Investigating Engineering Students' Choices and Motivations – a work in progress

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***Abstract**: Engineering students have differing reactions to open ended project activities. For example, not all mechanical or even automotive engineering students desire to be involved in a Formula SAE Team. Yet, engineering as a profession seeks to solve open problems that generally deliver technical solutions. Engineering activity spans design, manufacture, operation and maintenance and these in themselves offer wide ranging opportunities for routine and novel approaches to engineering practice. Therefore, if students engaged in their engineering education are preparing to deal with future issues not yet perceived (open problems), why do students make the choices they do and what motivates them? Why have they chosen an engineering pathway and what do they find exciting about this prospect? With a view to strengthening educational outcomes, a work in progress is reported in this paper which involves a student survey for investigating answers to these questions.*

Student Motivations – What are they?

Personal classroom and studio experiences of many engineering design educators point to a wide range of student attitudes towards open ended projects – some thrive on them, continually looking for new challenges; others shun them, wishing they would go away. These conflicting student attitudes naturally reflect preferences and constraints at the time students encounter their projects. Given the diversity of the student population and the engineering community, a range of responses with extremes is to be expected. While not all engineering students are destined to wear the label "designer," all will engage with the design process in some way throughout their engineering practice careers.

The work being conducted seeks to understand student choices. For many academics engaged in teaching engineering design, there is a strong belief that design is learnt by doing design. In support of this notion, many are passionate about providing students with project based opportunities. These projects aim to develop the students' skills and their understanding of the engineering profession and their capacities. However, not all students are excited about the projects, or the notion of design, or the practice of design as a creative aspect of engineering. Student engagement generally requires stepping out of their comfort zones, working in groups and tackling issues for which there are no absolute right answers; but there are a lot of wrong ones. Some students struggle with the complexities of both the social and the technical issues involved. It follows that there is a need to explore any correlation between life experience and student behaviour in relation to project work, with a view to improving learning outcomes. What are the students' motivations? What influences their motivation and how might their motivation be positively enhanced?

To address these and related questions, a survey instrument has been created. Gathering the data and analysing it is a work in progress.

The Work in Context

Exploring student choices and motivations is not new. A significant amount has been published in this area over the years. However, as society changes and those in it are exposed to different stimuli, the behaviours of individuals and cohorts naturally alter. It is also reasonable to believe that contexts for particular groups of students create significant influence. The pace of technological development ensures constantly changing contexts which is a positive thing for those interested in the social sciences as it continually provides new opportunities for exploration. For educators it underscores that there is no absolute right way to reach students. Therefore, it leads to a clear motivation to continue to seek new and appropriate ways to efficiently and effectively teach, mentor and coach, particularly within the context of project-based experiential and authentic learning environments.

In considering why university students have set their specific paths, it was proposed by Paa and McWhirter (2000) that background, environment and personal issues provide the influences that guide school students' career choices. The students' own perceptions of their strengths and abilities and their own perceived barriers to career choice options were argued to be significant issues. Paa and McWhirter highlighted the role parents and peer groups play in choices and the intrinsic motivation built within students. Bishop and Bishop (2003) also emphasised the importance of peers and role models in influencing educational responses in students.

Blunsdon et al (2003) identified that intrinsic interest was fundamental to student choices. Subjects studied were selected based on interest in the topic. In the context of this paper, this creates some challenges with compulsory courses. However, given students have selected engineering, it is hoped that there is strong intrinsic interest in things engineering and some understanding of what engineering is. While seeking to achieve educational goals, Blunsdon et al identified the need to stimulate student enjoyment while avoiding unnecessary entertainment.

The persistence of engineering students enrolled in an introductory course was studied by Lent et al (2003). Their work measured students' engineering output, expectations and technical interests. Environmental factors were shown to be very important in relation to student performance and development.

In exploring motivation, Song and Grabowski (2006) identified that research focused on facilitating motivation for solving open problems as dealt with in engineering design was minimal, despite the known importance of intrinsic motivation. Given education is to some extent goal oriented, motivation may be classified generally as a desire to learn or a desire to seek recognition. Some students' obsession with marks clearly fit the latter. Song and Grabowski also found that when students work in teams, groups formed from heterogeneous peer groups (those with diversity) performed better than those that were homogeneous in nature. This was because there were no existing peer norms constraining the groups' sources of inspiration.

Finally, from an engineering educator's perspective, the purpose for presenting students with project-based experiential learning scenarios in a curriculum is to replicate real world activity in the profession they have intrinsically chosen. Many authors have addressed these issues (including Dym et al (2005); Counce et al (2001); and Dutson et al (1997)). In such projects, students are given an opportunity to safely develop their domain and professional skills and grow in confidence and experience. Students are led through processes of divergent and convergent thinking while applying basic science and engineering principles. This naturally sits well with university education which seeks to equip students with the ability to respond to open problems and uncertainty which while pushing them beyond their comfort zones prepares them for the future.

The specific context and rationale for exploring the primary question of what motivates students and how this may be fostered is in part defined and driven by the author's particular educational experience and passion.

Experiential Learning Examples and Experience

There are many excellent projects run by enthusiastic educators and organisations across the broad domain of engineering design and design practice. Some are run within an individual class and others lead to participation at regional, state, national and even international competitions. One such example growing in take-up is the Engineers Without Borders (EWB) Challenge. It is "an Australasian design program for first-year university students. Students work in teams to develop conceptual designs for projects identified by EWB's community partners that contribute towards the sustainable development of disadvantaged communities" (EWB, 2010).

The author, in contributing specifically to mechanical design education in Australia, is directly involved with three specific projects, namely; F1inSchools, the Warman Design and Build Competition and Formula SAE (FSAE).

- Formula 1 in Schools (F1inSchools) engages secondary school students who are considering their career options, choices and preferences. "Through the appeal of Formula One, F1inSchools is engaging and inspiring young people, piquing their interest in engineering related careers, connecting students to industry and making learning relevant and fun" (F1inSchools, 2010). Teams of students use industry level CAD/ CAM and simulation technologies to design, analyse, test, manufacture, market and race miniature CO2 powered, balsa wood Formula 1 cars of the future. Teams may progress through a series of regional, state and national finals, with the best teams from each country competing for the F1 in Schools World Champions title and the Bernie Ecclestone Trophy.
- The Warman Design and Build Competition is a university based competition. Each year Weir-Warman and Engineers Australia sponsor the Competition among second year "mechanical" engineering students throughout Australia and New Zealand. The winning teams from participating campuses proceed to the National Final, typically held in Sydney in September. In a number of Australian and New Zealand Universities, the Warman is a compulsory activity. As stated by Smith (2008), "the projects posed have varied widely over the 23 years … [however] the intent to challenge 2nd year students with an open-ended statement of requirements in a practical and experiential exercise has been a constant. Students are faced with understanding their opportunity and their client's value system as expressed in a scoring algorithm; they are required to conceive, construct and demonstrate their device with limited prior knowledge and experience, and the learning outcomes clearly impact their appreciation for teamwork, leadership and product realisation."
- Formula SAE is a university based project and competition also. It is international, run by the Society of Automotive Engineers (SAE) (and the Institution of Mechanical Engineers in the UK). Students are asked to conceive, design, manufacture, race, and market a FSAE 'class' vehicle. It is an holistic systems realisation project offering extraordinary educational outcomes for all students involved. FSAE has its roots in the US where the first competition was held in 1978 and was originally called the Mini Indy. It was developed to remedy the shortage of applied technical skills possessed by engineering graduates of the day. The FSAE competition is now active in many universities around the world, with regional championships in Europe, South America, Australasia and North America (FSAE, 2010).

Prompted by the author's personal experiences, particularly in Session 1, 2010 while running the Warman Competition at UNSW@ADFA, the question arose as to why some students were drawn to such projects and others in some form resisted them. Could better understanding of the students lead to better educational outcomes? Of course the simple answer should be yes.

Session 1, 2010 Reflections

The compulsory course, ZEIT2501 Mechanical and Electronic Design, is the first course in the design sequence for the BE(Aero), BE(Mech) and BTech(Aero) programs at the Australian Defence Force Academy (ADFA). Positioned in 2nd year, a foundation of basic mechanical and electronic design principles is laid through broad discussion and hands on project-based learning opportunities centred on the Warman Competition. As advised in the course outline, it is noted that students may not be armed with all the analytical tools available to fully assess their designs as they enter 2nd year but the project, through reflection, should provide a vehicle for understanding the importance of good planning, a systematic approach to design (mechanical and electronic) and the inherent decision making. System design in general involves solving an open problem with incomplete information and within time constraints. The course aims to model this reality to engage students.

A more extreme overall approach to student discovery in the course was trialled in Session 1, 2010. An attempt was made to make the course more student-led than in past incarnations as students were asked to perceive the challenges ahead of them and consider their pathways to a solution. They were asked to discuss the issues arising in their groups and across groups. The intent was for them individually, in groups, and as a class to identify what they needed to know and to consider how to seek out the necessary information and knowledge. The material presented to them in "lectures" and "discussions" was then intended to be responsive to their stated need rather than anticipatory of it. This created a rather awkward standoff as a significant number of students who resisted making progress on their own, waited to be led to a "directed-staff solution". While this scenario played out during the session, and has led to much reflection amongst the staff involved, the fundamental question of trying to understand student engagement behaviours remained paramount. A survey instrument has been developed to address the question as to why some students are drawn to such projects and others resist them.

The Survey

The aim of the survey project is to understand student choices; first in choosing to study engineering and secondly in choosing and navigating their paths through their engineering education into a career. Participants will be asked questions about themselves, their schooling, their engineering career decisions, their university studies and their plans for their futures.

Of interest is learning what influences have guided them and what motivates them in their academic university pursuits. Particularly sought after are their thoughts about project work, and what the education literature labels project-based experiential and/or authentic learning. Do they find these experiences stimulating and motivating? Do they find them exciting or do they prefer not to become involved with them? In the context of their university education, what do they value?

The target subjects for the survey are current tertiary students who are pursuing engineering degrees and graduates who have obtained their degrees and are practicing. The survey will be conducted blind although it will request demographic information to be provided to allow the data to be sorted and analysed against it.

It is planned to first execute the survey with an international group of students engaged in Formula Student (the UK version of FSAE) in July 2010. Subsequently, UNSW@ADFA engineering cohorts will be invited to participate in July/August 2010. Other groups from other Australasian universities will be surveyed as the opportunity arises.

The survey is voluntary, anonymous and responses are confidential. Individuals will not be identifiable from their responses. All data collected will be held securely and used for research purposes in accordance with the policy of the University of NSW. The UNSW@ADFA ethics approval number for this project is A-10-28.

Anticipated Outcomes

The project is clearly a "work in progress" but some results are expected to be able to be presented at the 2010 AAEE conference in Sydney in December. The work fits well with the conference theme – Past, Present, Future - the "keys" to engineering education research and practice. Certainly, the desired and anticipated outcome of the research is to unlock some thoughts about student choices and motivations.

Fundamentally, the prepared survey instrument attempts to address these broad issues, and the participants' responses gathered and analysed are expected to provide significant evidence from which to frame an adaptive response in the delivery and improved efficacy of project-based experiential learning opportunities.

So why are students exposed to such projects? A simple answer, as addressed earlier, is that participation in the projects model for the students their chosen careers. By exposing students to authentic experiential learning projects, students practice and develop their skills for problem solving – which is arguably the essence of engineering. It is also a clear way to address the development of the graduate attributes so regularly articulated by universities and accrediting peak professional bodies. A university education has desired outcomes of the development of the capacity for analytical and critical thinking and for creative problem-solving, the development of the capacity for enterprise, initiative and creativity and the development of the ability to engage in independent and reflective learning (UNSW graduate attributes, (UNSW, 2010)). Projects obviously address these issues. Dealing with open problems in the classroom also facilitates directly in students the realisation that to resolve such problems requires new and consistent enquiry, leading to an understanding of the profession's expectation upon them to undertake lifelong learning, and the development of the capacity to do so (EA Professional Engineer Stage 1 Competencies, (EA, 2010)).

References

Bishop, J.H., and Bishop, M. (2003). Make Middle-Schoolers COOL with School Success. *Education Digest*, 69, 51-53.

Blundson, B., Reed, K., McNeil, N. and McEachern, S. (2003). Experiential Learning in Social Science Theory: An Investigation of the Relationship between Student Enjoyment and Learning. *Higher Education and Development*, 22, 43-56.

Counce, R.M., Holmes, J.M., and Reimer, R.A. (2001). An Honors Capstone Design Experience Utilizing Authentic Industrial Projects. *International Journal of Engineering Education*, 17, 396-399.

Dutson, A.J., Todd, R.H., Magleby, S.P., and Sorenson, C.D. (1997). A Review of Literature on Teaching Engineering Design through Project-Oriented Capstone Courses. *Journal of Engineering Education*, 86(1), 17-28

Dym, C.L., Agogino, A.M., Eris, O., Frey, D.D., and Leifer, L.J. (2005). Engineering Design Thinking, Teaching and Learning. *Journal of Engineering Education*, 94(1), 103-119.

EA. (2010). Engineers Australia National Generic Competency Standards – Stage 1 Competency Standard for Professional Engineers, Document P05 Rev 1, dated 19/07/06, Accessed at http://www.engineersaustralia.org.au/about-us/program-accreditation/management-system-for-professional-engineers/management-system-for-professional-engineers_home.cfm on 21 June, 2010.

EWB. (2010). Accessed at http://www.ewb.org.au/explore/initiatives/ewbchallenge on 17 June, 2010.

F1inSchools. (2010). Accessed at http://www.f1inschools.org.au/ on 17 June, 2010.

FSAE. (2010). Accessed at http://www.saea.com.au/formula-sae-a/competition-overview on 17 June, 2010.

Lent, R.W, Brown, S.D., Schmidt, J., Lyons, H., and Treistman, D. (2003). Relations of Contextual Supports and Barriers to Choice Behaviour in Engineering Majors: Test of Alternative Social Cognitive Models. *Journal of Counselling Psychology*, 50, 458-465.

Paa, H.K., and McWhirter, E.H. (2000). Perceived Influences on High School Students' Current Career Expectations. *The Career Development Quarterly*, 49.

Smith, W.F. (2008). Twenty-One Years of the Warman Design and Build Competition, AAEE.

Song, H.D., and Grabowski, B. (2006). Stimulating Intrinsic Motivation for Problem Solving using Goal-Oriented Contexts and Peer Group Composition. *Educational Technology Research and Development*, 54, 445-466.

UNSW. (2010). Accessed at http://learningandteaching.unsw.edu.au/content/userDocs/grad_attributes.pdf on 21 June, 2010.

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