Supporting transition, engagement and retention in first year engineering

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Abstract: Over the last decade The University of Queensland implemented a comprehensive first year engineering program of curricular and extra-curricular activities to support the transition, engagement and retention of students. This includes small group ‘design and build’ projects beginning with an Orientation to Engineering Project Day, a comprehensive program of pre-arrival academic advising, and on line diagnostic testing of pre-requisite knowledge and skills. Dedicated physical (Engineering Learning Centre) and virtual (First year Hub) learning spaces are also provided. Quantitative and qualitative data on first year attrition, academic success and retention, the student experience, and student engagement is presented as evidence of the efficacy of this program.

Introduction

This paper outlines the experience of the last decade at The University of Queensland (UQ) in implementing and evaluating a comprehensive first year engineering program of curricular and extra-curricular activities based on accepted principles of good practice and research, and aiming to support the transition, engagement and retention of first year engineering students.

National context

Australia’s continuing engineering skills shortage coupled with lower than average national university degree completion rates for engineering, reportedly between 54% (King 2008) and 65% (Godfrey et al. 2011), has provoked re-examination of student demand, enrolments, retention, and success in engineering degrees across the country. As identified for the USA (Ohland et al. 2008) and confirmed by several Australian higher education reports (Krause et al. 2005, Marks 2007, Olsen et al. 2008), attrition from engineering degrees is lower than from degrees in all other discipline areas except medicine and health. Regardless of attitudes to attrition in other disciplines, the average loss of approximately 46% of the commencing engineering student cohort is viewed by industry and the profession as an unacceptable loss to the engineering workforce, particularly at a time when the global demand for engineering graduates is increasing, with an estimated shortfall of 20,000 engineers in Australia alone (King 2008).

Many initiatives addressing engagement and retention in engineering programs have been implemented, most concentrated in the first year of study (Godfrey et al. 2011). Studies have shown that the first year student experience is critical in meeting ambitious national targets for increased participation in higher education (Krause et al. 2005, James et al. 2010) and successfully managing the desired growth. It is also imperative to successfully manage the experience in order to increase the cohort diversity, and adapt to the changing patterns of student engagement with teaching and learning (James et al. 2010). In Australian higher education, a comparison between students commencing in 2004 and 2009 (James et al. 2010) found that:

‘the 2009 students are more likely to believe the final year of school prepared them well for university and their university subjects are building on their schooling. They are also more satisfied with the advice they received on subject choices’

thereby reflecting efforts undertaken by universities and schools.
The UQ Environment

UQ is a member of Australia’s ‘Group of 8’, a coalition of research intensive universities offering comprehensive general and profession education. They are Australia’s oldest universities with the highest international rankings, and having the highest admission criteria for commencing students. They have the lowest participation by part-time students, and their retention rates are, on average, the highest in the university system (Godfrey et al. 2010). Engineering is a founding faculty of UQ which celebrated its centenary in 2010. UQ offers professionally accredited 4 year engineering degrees in 18 different areas with the option to also incorporate some of these into 5 – 5.5 year dual degree programs with arts, business, information technology and science degrees.

In the last decade, the total number of students commencing first year engineering more than doubled from 484 in 2002 to 1,077 in 2011 (Table 1). During that time the proportions of international students and female students commencing first year engineering increased slightly from 9% to 11% and 17% to 19% respectively. The majority of domestic students are school leavers and approximately 90% of all first year students are under 19 years of age. The majority study full time with only 6% of all engineering students enrolled part-time in 2011. The educational background and admission scores of the incoming cohort have also fluctuated considerably with a period of relatively low entry scores occurring between 2005 and 2008 when the entry scores fell from being around the top 10 to the top 20% nationally (ATAR/ITI ranks) as shown in Table 1. (Enrolment figures for 2012 are yet to be finalised.) Pre-requisite subjects for entry to engineering include English, Queensland Maths B, and Chemistry or Physics. Bonus entry rank points are awarded for the prior study of advanced mathematics (Queensland Maths C) with just over 50% of the year 1 intake qualifying for bonus ranks points.

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<tr>
<td>ATAR/ITI</td>
<td>91.6</td>
<td>88.7</td>
<td>84.6</td>
<td>85.8</td>
<td>81.8</td>
<td>82.1</td>
<td>80.9</td>
<td>82.2</td>
<td>89.6</td>
<td>88.6</td>
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<tr>
<td>Total Year 1 BE enrolment</td>
<td>919#</td>
<td>1077</td>
<td>987</td>
<td>861</td>
<td>865</td>
<td>825</td>
<td>721</td>
<td>559</td>
<td>518</td>
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The first year of engineering studies is common to all students and has been designed to provide a broad foundation for all engineering disciplines. It encompasses eight courses: two compulsory mathematics courses, two compulsory engineering practice courses involving small group project centred learning, and four electives chosen from a small set of engineering and enabling science courses. A choice of engineering specialisation is not required until the student enters the second year of the engineering degree program. At this stage the student affiliates with whichever of the four Schools of Engineering (Chemical, Civil, Information Technology and Electrical, Mechanical and Mining) at UQ delivers their chosen major (e.g. Aerospace, Mechatronic, or Chemical Engineering).

The program that has evolved to support the transition of first year engineering students reflects various reports and research on good practice that suggest that successful outcomes are likely when efforts recognise, and are directed to address, a range of factors that are known to influence student engagement, persistence, academic success and retention. This includes the levels of academic challenge and interest in the formal curriculum and the class room experiences, facilitation of formation of learning communities, and provision of extra-curricular activities, social activities and support services (Yorke et al. 2007, Knight et al. 2007, Meyers et al. 2010, Tinto 1975, 2009, and 2012). The relative homogeneity of the cohort has simplified the range of issues and needs to be addressed and the approaches used.

What we did and why

Overview

In the last 10 years UQ has progressively invested in dedicated first year engineering resources in the form of people, places, and implemented processes that support the student experience and the transition to university and engineering studies. The major initiatives and developments include:

- a survey in 2002 of first year student perceptions and their expectations of engineering studies and professional practice establishes that many students arrive at University with the expectation of just doing “figures and calculations (i.e. ‘Solve for X’”) and are dismayed, bewildered, or indifferent when more is required (Jolly et al. 2002);
the introduction in 2003 of Engineering Project Day: a day long activity held during Orientation Week designed around the theme of ‘Beyond Solve for X’. The purpose of the activity is to foster a sense of identity and belonging among students and to explore through a fun, hands-on exercise conceptions of engineering including consideration of sustainability issues associated with a design and build activity. Student feedback indicates enhanced understanding of what engineers actually do, and an appreciation of the opportunity this provides to initiate contact within the first year student cohort (Crosthowe et al. 2003). Project Day is a continuing feature of first year engineering student orientation;

• the provision of a First Year Engineering Learning Centre (FYELC), a multi-purpose space located in the heart of the Engineering Precinct, in March 2007 as a social learning space exclusively for first year engineering students. The evaluation and adaptation of the use and impact of the FYELC is ongoing;

• an optional student-student mentoring scheme begins in 2007 matching small groups of first year students with advanced level students;

• an on-line competency test, first run as a pilot in 2009, encompassing questions on key concepts in chemistry, physics, mathematics, and thermodynamics, that measures and reports on the alignment between the levels of competency that academics assume the students possess, the skills sets that students actually possess, and the skills required to successfully navigate through first year engineering. The test is administered before the start of the academic year and results are used both to inform first year lecturers of the range and diversity of the cohort knowledge base and to trigger knowledge review by students (Kavanagh et al. 2009). Positive experiences and feedback ensures continued development targeting the support of ‘at-risk’ students and mandating the on-line competency test for all commencing year 1 engineering students in following years;

• the appointment in 2010 of a senior academic as Director of First Year Engineering with responsibility for the development, implementation, and evaluation of first year curricular and co-curricular programs and activities including transition; and

• a pilot in 2011 of the introduction of a compulsory build activity for all students as part of the introductory foundation courses in engineering.

The following section briefly describes the rationale for these developments, gives an overview of each, and summarises headlines from evaluations undertaken to date.

Managing Expectations

As outlined in Burton et al. (2011), students:

• enter university with expectations about the learning experience which influence their approach to study and, in turn, their retention (Krause et al. 2005);

• are often poorly informed about the nature of their coursework (Krause et al. 2005);

• may withdraw through inappropriate discipline choice (Yorke & Longden 2008);

• become discouraged when they perceive their performance to be inferior to their peers, switching majors or dropping out of university entirely (Hutchison-Green, 2008); and

• require a “sense of self” to persist with an engineering degree program (Matusovich et al. 2010).

These issues have also been identified by students who withdrew from engineering studies at UQ as influencing their decision to leave. Another common theme that emerged in this group was that many had made the decision to do engineering very late in their school career, often based on incomplete or inaccurate information. Therefore, the first year engineering program at UQ (Table 2) aims to ‘help first year students increase their understanding of engineering, experience early success, gain confidence in their self-efficacy, and bridge the gap between their expectations and those of the institution’ (Burton et al. 2011). This includes conventional activities such as provision of written and on-line information about the degree program, academic advising. and transition lecture sessions as well as the compulsory Engineering Project Day held during Orientation Week and the on-line diagnostic quiz

Engineering Project Day has three main objectives: to introduce students to each other so that every new student starts the academic year having met and shared this day with new colleagues; to introduce students to key academic and professional staff with whom they will be involved throughout the year; and to introduce students to non-technical considerations and professional skills inherent in successful engineering practice that will be part of the project work undertaken in the first year curriculum. All new students are asked to attend with attendance rates generally in the order of 85%. Each student is randomly assigned to a small group; and all groups are accommodated in one large exhibition hall (Figure 1).
Table 2: Communicating and managing expectations

<table>
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<tr>
<th>Activity</th>
<th>Timing/ Duration</th>
<th>Objectives</th>
<th>Details</th>
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| Program Guide     | Mailed out with offers of a place in engineering | Welcome students to the community  
Provide explicit BE program information | UQ has moved to online information but Engineering has found students (and parents) value a hard copy program guide [http://issuu.com/uqeaitfaculty/docs/engineering-guide-final-2012](http://issuu.com/uqeaitfaculty/docs/engineering-guide-final-2012) |
| Transition lectures | Month preceding start of the academic year | Welcome students to the community  
Provide explicit BE program information  
Provide individual academic/timetabling/course selection advice | All students expected to attend at least one of 3 repeat sessions offered.  
Academic advisors from all disciplines are available to students for degree program and career advice |
| Project Day       | Orientation - Week | Welcome students to community  
Allow initial student contacts to be made  
Introduce 1st year lecturers  
Introduce the scope of engineering | A day-long, team-based, fun, engineering design and build activity with accompanying triple bottom line considerations, interspersed with various get to know other students, your university and engineering sessions. |
| Get Set quiz      | Between receipt of offer letter and Orientation week | Get students to review high school knowledge  
Be explicit about 1st year knowledge expectations  
Provide lectures with 1st year cohort knowledge level  
Identify students at risk (currently Work in Progress) | The online quiz reduces the knowledge expectation gap between students and lecturers, provides links to review material for assumed knowledge, and shows students what knowledge is needed for each course |

Professional facilitators experienced in working with this age group are employed for the day which comprises a series of activities including energetic ‘ice-breakers’ (Figure 2), panel sessions with key staff and students, and the design and build activity (Figure 3). Teams are marked on their build performance and teamwork, and prizes are awarded for the best overall mark, the best teamwork, and the best performance.

![Figure 1: Engineering Project Day](image1)

![Figure 2: Engineering Project Day ‘ice breaker’ activity](image2)
Evaluations of Project Day indicate that the objectives are being met. In 2005, 86% of respondents indicated that they had a better idea of what engineers do after Project Day; 77% had a clear idea of what is expected of students; and many made comments about the benefit of meeting other students in a small group situation before semester commenced. Connections made on Project Day are known to endure as indicated by this comment made by a student several years after their Project Day (Nedhurst Consulting, 2008): ‘The group activity in O Week was really good. You got to know some people - I still talk to my bridge building friends’.

The Get Set quiz consists of 60 questions focusing on fundamental knowledge, motivations for studying engineering, learning approaches, and perceived difficulties in studying (Kavanagh et al. 2009). It is used to:

1. allow first year lecturers to adapt their teaching accordingly (e.g. 95% of students can balance moments, and 56% can do a definite integral);
2. allow each student, via a report showing which piece of knowledge is required for which first year course, to select courses on the basis of their previous studies (e.g. ‘I need to take a physics course before I take thermodynamics’);
3. provide student support via links to internet sites and other resources for self-study where a question was answered incorrectly and/or knowledge has been forgotten; and
4. identify students “at risk” through linking test data with demographic details of each student and their academic performance although this has proved difficult and is an ongoing task.

Evaluation and anecdotal evidence indicate that first year lecturers value and use the information provided through this test, and students follow up on the individual reports provided to them by using recommended resources for revision and acting on advice regarding course selection. Most recent data available indicates that 86% of the students who took the quiz in 2011 passed all their courses and 63% completed the year with an overall cumulative Grade Point Average greater than 5. Grading is done on a 7 point scale where 4 is the minimum passing grade and 7 is a pass with high distinction.

The Get Set quiz has been so successful that it has been adopted by Auckland University (Shepherd et al. 2011) and is currently being trialled at 4 other Australian institutions.

Providing a home base: The First Year Engineering Learning Centre (FYELC)

The FYELC is tailored to collaborative learning and the networking needs of first year engineering students. It is intended to help nurture a sense of belonging and identity and provides a ‘home base’ for first year students, with dedicated tutoring by high achieving undergraduate tutors and advising and pastoral care by administrative support staff during office hours. The space is used by first year students to study, meet with project teams to work on assessment tasks, socialise, relax, catch up and generally enjoy being a student.

The FYELC is an open plan space that can accommodate about 100 students at any one time. The room is configured as 3 distinct zones (Figure 4), all of which are designed to encourage cooperative learning and student interaction, both social and studious (Figure 5).
The FYELC has proved to be an outstanding success both in terms of frequency of use and students’ feedback on their perceptions of the learning outcomes, benefits and advantages of the centre (Steer & Howell 2009):

‘at the ELC you can pull up a chair and gather in. You have a sense of identity by going in there, you feel like an engineer’

‘...it is a place to discuss ideas, feel involved in the university, to make new acquaintances, to have fun, to learn and to research with group members’

‘everyone surrounding you is a first year engineer. It means that whenever you turn up there people know what assignments you are doing and they are willing to help’

It continues to be developed and adapted in order to maximise its usefulness. Currently a number of trials are being conducted and evaluated with the aim of increasing engineering student creativity and critical thinking (Wells & Kavanagh 2012).
Innovation, Practice and Research in Engineering Education

The FYELC proved to be so successful that several more discipline-based learning centres have since been built by faculties at UQ including Science, Mathematics, Law, and Psychology. In addition, demands for similar spaces from students who experienced the FYELC and then progressed to later years, led to the construction of more engineering learning centres to accommodate discipline-based clusters of later year students.

The physical space has been supplemented with a virtual First Year Engineering Hub which provides an on-line portal with announcements about important events, scholarships, and job opportunities. The hub is linked to the Blackboard (UQ’s learning management system) sites for first year courses. Students appreciate the on-line learning environment as a complement to the physical learning environment: ‘There are some great resources for study and it’s fantastic that lecture notes and even recordings of lectures are on Blackboard. I didn’t expect that’.

**The Right People: First Year Engineering Support Team**

First year engineering students undertake a common first year before affiliation in second year with one of the Schools of Engineering at UQ. Therefore first year is ‘owned’ by Faculty and a dedicated team of people (Table 3) are required to underpin the initiatives described in the preceding section. Academic leadership, vested in a Director of First Year Engineering, has been crucial in consolidating extra-curricular and curricular activities into a coherent and effective framework that has effectively harnessed the drive to improve the first year student experience.

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<th>Staff/ Level</th>
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<td>Director of First Year Engineering / Senior (Reader) academic</td>
<td>Academic oversight of first year program including: transition and orientation activities, coordination of foundation engineering courses, curriculum review and evaluation, liaison with the Schools of Engineering, and coordination of the First Year Engineering Teaching Team (FYETT).</td>
</tr>
<tr>
<td>First Year Engineering Manager / Professional staff</td>
<td>Administrative and organisational support for Director of First Year Engineering and the FYETT, and FYELC management.</td>
</tr>
<tr>
<td>Student Enquiries Officer / Professional staff</td>
<td>Enrolment, timetable and general enquiries.</td>
</tr>
<tr>
<td>Academic advisors / Senior (Professorial) academic</td>
<td>Program, engineering specialisations and course enquiries.</td>
</tr>
<tr>
<td>Academic tutors / High achieving undergraduates</td>
<td>Learning assistance. All first year courses are covered every week on a rostered basis.</td>
</tr>
<tr>
<td>Student mentors / Second year engineering undergraduates</td>
<td>Acclimatise first year students to UQ and Engineering by providing a student perspective on, and advice on, just about anything.</td>
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A review of first year undertaken by an independent consultant identified the FYELC and its tutor roster as one of the highlights of the first year student experience (Nedhurst Consulting 2008) as evidenced by the following student quotes.

‘It’s great that they have tutors in the Learning Centre to help you. They are a great sounding board.’

‘I think it really boosts your productivity having tutors in the Learning Centre’.

In a similar vein although only a small proportion of the first year sign up for a mentor those who do report favourably on the experience: ‘I’ve got a mentor and they are fantastic. She’s mad but really helpful’.

**Engagement in Active Learning**

The final piece of the first year engineering program addresses the need to provide academic challenge and interest in the formal curriculum and class room experiences. Project Day introduces students to active learning and this is built on and extended in the first semester compulsory course, Introduction to Professional Engineering (ENGG1000). The course engages students in active
learning and connects them with a learning community through small group projects, peer interaction, peer assisted learning, and peer assessment. Although small group project-centred learning has been used in this course for over 15 years, a number of changes made since 2005 have effectively enhanced student interactions and engagement. These include the introduction in 2006 of student profiling, purposeful project team formation, and the use of peer assessment (Kavanagh & Steer 2007) and in 2011, the incorporation of a ‘build’ component into these projects. Figure 6 illustrates the outcomes of the student projects.

Figure 6: Demonstration Day 2011

Student feedback on the value of the small group project in first year is consistently positive, even many years after the event (Nedhurst, 2008). In particular students value:

- the introduction to teams (‘I loved the ENGG1000 project. It was a great introduction to teamwork to me.’) that works towards improving teamwork skills (‘When you look back on it ENGG1000 was really important. It taught you how to work in a team, how to organise meetings, and delegate.’);
- the connection with other students and to the general learning community (‘In a way ENGG1000 is a real icebreaker – you get to know a whole lot of people you wouldn’t otherwise know. It makes you feel like you’re part of something.’);
- the increase in their sense of worth (‘It was great to be able to work with a team on a project and have a really cool outcome.’); and
- the aims and delivery of the course (‘It’s really important that the School selects the team. It would really change the dynamics if you just picked to work with your friends.’, and ‘Group based projects are really important because you learn team skills that you’ll need for work.’).

Overall outcomes

Information from evaluations and feedback on individual initiatives has been presented in the preceding sections. This section looks at the outcomes of the complete ‘package’ in terms of the first year cohort performance and overall experience.
The biggest loss of students from engineering occurs during the first year of study. Figure 7 shows that despite the rapid increase in size of the first year cohort and the variability in the entry rank, the retention and progression of students into second year have effectively been held constant. The attrition rates are below the UQ average for Bachelor Pass degrees (16.6% in 2002 to 15.7% in 2011).

In addition, qualitative data collected through final year student focus groups asked to reflect on their first year student experience (Nedhurst Consulting 2008) point to the success of the effort and investment in improving the first year experience. Students recognise the quality, quantity, and benefits of the organisation and resources dedicated to first year engineering.

‘First year is really well structured and really well resourced. As you get to later years the resources aren’t there’

‘First year courses are really well organised. The quality of organisation and the amount of support you get goes down as your years go up’

Conclusion

The size of the first year engineering cohort at UQ has more than doubled in the past 10 years resulting in an increase in student to staff ratios. This could have had a disastrous effect on student retention and satisfaction, but strategic deployment of resources into people, processes, and places to effectively engage with new students in ways that recognise and address their interests, uncertainties and insecurities, has been successful. Attrition rates have remained constantly low and students report satisfaction in their overall experience: making connections with each other, actively engaging with their lecturers and their studies, and being clear about academic expectations. The first year engineering program is not a ‘quick fix’; it requires significant investment of both time and money, but it is successful as the students attest. The next part of the equation is to maintain the momentum and do the same for the latter years of their engineering studies.

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