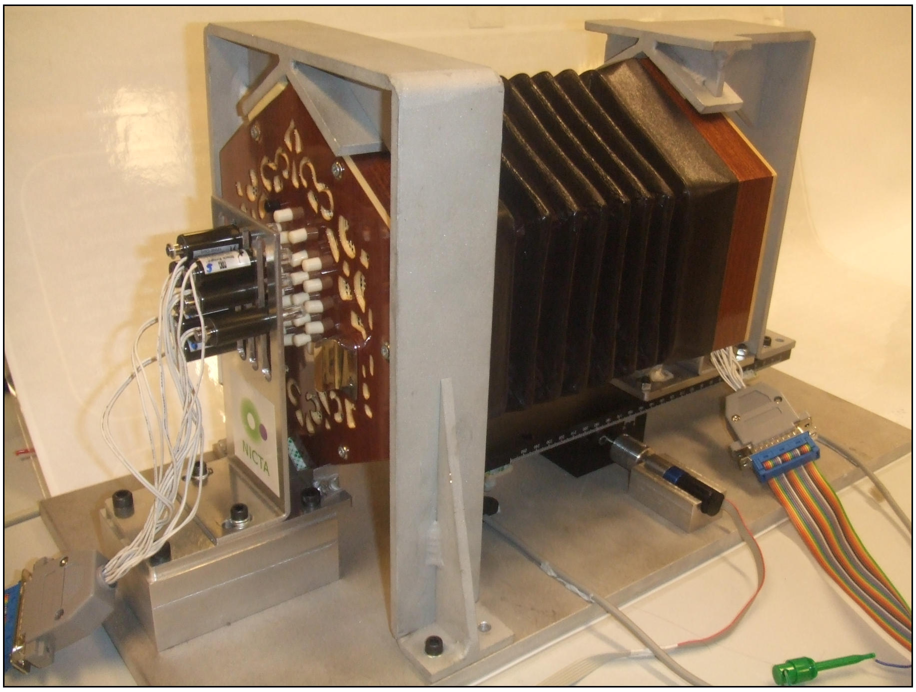

Figure 1: The robotic concertina

NICTA has also displayed the Concertina and previous competition entries at the Amazing World of Science exhibition as part of the annual Australian Science Festival in Canberra. The exhibition attracts thousands of school students of varying ages. In 2009 the Concertina display contributed to the fact that the NICTA stand was voted the third most popular in the exhibition. Over three years, three different musical instrument playing robots have been demonstrated at the exhibition. The robots attract a good degree of interest from kindergarten, infant and primary school students who, when the device is playing, are simply fascinated. For secondary students the robot attracts those who already have an ICT interest but it also attracts others who are interested in the music and who may play the musical instrument in question. A question yet to be resolved is whether or not this music based attraction, for any of the age groups, will prompt an ongoing and lasting ICT interest.

iAwards

The students also took first prize in the tertiary student project category at the SA iAwards for innovation in ICT. Following their state win they went forward to the National Finals where they received a special Merit Award entitling them to represent Australia against the Asia Pacific region at the APICTA (Asia-Pacific ICT Alliance) Awards 2009.

Student Feedback – Analysis of the Reflective Essays

Analysis of the reflective essays indicates the students have readily acknowledged the benefits of a team project in terms of the basic outcomes one might expect with comments including ‘help(s) us to improve…(project) management (skills)’, and, ‘my ability (to) solve problems has been improved’. The PBL nature of the project is also acknowledged. Student C notes the project ‘refers to many aspects of knowledge which are not familiar for…the members (of the team)'. Their reflection on teamwork is summarised in Table 1 alongside two other aspects frequently discussed.

Table 1: Student Feedback

Student	Teamwork	Negotiation	Vicarious learning
A		'negotiation very valuable'	
B	'keeps us energized, motivated and provides support'	'when…we could not decide whose opinion is better, we let the proposers do further research to find more evidence'	'we have learned a lot from other members' 'I learn a lot from group discussion'
C	'learn to co-operate to solve problems'		'I learnt to share information'
D		'I've learned to trust my group members and (to) co-operate with them'	
E	'(learn) to divide project into parts'		
F	'learned team co-operation'		

The essays clearly indicate the students are reflective of their learning process, their acquisition of engineering skills and also the subtleties of group dynamics. The support of their learning provided by the team is also recognised.

Conclusions

The setting of a challenging mini-project has been shown to engage international students. The team achieved exceptional success in national and international competition allowing the students to travel, and broaden and deepen their cultural experiences. With the pace of technological change it is unrealistic to expect that engineering education will cover all the scientific, technical and higher mathematical topics that a practising engineer may encounter. By utilising a PBL approach, the skills necessary to acquire knowledge 'on the job' are imparted and soft skills developed but not to the detriment of knowledge acquisition. From the perspective of course delivery and project supervision, the use of a team project has greatly reduced the burden of supervision.

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