Empowering Undergraduate Education through Support of Student Societies

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CONTEXT

An engineering student's first exposure to industry occurs during their years of formative study in the discipline. This exposure comes in the form of final year design projects, work experience, university and inter-university competitions and involvement in extracurricular projects through engineering focused student societies. Through these experiences, students develop a range of skills above and beyond those developed through classroom learning. This paper concerns the effects that student engineering societies have on assisting students to engage in engineering, collaborate on small and large scale projects, and ultimately develop desired employability skills.

PURPOSE

This paper will focus on the positive effects that a student-directed engineering society has on individuals directly involved with the organisation. It is also intended to demonstrate that a student's learning experience may be improved through extension beyond the faculty course structure and twelve weeks required engineering work experience. By encouraging and supporting student-led engineering societies, universities can further support the honing of critical skills and development of lifelong learning abilities.

APPROACH

This paper examines examples of student projects completed through the Australian Maritime College Autonomous Technologies Society (AMCAT) and discusses the skills development benefits of involvement with these projects. Graduate attributes desired by Engineers Australia and identified in the 2013 Construction, Mining and Engineering Graduate Outlook Survey are used to gauge the relevance of these skills.

OUTCOMES

Each of the four projects discussed was shown to contribute to the development of a majority of the desired attributes. Competitive projects were shown to foster a wider range of skills development. The graduate attributes most desired by employers were encouraged in nearly every case.

CONCLUSIONS

Strong connections have been drawn between self-directed learning and the development of desired graduate attributes. Student directed engineering societies such as AMCAT provide a supportive and encouraging environment in which students can pursue self-directed learning through projects which are relevant to a wide range of desired graduate attributes. The resulting engagement and holistic development complements traditional engineering education and improves competence, understanding, and employability.

KEYWORDS

Engineering student societies, student competitions, graduate attributes, core standards

Introduction

An engineering education must cover a wide range of skills and experiences to prepare graduates for employment, ranging from a theoretical understanding of the natural and physical sciences to application of design processes and effective team membership and leadership (Engineers Australia, 2013). The development of these varied skills requires a range of approaches.

As Crosthwaite et al. (2006) posit, the setting and context of learning impacts the development of graduate attributes:

> *"Development of the broader spectrum of attributes is more likely when students are engaged with realistic and relevant experiences that demand the integration and practice of these attributes in contexts that the students find meaningful."*

Classroom learning is passive compared with project-based learning (Palmquist, 2005). Active engagement with the problem or material may encourage the development of particular attributes.

Armstrong et al. (2013) suggest that a classroom setting may better support content-based learning while student-directed learning may foster leadership skills. Student direction of learning provides desired engagement, as put forward by Todd and Todd:

> *"The value of student-directed learning groups is that they provide a milieu in which understanding may be achieved for its own sake, and where achievement of a satisfactory solution is its own reward." (1979)*

The Australian Maritime College Autonomous Technology Society (AMCAT) seeks to expand learning opportunities for engineering students through involvement in national and international competitions and original design projects. This paper will explore how student led engineering societies such as AMCAT can complement existing course structures by developing desired graduate attributes and should be encouraged and supported as an extension of traditional engineering formation.

Methods

As a means of measuring the benefit provided by involvement with AMCAT projects, two sets of graduate attributes have been used as benchmarks. The graduate attributes required of professional engineers by Engineers Australia have been employed with a view to quantifying desired outcomes from a tertiary education perspective. The most desired graduate characteristics identified in the 2013 Construction, Mining and Engineering Graduate Outlook Survey (listed at the bottom of Table 1), were similarly considered to demonstrate improvements made to employability. For each case an attempt has been made to clearly identify the attributes developed through involvement with the project. A range of qualitative advantages to AMCAT participants have also been identified.

Case studies

The following sections briefly illustrate a range of projects in which AMCAT members have been involved in 2014 and outline the relevant graduate attributes developed through each.

Maritime robotx challenge: autonomous surface vessel

AMCAT will compete in the inaugural Maritime RobotX Challenge in conjunction with Flinders University. This competition features 15 teams from around the Asia-Pacific region competing to automate a 16’ Wave Adaptive Modular Vessel as a platform for autonomous subsea operations. The challenge, which is co-sponsored by the Office of Naval Research, the Association for Unmanned Vehicle Systems International Foundation and the Singaporean Ministry of Defence, aims to encourage development in the field of autonomous surface vessels using a standardised platform. Three Australian teams will compete for the $100,000 prize with the support of the Australian Defence Science and Technology Association (Keane, et al., 2014).

Development of the AMCAT/Flinders vessel required the design and construction of a propulsion system, the assessment of resistance and propulsion characteristics, and the derivation of hydrodynamic sway and yaw coefficients. Vessel testing towards these goals, including two rounds of bollard pull testing, was completed in the Australian Maritime College (AMC) towing tank and survival centre. Thrust coefficients were validated using computational fluid dynamics analysis, while sway and yaw coefficients were derived theoretically and semi-empirically. The automation process is ongoing at Flinders University (Keane, et al., 2014).

The cross-institutional nature of this project required teamwork and high-level, multi-platform communication skills, especially as the working relationship between AMCAT and the Flinders University team was established. The design and construction phases required analytical and problem solving skills as well as decision-making ability under time pressure. Problems encountered included a lack of availability of the desired propulsion system in Australia, higher than expected propeller ventilation, and uneven thrust across the two screws. Addressing these issues required risk assessments, organizing support vessels, arranging testing locations and transport for the test team in addition to engineering problem-solving skills.

National instruments competition: autonomous ground vehicle

National Instruments hosts an annual autonomous robotics competition open to Australian and New Zealand universities. Each year the theme of the competition varies, however the goal of the competition is to develop an autonomous ground vehicle to perform a set of tasks to complete a specific mission. The 2014 competition required universities to design a robot to navigate a farmyard, gather seeds and then sow them in an adjacent field. AMCAT was approached by AMC for students who were interested in robotics and automation; seven of the eight competition team members were selected in this way.

National Instruments became the client for the team’s project, setting milestones that must be achieved to successfully proceed to the final competition. To meet these deadlines, the team needed to be self-organised and motivated. Half of the team concentrated on the mechanical design of the robot while the other half focused on the electronics and programming. Continuous, clear communication between these specialist sub-teams was required to ensure a cohesive design was built, requiring regular meetings and attentive scheduling by team appointed directors.

The National Instruments competition challenges team members to learn advanced systems control and electronics, which are only taught to a fundamental level in the basic ocean engineering and naval architecture degrees. Team members learnt a new programming language (National Instruments' Labview software), brushed motor control using motor drivers, and power distribution based on sensor, system and actuator demand.

The progress of the robot build and programming was reported back to AMCAT during weekly meetings. In this way the knowledge developed within the team was shared with the rest of the society. Other members can thus apply the lessons learned from this project to other projects.

Involvement in this project has reinforced students' project management and communication skills as well as honed engineering problem-solving abilities. The collective knowledge of programming languages and their applications has been increased among participants and AMCAT members at large, including use of Kalman filters, fuzzy logic control, and skid-steering kinematics.

Hydrocontest: remotely operated hydrofoil vessel

The AMCAT society's first completed competition was the 2014 HYDRO contest, a challenge aimed at encouraging efficient vessel design. The contest, held in Lausanne, Switzerland and featuring 13 teams from around the world, involved time-trial and endurance racing of remote-controlled vessels designed and constructed by students. The time trial races were divided by weight class, including lightweight and heavyweight sections.

Key challenges experienced during the contest included communication with international contacts and industry sponsors, rapid design and construction of a unique vessel, and team management during the phases leading up to and including the competition.

Participation in this international competition and liaising with officials and other teams required communication skills that engineers working in an international industry require. The multilingual nature of the competition, the responsibility of upholding various sponsoring institution reputations, and the absence of an authoritative staff member put particular focus on professional communications.

Challenges such as this are intended to advance skills and technology through competition. They are therefore an ideal learning space for developing problem-solving abilities and technical skills. The rapid design and refinement of a unique vessel required direct application of naval architecture expertise whilst requiring compromise to achieve construction deadlines.

Project management and risk assessment skills were also called upon. With the resources to produce one vessel only, the team was forced to evaluate whether to design a single vessel with lightweight and heavyweight capabilities or to specialise. After considering the dangers of participating in the heavyweight contest with the desired hydrofoiling vessel, the team decided to withdraw from that section and focus on the lightweight competition. The decision proved to be favourable as the team was awarded best lightweight boat technology. This risk versus reward situation may be comparable to tender applications and other design prioritisations made by engineers in industry.

The constant refinement work and competitive atmosphere led to a high stress environment with real consequences of failure always in mind. Constantly shifting team dynamics and the continuous need to manage tasks and decisions created an environment in which professional behaviour, communication, and problem solving abilities were tested and improved across the team.

Student project: unmanned aerial vehicle

The unmanned aerial vehicle (UAV) project began in early 2014 with the goal of developing an autonomous device that is capable of flight whilst being able to carry a payload. A quad-copter design was chosen after consideration of these requirements. Several versions of the UAV have been produced, with the current vehicle capable of flight while carrying a payload such as a video camera. Automation work is ongoing using Arduino.

The team working on the project consists of seven students with an interest in remote control and autonomous technology. During weekly AMCAT meetings, members of the project are given the opportunity to develop communication skills through ongoing reporting to their peers. This process of feedback to the society further serves to increase the overall knowledge base of other AMCAT members.

The project has consisted of distinct stages including research, planning, construction, design critique and re-evaluation. Utilising self-directed learning, students planned the construction of the quad-copter by setting milestones and goals. The schedule was constantly challenged by course work fluctuations. This process enhanced the students' abilities to manage and estimate time and encouraged flexibility and task sharing.

The majority of participants had minimal model building experience and were able to significantly improve their practical skills in this area through involvement with the construction process. Each iteration of the UAV was evaluated to assess the quality and effectiveness of design and construction work. Through this process of reflection and refinement, self-assessment skills and design review techniques were developed across the team. Communication skills were fostered by the large team size and through informal presentations at weekly AMCAT meetings.

The UAV project continues to complement formal teaching by enhancing desired engineering abilities. Multiple UAV units are now being developed by members of the project team. The UAV project has attracted interest from AMC, who have put forward funding towards a fully developed model for marketing use. This allows the project to continue, with students in lower years anticipated as team members.

Discussion

The benefits of participation in each AMCAT project are identified as part of the planning and funding processes. Supporting academic staff and society leadership monitor the actual value of participation through regular verbal reports. The authors of this paper have assessed the development of graduate attributes based on these reports and in consultation with participating students.

Table 1 summarizes the application of desired skills to each of the above case studies. Darkened cells indicate that the attribute was developed or honed as a result of involvement in the project. Each of the case studies was evaluated in terms of the type of work the students were engaged in and compared to the desired attributes.

As shown in Table 1 the projects discussed here have contributed to the development of relevant academic, personal and professional skills. Each of the projects discussed developed most if not all of the graduate attributes and desired graduate attributes listed by Engineers Australia and the Graduate Outlook Survey.

In all of these projects, a fundamental and comprehensive understanding of the applicable engineering sciences was required. Examples of required knowledge include the mechanics of multi-rotor flight, principles of hydrofoil dynamics, skid-steering kinematics of wheeled ground vehicles, and manoeuvring equations of catamaran small craft. Each of the projects required students to solve engineering problems during the design phase as well as during construction and testing. The competitive and commercial uses of these designs provided impetus to acquire and apply relevant knowledge and skills efficiently.

In each case, the majority of projects are supported and financially backed by the AMC and professional sponsors. To maintain this support, students were required to present themselves professionally during presentations, competitions, and during all communications with AMC, sponsors, suppliers, competition organisations, and other professionals and organisations.

Finally, each of the projects developed attributes desired by employers. The final section within Table 1 identifies four of the top ten most desirable graduate attributes as found by the Graduate Outlook Survey (Graduate Careers Australia, 2013). Students developed interpersonal and communication skills as they were required to interact with multiple organisations to secure funding, receive professional advice, arrange experiments and testing with professional research facilities, and co-ordinate with local and international transport organisations and authorities for transfer of equipment and personnel. Competitive projects such as Hydros and RobotX are recognised as work experience and provide clear skills development akin to other types of industry work.

Table 1: Summary of graduate attributes

Attribute	Unmanned Aerial Vehicle	Autonomous Ground Vehicle	Hydrofoiling vessel	Autonomous Surface Vessel
Engineers Australia Graduate Attributes				
Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.				
Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.				
In-depth understanding of specialist bodies of knowledge within the engineering discipline.				
Discernment of knowledge development and research directions within the engineering discipline.				
Knowledge of engineering design practice and contextual factors impacting the engineering discipline.				
Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline.				
Application of established engineering methods to complex engineering problem solving.				
Fluent application of engineering techniques, tools and resources.				
Application of systematic engineering synthesis and design processes.				
Application of systematic approaches to the conduct and management of engineering projects.				
Ethical conduct and professional accountability.				
Effective oral and written communication in professional and lay domains.				
Creative, innovative and pro-active demeanour.				
Professional use and management of information.				
Orderly management of self, and professional conduct.				
Effective team membership and team leadership.				
Graduate Outlook Survey Desired Attributes				
Interpersonal and communication skills (written and oral)				
Passion/knowledge of industry				
Work experience				
Critical reasoning and analytical skills				

Conclusions

Engineering student societies provide a platform for students to develop their own projects, allowing for skills and knowledge development and practical experience beyond the standard course projects and work experience. Student directed societies such as AMCAT provide a supportive and encouraging environment in which students can pursue self-directed learning. Strong connections have been drawn between self-directed learning and the development of desired graduate attributes. The resulting engagement and holistic development complements traditional engineering education and improves competence, understanding, and employability.

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