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Developing a National Design Competition Through Collaborative Partnerships

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ABSTRACT

The use of competitive design work embedded in first year engineering experiences (FYEEs) has been demonstrated to be an excellent learning and teaching tool. A well structured design competition enhances the FYEE and improves retention and graduation rates while also providing an excellent vehicle for developing many of the graduate attributes espoused as desirable by employers and accreditation bodies such as Engineers Australia and ABET. An opportunity was seen to exist in Australia to develop a national design competition – a possibility due to relative small number of universities and the national professional and accreditation role played by Engineers Australia. It was essential that any competition would meet all relevant learning and teaching criteria, be attractive to all universities and students and could be sustained into the future. The paper describes the development of a collaborative partnership between the Australian Council of Engineering Deans, the Australasian Association of Engineering Education, Engineers Australia, Engineers Without Borders, Australia (EWB) and Thiess. The competition was largely developed by EWB and is based on a real-life project, which enables engineering design teams to explore sustainable development and provide design solutions that will be judged by profession engineers. EWB has assumed the role of national coordinator of the competition that is now termed "The EWB Challenge". The competition should grow to become the design base for many engineering programs in Australia.

INTRODUCTION

In Australia the last quantum step taken in engineering education was in 1996 when the report '*Changing the Culture: Engineering Education into the Future'*, jointly sponsored by the Australian Council of Engineering Deans (ACED), Engineers Australia (EA), the Australasian Association for Engineering Education (AaeE), and the Australian Academy of Technological Sciences and Engineering (AATSE), was published. The report recommended outcome based teaching and learning and identified the key generic attributes that the profession and educators considered that graduates should possess, resulting in the now very familiar list of (a) to (j) graduate attributes.

For the non-engineering fraternity, the ACED provides a forum for deans to address matters of mutual interest in engineering education and research. Its mission is: '*to promote and advance engineering education, research and scholarship in Australia'*. Engineers Australia is the national peak body for all engineering disciplines, which partners with government, industry and tertiary education providers, *"to promote engineering as a discipline, and the professional development of our members"*. AaeE focuses on engineering education and states that it *"is committed to fostering excellence and innovation in engineering education"*. It is obvious that these organisations would need to play a key role in the construction of any national design competition.

I. DEFINING THE FYEE

The term FYEE is used here in the context of an experimental, design/build project based course that provides a stimulating introduction to engineering for first year students. The rationale for having an FYEE in a university covers a wide spectrum. Some points are listed below – not intended to be exhaustive, exclusive or ranked in any particular order. The FYEE addresses many issues raised by academics in the past about engineering programs, such as; too much focus on engineering science, poor design experiences, lack of communication skills, and poor awareness of environmental and social issues (Mills and Treagust 2003). The reader is referred to the literature for more details of the benefits of the FYEE (Osborn and Nag 2002, Froyd and Ohland 2005, Bullen and Knight 2006).

- The role of the professional engineer in society.
- Understanding team roles and teamwork.
- Understanding the globalization of engineering.
- The use of diverse assessment criteria.
- Addressing accreditation criteria.
- Illustrating the multidisciplinary nature of engineering.
- **Forming the foundation of design streams.**
- Providing a professional base to retain students.
- Helping program integration.
- Assisting with the pastoral care of students.

II. Benefits of centralised competitive design

The advantages cited for centralised competitions are that they allow optimisation of resources, comparative and objective assessment of the design capability of each team during the evaluation phase. They also promote reflective learning as teams are provided with the relative strengths and weaknesses of their design (Colley et al 1999, Dave and Boronkay 1997, Yuille 2002). There are also disadvantages and Cooley et al (1999) provide a detailed summary of both the advantages and disadvantages of using competitions for teaching engineering design. Some of the advantages are:

- Common design rules can be translated into the performance requirements for the design
- Competitive elements require teams to develop problem-solving strategies.
- 'Judging' in design competitions provides a defined end to the design and enforces deadlines.
- Technical challenges incorporated in the competition stretch imagination and innovation.
- The winning designs can have applications in real life and benefit society
- Evaluation allows teams to see alternative and perhaps superior design paths to their own
- Cost savings are obtained by optimising resources

These must balanced against the following disadvantages:

- Design competitions are often focused on the technical aspects.
- They omit equally important factors such as safety, ethics and sustainability
- The design problem is typically contrived and does not address realistic constraints.
- The products created may have no practical use once the competition is over.
- Addition staff costs occur to support the design and build competition.
- Competition reducing the pooling and sharing of information between teams.

The use of design competitions as part of an introductory design course (such as a FYEE) is not new and Dave and Boronkay (1997) found a decade ago that such competitions added excitement and helped the students develop *"additional insight"* in solving open-ended projects and better prepared them for ensuing design and the professional workplace. Yuille (2002) suggested that the centralisation of design via some national or international body may make the projects (and engineering) attractive to a wider student population and can help regulate expenditure through appropriate guidelines and rules. Centralisation can also make fundraising easier as major sponsors are often more attracted to national competitions.

III. Example of successful design competitions

A. Australia

The Warman Student Design Competition (2007) is a national competition for second year mechanical engineering students. The design and build competition was initiated in 1988 by the Panel on Engineering Design. Students are given a design brief, usually within a very specific context. They work in small teams of 4 to 6 students, manufacture a product that will allow them to achieve the design outcomes, and compete on their own campus. Campus winners compete at the National Finals. Incorporation of the competition into local curricula is the responsibility of the home university, but is typically worth around 10% of the subject that has carriage of the design. Some universities encourage multidisciplinary engineering teams to participate in the competition. The ongoing success of the competition demonstrates that a national design competition is feasible. EA and Warman indirectly provide the only national design experience for mechanical engineering undergraduates in Australia.

B. The United States of America

One National Engineering Design Competition in the US is sponsored by JETS (2006) (Junior Engineering Technical Society), NISH and JWOD for high schools. NISH is a national nonprofit agency focused on creating employment opportunities for people with severe disabilities. Employment is done through the Javits-Wagner-O'Day (JWOD) Program by securing Federal contracts for its community-based, non profit agencies. The competition involves design to assist people in the workplace with disabilities. Teams must select a technical mentor, undertake an internet search to learn about disabilities and biomedical and rehabilitation engineering, write a summary of key findings and finally select a workplace problem to solve. The prizes include a trip to Washington, D.C. to participate in the National Finals, $3,000 for the school's sponsoring department, plus a trip to the NISH annual conference. In addition, two 'best of' awards of $1500 are awarded to the school's sponsoring department and each national finalist team member receives a Discovery Store $50 gift certificate.

C. The United Kingdom

A national design competition was launched in 2003 by the Construction Industry Training Board (CITB) (2006), to address predicted future skills shortages in the construction industry. The CITB-Construction Skills specifically targeted the 11 to 14 year age cohort in schools and used an innovative approach to capture the interest of the schools. The competition is called Creative Spaces and asks student to redesign part of their school and provides a top prize of GBP50,000. This assists the winning school to build the winning design and regional winners also receive GBP3,000. Over 250 schools entered the inaugural competition in 2004.

D. Multi-National

Examples of international design competitions are the SAE International (2006) and the World Solar Challenge (2006). However these focus on specific engineering disciplines and require significant funds to allow students to participate competitively. An Australian university would need to raise upwards of AUS$150,000 to allow a limited number of young mechanical engineers to compete at just the national level.

One discipline specific competition has been taken international very successfully, due likely to its social basis and low entry costs. The IEEE Computer Society (Institute of Electrical and Electronics Engineers Inc.) saw a need for an innovative and attractive system design competition in the areas of computer science and computer systems and constructed the Computer Society International Design Competition (CSIDC) (2007). The vision for the competition was *"The Computer Society International Design Competition will advance excellence in education by having undergraduate student teams design and implement computer-based solutions to real-world problems"*. Details of the initial competition are provided in Clements 2001), but in summary the CSDIC was for teams of 3 to 5 students in the final year of their course. A kit is provided to teams and a limit of US$200 imposed on any additional funding.

Table 1. CSDIC Winners

Year	Competitors	Winner	Project
2005	200 teams from 109 universities, 50 countries	North Carolina, USA	NEAT – Networks for Endangered Animal Tracking
2004	250 teams from 144 universities, 28 countries	Poznan University of Technology	Lifetch – Life Saving Systems
2003	150 teams	National University of Taiwan	NEWS – Novel Educational Wireless Style
2002	70 teams	Politechnica University of Bucharest	BE Secure-Building Surveillance Equipment
2001	75 teams	Poznan University of Technology	Blues Eyes – Conscious Brain Involvement Monitor
2000	50 teams	McMaster University, Canada	The Total Health Care Unit

Team submissions are emailed to members of Submission Evaluation Teams (SET) located around the world. In 2006 the prize money for 1st to 3rd was US$20,000, $12,000 and $8,000 with the topic "Preserving, Protecting and Enhancing the Environment". The information in Table 1 suggests that the CSIDC approach of keeping the guidelines simple, minimizing participation cost and providing significant prize money has worked well, with participating teams growing from 50 in 2000 to 200 in 2005. In 2006 the number of teams was limited to 300, selected at random and subject to geographical considerations.

IV. A NATIONAL DESIGN COMPETITION FOR AUSTRALIA

As indicated earlier the obvious partners at the national level were EA, ACED and AaeE. Engineers Without Borders, Australia (EWB), were seen as potential players - EWB is a volunteer organisation that, "*works with disadvantaged communities to improve their quality of life through education and the implementation of sustainable engineering projects"*.

One aspect that should be considered is ensuring that students possess adequate knowledge, skills and access to resources to tackle and complete the design. One criticism sometimes leveled at the Warman Competition (2007) is that students do not always have an adequate founding in engineering science to carry out a full design and that the 'build' part of the competition requires the commitment of excessive resources from both the students and the department. It was important to ensure that the design task is shaped such that it fits within these limitations. This aspect was taken into account when scoping the design event.

While the educational benefits do not need reiterating here, it is still worth matching some of the EA generic attributes against a competitive design (Table 2). Educators can use non-competition components of their FYEEs to address the development of other generic attributes.

Table 2. Matching EA generic attributes to design

EA Generic Attribute	Competitive Design
ability to apply knowledge of basic science and engineering	Design topic and rules.
ability to communicate effectively with engineers and community	Display and defense of project outcomes
ability to undertake problem identification, formulation and solution	The overall competition.
function effectively as leader, manager, team member in multi-disciplinary, multi-cultural teams.	Team based competition
understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development	Type and scope of the design content

V. FORMING THE COLLABORATIVE PARTNERSHIP

The use of collaborative partnerships in engineering education is very common and they form the foundation of experiential learning. In the financial constrained Australian tertiary education scene many programs exist due only to collaborative partnerships with industry. In the case of the design competition the situation was complex as it was essential that the collaborators spanned all university and state boundaries.

The conceptual framework of the competition was formed by the first author during his study leave at the University of Colorado. The subsequent process adopted was to write a position paper, which led to the ACED providing $2000 seed funding. A draft competition was approved in principle by ACED who allocated a further $2000 for preparation of a flyer that could be distributed to all Australian and New Zealand universities.

Parallel to the above events the University of Tasmania and EWB Tasmania were discussing the merits of the EWB playing a role in the design competition. EWB Australia immediately recognised the potential of the design competition and offered to provide a national coordination role. AaeE saw the educational merits of the proposed design competition and committed $2000 towards the project. The design competition was launched as the "EWB Challenge" at

the 2006 AaeE Conference with much enthusiasm and acclaim. The national profile of EWB had also attracted a major sponsor for the Challenge, a success that completed the collaborative partnership (figure 1) when Thiess (2007), Australasia's largest construction, mining and services company became the exclusive corporate sponsor.

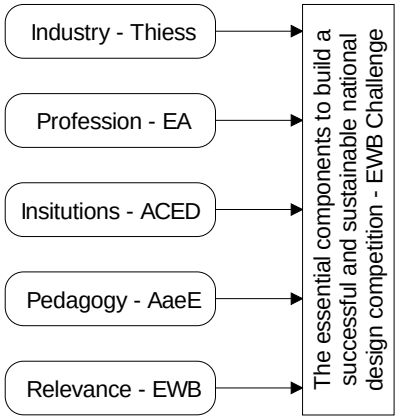

Figure 1

VI. The 2007 Challenge

The EWB Challenge (2007) is described as *"a national design competition for first-year university students"*. The competition aims to develop students' learning experiences and key attributes *"through a team-based design approach utilising inspirational sustainable development projects"*. The aims and objectives of the Challenge are detailed in the 2007 Competition University Information Pack (EWB 2007), which includes, *"the objective of the EWB Challenge is to actively engage first-year university students in real-life, sustainable development projects. The competition will help ensure that new university students are inspired and motivated by their 'first year engineering experience', producing more effective educational outcomes through exposure to holistic design"*. EWB worked closely with AaeE and ACED to ensure that the Challenge supported the core curriculum of an ideal FYEE including the following:

- Introduction to the engineering design process;
- Developing communication skills;
- Introduction to teams, teamwork and team dynamics;
- Hands-on design project, including reverse engineering;
- Ethical, professional and sustainability considerations.

The 2007 EWB Challenge focuses on the sustainable development of the Uluru Children's Home, an orphanage located in Alamparai in the southern Indian state of Tamil Nadu. In 2001, The East West Overseas Aid Foundation (TEWOAF) (2007) began the construction of Uluru Children's Home (UCH) with the aim of providing shelter to orphaned, abandoned and destitute female children. TEWOAF aims to assist in easing the suffering of the poor and disadvantaged overseas through a range of initiatives in health care, child welfare and education.

The first phase of construction work at UCH was completed in January 2002. The Home was initially purpose-build to house approximately 25 infants and children, as well as live-in staff. In 2007 - 2008, the number of infants and children requiring care will rise to 80. There is a corresponding requirement to house more support staff on-site and to provide accommodation for visiting guests. In addition, there is a desire to expand educational facilities that reach out into the wider community.

A number of projects, listed below, have been identified by EWB for investigation. Design outcomes should assist in the development of various infrastructure features which would help make UCH a more sustainable and effective facility from a social, environmental and financial perspective. Design teams are able to address a single issue or provide an integrated design solution for two or more issues and must consider layout and functionality. The Challenge is an open-ended learning experience and the breadth and depth of design is left to individual universities and design teams.

- Building Extensions and New Facilities
- Computer Education Centre Expansion
- Educational Software
- Water Supply and Treatment
- Waste Water Management
- Solid Waste Management
- Power Supply
- Cooling System
- Cooking Methods
- Permaculture

A. Submission and Judging Requirements

Challenge rule details are available in the Competition University Information Pack. The intent is that the EWB Challenge will be incorporated into first year design subjects offered by universities during semester one (normally running in period February to June). Individual universities will decide how to integrate the competition into their curriculum, and the design could consume up to around 15% of a semester's workload. Each university may enter an unlimited number of teams into the competition within the home institution and will assess their own teams' submissions. Up to 4 team submissions may be lodged for external judging in the national finals. Each submission must consist of a design report written in English, which should not exceed 20,000 words in length. One hard copy and one electronic copy of the submission must be provided to the judging panel for evaluation. As a minimum, each team design report should:

- Provide an overview (executive summary) of the recommended design.
- Identify alternative options and justification for the selected technology, approach and/or process.
- Details of the conceptual design, analysis and final design. Appropriate calculations may be provided.
- Identify schedules, detailed design, and associated with construction and maintenance costs.
- Identify how the selected design is appropriate to the

social, environmental and economic context.
- Discuss the long term sustainability and maintenance of the engineering work that would be completed.
- Provide basic advice on the construction and operation of the design including the role of all relevant groups.
- Contain a statement that provides full details of any external assistance and content that is not attributable to the design team.

Each entry must be accompanied by a 4 page maximum executive summary that provides a concise description of how the design addresses each of the criteria. The summary must also include a team reflection on their learning/experience. The entries will be reviewed by a multidisciplinary panel that includes representatives from EWB, TEWOAF, Thiess, EA, ACED, AaeE and SpeakOut (2007). The panel will select a short-list of 6 entries to be presented by the teams during a special session at the annual AaeE conference. Submissions will be evaluated on both the written and team presentations with the relative contribution being 75% for the written submission and 25% for the team presentations. The methodology of assessment as part of university curricula remains with the home institution but it is envisaged that some broad guidelines relating to fraction of a student's total semester workload will emerge from this first competition.

The EWB Challenge awards ceremony will be held at the AaeE conference and all 6 finalist team members will receive certificates to acknowledge their achievement. Money prizes will be rewarded to 3 teams with first prize being AUS$3,000, second $2,000 and third $1,000. The winning team can also join EWB for an international study tour on community development. The tour will run for approximately three weeks and include an observation visit to UCH.

VII. State of Play

At the time of writing, 19 Australian universities and 1 New Zealand university will participate in the EWB Challenge in Semester 1, 2007. An additional 5 Australian universities plan to offer the 2007 design brief to students enrolled in Semester 2 courses, external to the competition. These students will not be considered for final judging, however they will have the opportunity to present their work to their peers at regional showcase events, along with competition participants from Semester 1. EWB Chapters (member groups) will hold EWB Challenge showcase events during Engineering Week. These events will provide students with the opportunity to share their ideas and experiences with their peers and the broader engineering community.

EWB is supporting the integration of the EWB Challenge into course work through direct communication with course coordinators and presentations at participating universities. The presentations will provide students with an overview of EWB and the Challenge design brief in 2007.

A new website has been created for the competition (www.ewb.org.au/ewbchallenge). The website facilitates information dissemination to students and universities and streamlines the competition registration process. It includes a resource centre and a forum for students to post questions to EWB regarding the design brief. In addition, students may subscribe to the EWB Challenge eNewsletter through the website. The EWB Challenge eNewsletter is issued monthly and provides students with articles and resource links on appropriate technologies and sustainable community development.

VIII. Summary

The use of competitive design as a teaching and learning tool has been well established, encouraging students to develop technical, design, teamwork and communication skills. While the engineering education system in Australia is very diverse, it appears that it has embraced the fledging Challenge with vigor. The implementation of this national competition based on design should also encourage all engineering schools to incorporate a FYEE into their first year programs.

The various methodologies employed by universities to assess and incorporate the competition into curriculum will be reviewed and some broad guidelines as to relative workload for the competition will emerge as a consequence of the initial competition.

The profession and industry can and should play a larger role in developing and funding FYEEs and their embedded design as it has been the profession's need for more rounded graduates that has stimulated FYEE growth. Industry involvement could involve sponsoring a national design competition (as in the Challenge), or by injection of funds for the purchase of equipment and staff support to allow departments to compete. In the case of the Challenge it was ACED, AaeE and EWB that provided the impetus for developing a national first year engineering design competition. It was the dynamic drive of the EWB and the corporate support that enabled the Challenge to achieve national status.

In 2005 Australia had 38 institutions offering about 340 professional engineering programs and New Zealand had 7 institutions offering about 37 professional engineering programs. Since the launch of the Challenge, over 25 universities from Australia and New Zealand have registered their interest to participate in the Challenge. The high response rate to the Challenge is very encouraging to EWB and its supporters. With over 8000 student entering first year engineering in just Australia in 2007, the preliminary data suggests that there could be over **1000** first year engineering student teams preparing a broad spectrum of designs for Uluru Children's' Home at Alampara. The true success of the Challenge will be judged by the quality of the sustainable designs submitted by the student teams..

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