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# Students' successful experiences in innovation in the second year of their programme: a case study

**Kollengode S. Ananthakrishnan† & Kevin J. McDermott‡**

University of South Australia, Whyalla Norrie, Australia†
University of South Australia, Mawson Lakes, Australia‡

ABSTRACT: Modern engineers are expected to be innovative and to possess the generic skills necessary to transform innovation into reality. Engineering programmes in universities are changing from content transmission models to facilitation models. The article describes highly successful outcomes from a second year course in engineering innovation and practice as part of a four year undergraduate programme run in a small, geographically isolated campus of a major university. Student projects prepared as part of the course requirements have been recognised in national design competitions. Students have exhibited enthusiasm and enhanced motivation, the development of transferable generic skills, as well as an induction into a culture of innovation. It is argued that these outcomes favour the adoption of formal innovation experiences into the second year of engineering programmes.

## INTRODUCTION

The 1995 Review of Engineering Education in Australia was conducted under the auspices of the Institution of Engineers, Australia (IEAust), the Academy of Technological Sciences and Engineering (ATSE) and the Australian Council of Engineering Deans (ACED). The Review recommended that there be significant changes to the traditional engineering curriculum at Australian universities. The Review Report advocated a cultural shift from content transmission to the learning and exercise of skills that support innovation and implementation [1].

Concurrently, the Engineering Schools at the University of South Australia (UniSA) made a concerted change away from the previous transmission model towards a facilitation model. As part of the change, a new course (subject), titled *Engineering Innovation and Practice* was developed for inclusion in the second year of all engineering degree programmes.

The new course was adopted as part of the common core of programmes offered at the geographically isolated Whyalla campus of the University. Because there were fewer disciplines on offer at Whyalla than in the metropolis, hence less in the way of competing disciplinary practice demands, and because of the high proportion of industry-sponsored cadets with guaranteed participation in structured practical experience, the *practice* element could be de-emphasised and more time and effort devoted to the *innovation* component.

The few mechanical students enrolled in the course were encouraged to participate in a joint project at the national level. The role of these remote area mechanical engineering students was to examine the existing safety structures of Formula V racing cars, and to propose innovative solutions for improved safety structures for the next generation of vehicles. Students from collaborating institutions within South Australia undertook the design of other sub-systems for the FV 2000 concept car. The vehicle design was entered in the 2001 National Engineering Competition and was declared the outright winner against potential and actual competition from all Australian schools and faculties of engineering.

Another student, working independently, was required to design an innovative toy. His concept of a handlebar-powered child's tricycle has since been elaborated as part of his subsequent studies in industrial design. The prototype was selected against strong competition as a 2002 national finalist in the prestigious Australian Design Awards.

This article principally discusses the role played by the second year mechanical engineering students, working distantly from their colleagues, in contributing so much to the successful outcome of the joint racing car project and, to a lesser extent, the creativity displayed by the individual student in his innovative design. These examples demonstrate clearly that incorporating innovation formally into the early levels of engineering courses can potentially lead to worthwhile creative achievements. This, in turn, contributes to the formation of engineering graduates who are imbued with the values of, and equipped for, the practice of contemporary professional engineering.

## THE COURSE *ENGINEERING INNOVATION AND PRACTICE*

The course, Engineering Innovation and Practice, was a compulsory unit in the second year of the 4-year Bachelor of Engineering programmes in Electrical and Electronic, Mechanical and Manufacturing, and Materials Engineering offered at the Whyalla campus of the University of South Australia. The main aims of the course were:

- To provide students with an application of a range of practical skills that are fundamental to their area of specialisation;
- To provide experience in the application of these and other skills to create innovative solutions for problems both within and beyond their selected engineering option [2].

In addition to meeting academic objectives, students in the course were expected to progress in the development of the seven desired graduate qualities as identified by the university. These qualities, and their weighting within the course, were as follows (total 4.5 points):

- Body of knowledge 0.8
- Life-long learning 0.2
- Effective problem solvers 1.4
- Work alone and in teams 1.4
- Ethical action 0.1
- Communicate effectively 0.5
- International perspective 0.1

The assessment for the course was based on the following three components:

- Assignments 10% (based on lectures)
- Major project 60%
- Minor project 30%

The major eight-week project focused on engineering practice in its broadest sense. For example, mechanical engineering students designed, manufactured and tested a bench vice, developing skills in prototype development to a given specification, and in fabrication, machining and assembly.

The minor four-week project focused on creativity and innovation. The assessable outcome of the minor project included an oral presentation and a report (about 1,000-1,500 words for each participant) for design review by a panel of experts within and external to the teaching academic institution. External opportunities provided foci for innovation for the student cohort. The efforts of students and their achievements were far greater than what was initially envisaged.

## AN OPPORTUNITY FOR MECHANICAL STUDENTS: THE RE-ENGINEERING AUSTRALIA FORUM

### Background

In times past, Australia developed an enviable reputation for innovation in many fields of engineering, from the Snowy Mountains Hydroelectric Scheme to the development of xerography and the cochlear hearing implant. Despite such achievements, in the past 30 years, there has been a noticeable decline in support for engineering capabilities.

The Re-Engineering Australia Forum was an initiative of Concentric Asia Pacific, a privately owned company, in order to stimulate and re-awaken the engineering talent of the country. Underlying this initiative was the belief that such critical areas of endeavour will determine Australia's future [3].

### Primary Goal of the Forum

The primary goal of the Forum was to advance Australian manufacturing and engineering technology, specifically through the achievement of the following objectives:

- To promote industry knowledge and skills as part of an effort to make Australia a world leader in this field;
- To create employment opportunities for Australians in the field of engineering technology;
- To work with educational organisations in order to create awareness and knowledge about the importance of the manufacturing field of industry;
- To facilitate networking opportunities between Forum members and the Government, and to help foster an industry community through regular luncheons, conferences, awards, etc.

The Forum's first major technology innovation programme was a national engineering technology competition for all Australian universities and tertiary institutions with an engineering faculty.

## ENGINEERING INNOVATION COMPETITION

The National Engineering Innovation Competition was specifically designed to create advanced industries and employment opportunities for rural and regional Australia. Every eligible institution was invited to compete by *adopting* a country town or region to develop a world leading product or process. Each innovation project entered had to meet the following competition guidelines:

- Must involve engineering design and, where possible, some manufacturing;
- Must encompass a component of e-business;
- Each university and tertiary institution must adopt at least one commercial organisation or company as an industry partner to help develop its engineering innovation project.

The competition winner's prize included sufficient funds for overseas travel and living up to $AU100,000; and this allowed for ten study tours of two weeks each to world class engineering organisations such as Boeing, BMW, Honda and British Aerospace. The successful universities or tertiary institutions could tailor these study tours to fit in with their own objectives.

## SOUTH AUSTRALIAN CONSORTIUM

Two of the three South Australian universities, the TAFE college with major provision for engineering study and a youth services agency, formed a consortium to produce an SA entry for the 2000 National Engineering Innovation Competition. This was the *Conceptual Design of a FV 2000 Racing Car*. The participating institutions were the University of Adelaide, University of South Australia (City West and Whyalla campuses), Regency Institute of TAFE (Regency and Elizabeth campuses) and the Reynella Enterprise and Youth Centre.

The principal innovative element underpinning the FV 2000 project was the engineering theme, *Developing Enhanced Racing Car Driver Safety*. The project was coordinated by Innovative Design and Research Concepts Inc., under the chairmanship of a former national president of the IEAust. The project was supported by Employment SA, the South Australian Centre for Manufacturing, Silicon Graphics, BHP, SANTOS, Dunlop, as well as the motor sport community through the Formula Vee Association and the Confederation of Australian Motor Sport as part of a national youth development programme.

FV2000 CONCEPTUAL DESIGN PROJECT

The conceptual design of FV 2000 project was modularised, with each participating institution focusing on specific design aspects of the various subsystems, as listed below:

- Suspension design, chassis design and cooling system (University of Adelaide, School of Mechanical Engineering);
- Body design (University of South Australia, School of Industrial Design);
- Safety structures (University of South Australia, Faculty of Information Technology, Engineering and the Environment - Whyalla campus and Regency Institute of TAFE Faculty of Mechanical Engineering - Regency campus);
- Graphic design and media liaison (Regency Institute of TAFE School of Graphic Arts - Elizabeth campus).

Students from the participating institutions had training on the use of the *CATIA* software package installed on Silicon Graphics 320 workstations, and both metropolitan and country students were exposed to systematic training in integrated project development.

ROLE OF STUDENTS FROM THE WHYALLA CAMPUS

The design of driver safety structures included an extension of the body nose cone to permit fitment of a collapsible energy absorbing structure ahead of the primary chassis, and the development of concepts of energy absorbing structures at the sides of the driver cockpit, which would also result in minimal increase in aerodynamic drag. A group of four mechanical engineering students from UniSA's Whyalla campus, enrolled in the course Engineering Innovation and Practice, focused their minor project on the development of a crushable nose cone structure that could be easily fitted on to the main body chassis of the FV 2000 car.

NOSE CONE STRUCTURE CONCEPTUAL DESIGN

The main aim of the nose cone structure was to maximise the impact time to give the structure more time to distribute the energy of the impact. Decreasing the transmitted force of the impact was another design consideration. It was envisaged that the combination of these two factors would provide a very safe structure for the driver of the car. Several materials and designs were investigated, manufactured, tested and evaluated [4]. Various designs were implemented by incorporating different combinations of notches, drilled sections and slits in the sample structures.

The samples were tested under static and dynamic conditions. The static test on samples was carried out using a 10T hydraulic press; the best design was then chosen from the test results.

The chosen sample demonstrated two desired qualities in the sample design. Firstly, huge impact force was not required to initiate the first deformations. Secondly, after the initial deformation, the sample became progressively more rigid, resulting in the impact being spread over the longest time possible. The force needed to initiate the deformation in the chosen design was 28.3 kN, and the resulting displacement of the sample was 93.5 mm. The sample design was implemented in square mild steel tube and incorporated several triangular notches that started off relatively large, and gradually decreased in size. The notching method was chosen so that the energy from the impact would be concentrated on the line between the extremities of each set of notches, forcing the structure to fail along that line [5].

Figure 1 illustrates the FV 2000 chassis design incorporating a safer nose structure.

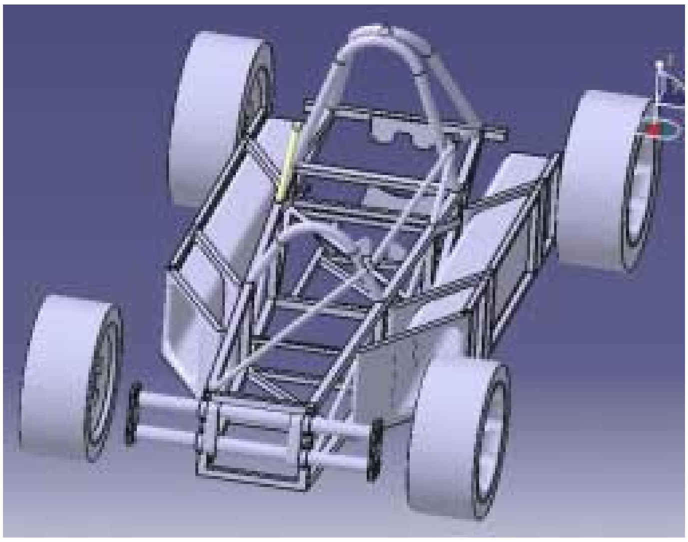

Figure 1: FV 2000 chassis design incorporating a safer nose structure.

THE OUTCOME

The SA entry, FV 2000, won the first place in the inaugural National Engineering Innovation Competition 2001 against entries from Victoria and New South Wales. Of the other entries, two Victorian entries were both in the field of aerospace, while the NSW team built a four-seater light plane.

HANDLEBAR OPERATED TRICYCLE

Of no less significance was the innovative design of a child's tricycle, deriving its motive power through the pushing and pulling of the handlebar rather than through pedals. This design was created by a student from a different cohort, but also completing his studies in 2003. Although the brief was to produce a design for a toy, the student's thought progressed from it being a wheeled toy – *I reckon they're the most fun* – to the socially aware concept that his design should provide targeted physical development, especially for children with existing disabilities.

This student has since advanced his invention to the prototype stage (see Figure 2). This was submitted as an entry in the student section of the Australian Design Awards. The national manager for the competition said that it was:

*… one of 19 highly creative designs… Each one of them has made it into the final selection because they are truly practical and provide innovative solutions to issues that have previously confronted us* [6].

Figure2: Handlebar powered tricycle (*Advertiser* photograph).

The student himself gave credit for the genesis of his project to the need to design a toy as the minor project in the second year of his programme.

EVALUATION

The Whyalla engineering students, as part of their formal reporting, made self-determinations on the extent to which they had met the objectives of the course, of their project and in the development of the prescribed graduate qualities. All reported significant gains in their ability to derive innovative solutions to engineering problems and turn them into some kind of objective reality. They also claimed significant improvement in all of the generic skills in the set of graduate qualities, as well as an increased understanding of the need for them in professional practice.

Follow up evaluations conducted this year have revealed that the generic skills learned have been genuinely transferable. Students believed that the exposure to the process of innovation in their second year had proved valuable throughout their study programmes, particularly in their final year project work. They also strongly agreed that the experience would be beneficial to their professional careers and their lives as citizens.

CONCLUSIONS

The successful outcomes of student projects, their enthusiasm and enhanced motivation, the development of transferable generic skills, as well as an induction into a culture of innovation, are all strong arguments for the adoption of formal innovation experiences into the second year of engineering programmes.

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