Integrated Learning Engineering – Taking First Year Engineering into Secondary Schools

Dr Richard White, School of Science and Education, University of the Sunshine Coast

Abstract

A program (Integrated Learning Engineering) that takes first year engineering courses and delivers them within a secondary school setting to Year 11 and Year 12 students is discussed. The program admission criteria, likely benefits and issues to be considered are presented. Indicators of student effort and engagement with the program are discussed as possible identifiers of the need for intervention and support for students in the program. Feedback from students who participated in the program is also presented and indicates significant recognition of the opportunity provided. The feedback also suggests the program provided a positive sample of what the first year university experience might be like and so could be a very effective way to present engineering as a possible career option to secondary students. The approach taken in the Integrated Learning Engineering Program could be applied to other disciplines as well.

Introduction

The University of the Sunshine Coast (USC) is a small, regional university located approximately 100 km north of Brisbane. In common with a number of other Australia universities, USC offers a transition program, called Headstart, which enables Year 11 and 12 students to study two courses at USC whilst completing their final year(s) at secondary school (University of the Sunshine Coast, 2010). The selection criteria for Headstart include academic, personal, and community achievements, with applicants requiring school support and approval. Students are expected to attend lectures, tutorials, and workshops/laboratory sessions that are conducted on USC's campus.

Whilst Headstart has been successful in introducing secondary students to university life, it has a significant draw back for students who live at too great a distance from USC for it to be practical for them to participate in Headstart, even though they might meet and exceed the selection criteria. This tyranny of distance is an ongoing issue for a regional university such as USC with potential students living 100 km or more from the university campus.

This paper discusses an approach that is an alternative opportunity for students and has been trialled by USC called "Integrated Learning Engineering" (ILE). In this approach, an engineering academic travels to the school and delivers the lectures and tutorials within the secondary school. ILE students take one USC undergraduate course in each of two semesters. Both of these courses are required courses in the USC engineering program. ILE students are expected to submit the same assessment tasks as undergraduate students, and the same marking criteria are applied. The purpose of the ILE trial was determine the feasibility of delivering two first year courses in this manner, and to introduce engineering as a possible career choice to high achieving students.

Literature Background to ILE Project

Darvall (1993) indentified that a suitably qualified engineering workforce is required for a region, or indeed a country, to be technologically competitive and enable industry productivity to match international standards. The validity of this comment has not changed in the 17 years since it was made. Of the Sunshine Coast Region school leavers who commence a university education, 55% leave the region (DETA, 2008). USC had introduced engineering studies in 2008 to provide local students with an alternative to living in Brisbane to study engineering. Staying in the Sunshine Coast Region also encourages students to look for local employment when they have finished their degrees. The Sunshine Coast Regional Council, local engineering consultants, and engineering companies had previously indicated recruiting engineers was at times problematic. USC has a program portfolio with the aim of supporting sustainable regional growth and the new engineering program is an important component of that plan.

A long term goal of the ILE project was to support development and retention of human capital in the Sunshine Coast Region, with an emphasis of training and retaining engineers in the region. That human capital formation is a key role of university activities has been identified by Gunasekara (2004), with two other key roles being teaching and research. Thus, universities may enable, and at time lead, regional economic and social development. This was reinforced by Garlick (2005) who stated universities' have the potential to generate human capital via community engagement so that appropriate program offerings may meet skill shortages, undertake targeted research and inform on trends that will enable business and industry to diversify and/or compete more widely.

King and O'Kane (2007) indicated only 29.5% of Australian high school graduates have the basic skills (in particular, mathematics) to pursue a university level engineering program and that the trend shows further decreases unless there are changes to policy and practice. The ILE program is one way of encouraging students to consider engineering, and so encourages them to take on appropriate secondary school studies in mathematics and the sciences.

The use of an engineering engagement program prior to students entering university raises awareness of the field of engineering and has a significant positive impact on student knowledge and choice of the field of engineering they undertake. Anderson and Gilbride (2003) showed positive increases for male students and even larger increases for female students considering engineering as a career option as a result of engineering outreach programs. A significant outcome from Anderson and Gilbride's work was recognition that most students have a very limited understanding of what engineers do and what careers are involved in this profession. Involvement in the ILE program will address this.

Secondary students undertaking tertiary studies must be monitored and supported. Specific, individual intervention may assist ILE's students who may not be coping with their higher level studies. It is therefore necessary to determine which students require intervention. Wilson and Lizzio (2008) reported that many predictors have been considered as indicators of likely success and retention (such as prior academic achievement, personality factors, and demographic characteristics). They suggested an intervention model based on student performance in the first assessment task. In particular, students who do not perform satisfactorily (i.e. fail or just pass) are contacted and invited to receive additional support. This includes a reflective workbook incorporating self-regulation and increased levels of contact with a tutor. The self-regulatory approach had been previously discussed by Boekaerts and Corno (2005) who described bottom-up SR and top-down SR. They concluded

that the use of several instruments (such as a student diary, self-report questionnaires, observations of overt behaviour, and interview evidence) to assess SR was preferable to the reliance on one instrument. The difficulties of applying these approaches an ILE's student include the length of time elapsed till the first assessment task is submitted, and the student's understanding of self-regulation (e.g. via a student diary) may be limited.

Wilson (2009) and Gerlich, Mills and Sollosy (2009) reported various indicators of student success, including attendance at lectures and tutorials, and cumulative GPA (which is considered a measure of student effort). The application of these indicators needs to be modified for ILE's students as their classes are held in their school (and so the students are a "captive audience") and as this is their first exposure to university learning they do not have a GPA (though students were selected on the basis of their academic results in Year 10, see below). Therefore, on time arrival for ILE's classes (a modification of attendance at lectures and tutorials) and assessment submission and participation in on-line discussion (both measures of student effort) would be evaluated for use as indicators of student success.

ILE Content

Rather than just provide the ILE's students with an extra course to study, it was decided to identify Queensland Studies Authority (QSA) subjects in Years 11 and 12 that complimented (albeit at different educational levels) the two USC engineering courses that would be offered in the ILE program. The first USC course (ENG101 Engineering Professional Practice), taught in first semester, examines how engineers carry out their professional duties and generic issues in the practice of engineering. ENG101 focuses on how engineers do what they do. Topics include teams, ethics, design, risk, quality, sustainability, engineering within the context of society, and innovation. The second USC course (COR111 Environment, Technology and Sustainability), taught in second semester, focuses on the environmental, technological and sustainability issues that face society. Topics include scientific method, sourcing reliable information, energy sources, climate change, and science within the context of society.

Based on the published QSA Senior Syllabus (QSA, 2007), Technology Studies was identified as having similar aims to the two USC engineering courses and also had assessment tasks that would support student learning in both their ILE's studies and their school (QSA) studies.

> *Technology Studies aims to (QSA, 2007) :*
>
> - *foster and develop enquiring minds and intellectual skills that will help students think critically, innovatively and purposefully about their material environment*
> - *enhance students' capacities to interact with past, present and future technologies*
> - *promote students' understanding of the industry application of design and appreciation of creative and innovative design solutions and products*
> - *encourage students to reflect on and respond to the interrelationship of technology, industry, society and sustainability*
> - *enable students to become responsible, discriminating and competent managers of resources*
> - *foster personal development and social skills conducive to developing concern for others and the environment, cooperation in the workplace, self-reliance, sense of personal worth and self-esteem*

- *respond to and critically evaluate the impact of aesthetic, cultural, economic, political, social, environmental, ethical, moral and functional considerations and decisions that affect the development of new products for personal, community and global markets*
- *promote an awareness and appreciation of safety issues and safe behaviours in all aspects of learning, and their application in everyday life*
- *provide students with opportunities to gain the knowledge and skills required for future pathways in a technological world.*

ENG101 aims to :

- introduce the professional life of an engineer
- to develop students' recognition of how an engineer carries out his/her job responsibilities
- to develop students' recognition of how an engineer manages his/her career
- to develop students' recognition of how engineering and technological advances effect engineers, their organisation and society
- to develop students' ability to access, evaluate and communicate engineering and technical information

COR111 aims to :

- to familiarise students with science/technology and the underlying scientific processes
- to develop students' ability to respond to scientific and technological advances effecting them and society
- to develop students' ability to access, evaluate and communicate scientific information
- explain and understand scientific and technological processes
- identify and evaluate current issues in environment, technology and sustainability
- highlight local, regional and global impacts of science and technology
- illustrate and understand relationships between science and technology, and socio-economic, cultural and political factors

Comparison of the above aims shows a number of similarities between the secondary education aims and the tertiary education aims. These include greater understanding of the relationship between technology, society and the environment, preparation for a career in engineering/technology, and increasing students' ability to respond to issues involving technology, society and the environment.

Detailed assessment techniques are available for Technology Studies (QSA, 2007) and include a design project, investigative analysis, and a design folio. The three assessment criteria are knowledge and application, reasoning processes, and production. The assessment tasks for the USC courses are written reports covering relevant topics, on-line discussions that extend tutorial activities, oral presentations, and end of semester exams.

The overlap of education aims and similarities between the assessment tasks enabled students to see the link between their school studies and possible university studies and a future career. It also meant that where there was sufficient overlap in assessment tasks, student responses to assessment requirements in their school studies could also be used as the basis of their responses to the university based assessment. For example, the school assessment required an extended written response regarding the design project the students were undertaking.

Students were able to use this material as the basis for a 1000 word report for their university course assessment task.

ILE Location and Venue

Having identified a suitable QSA subject, Sunshine Coast region schools that offered Technology Studies were contacted and asked if they wanted to participate in the ILE Program trial. A Queensland State High School, located in a city with a population of 45,000 people and situated 90 km (1 hour 15 min driving time) from the USC campus, became the participating school in the ILE trial.

The support of the school's principal and head of department for the ILE trial was crucial. Both were enthusiastic and actively promoted the program to students and parents, and ensured that an appropriate venue for the lectures and tutorial activities would be available. The mechanical drawing classroom was selected as the venue as it had a computer with internet access, data projector and DVD capabilities (all of which were required for classes).

Due to the need to fit around both school and university class timetables and teaching staff commitments, ILE's classes commenced at 8 am each week. This was approximately one hour before normal school classes started and required students to be committed to an early rise once per week to attend the ILE Program. The ILE's students continued their ILE's classes whilst other school Technology Studies students (who were not taking the ILE's courses) commenced their school classes at approximately 9 am. When the ILE's class finished, ILE's students joined their non-ILE's classmates for the remainder of the school's Technology Studies class.

ILE Student Participant Selection Criteria

At the end of Year 10, and again at the beginning of Year 11, students taking Technology Studies in Year 11 were informed of the opportunity to participate in the ILE program. The USC lecturer who would be delivering the ILE's classes visited the school to speak with students and their parents.

Academic criteria included the requirements that students attain an overall B average for all subjects taken in Year 10, and a minimum English grade of C+ in Year 10. It was also preferred that students would take Maths B (and Maths C) and Physics in Year 11, but these were recommended school studies rather than strict requirements for entry into the ILE Program. Students were required to complete and submit an application form in which they outlined their reasons for wanting to do the ILE Program and the school was asked to support the application. This school support included an appraisal of each student's capacity to undertake the program, including the likely commitment each student would have to learning the course material, prepare for tutorials and complete all assessment tasks.

The knowledge teachers have of individual students is very important as students who may be unable to successfully complete the ILE Program should not be set up to fail.

Assessing ILE Students School and University Assignments

As previously indicated, detailed assessment criteria (knowledge and application, reasoning processes, and production), and the five standards (A – E) that students would be expected to demonstrate are available for Technology Studies (QSA, 2007). Assessment criteria, though

less detailed, are also available for the ILE's university courses and include variety of topics and their relevance to the overall theme of courses, depth of understanding of topics, correct referencing, variety of references, evidence of scope of systematic research, and the ability to recognise and discuss alternate views on chosen topics.

The school assessment tasks were graded by the school and the university assessment tasks were graded by the university. In general, a student who achieved a high level of learning outcomes in the school studies also performed well in the ILE's studies. Informal discussions between the school classroom teacher and the university lecturer also noted similarities in attitude of the individual students regarding their school studies and their university/ILE studies. Thus, a student who was enthusiastic and reliable at school based work, was also the first to arrive for ILE's classes and had completed the necessary tutorial preparation to a high standard. Conversely, a student who was known to have ability but put little effort into school studies was also frequently arrived late for the ILE's classes.

ILE's Classes Structure

The ILE's classes were run in the same way as a university lecture or tutorial would be delivered. The first half of the class was used to deliver the course material via a lecture. The second half of the class was run as a tutorial based around the previous week's teaching material. An attendance roll was taken. This served the dual purpose of assisting the lecturer to know the names of the students, and also demonstrates to the students that their attendance, or non-attendance, at classes was noted.

ILE Outcomes

The five students participating in the ILE program had all met the selection criteria discussed above. On the basis of the students' applications, and the local teacher's direct knowledge of each student, each student was believed to have the academic capacity to pass both of the university courses included in the ILE program. Another student-centred factor that might influence a student's learning outcomes was personal motivation and engagement with the program as measured by the student's efforts in various activities associated with each course.

The following indicators of individual student effort were monitored during delivery of the ILE Program :

- attendance at classes
- late arrival to classes
- submission of assessment tasks
- participation in weekly on-line discussions of tutorial activities

These indicators for each student are compared with the overall mark each student obtained in both ILE courses (see Table 1, for both semester 1 and semester 2) and suggest late arrival to classes and low level of participation in weekly on-line discussions are associated with lower student performance in assessment tasks. Such student behaviour may be strong indicators of likely poor student performance and so could be used to determine when early intervention and support for students is required, i.e. for those students who chronically arrive late or don't participate in course activities away from the classroom.

Table 1 – Comparison of Student Effort Indicators and Overall Marks

SEM 1	tutorial attendance out of 13	late arrival out of 13	assessments submitted out of 3	participation in on-line discussion out of 12	overall mark (%)
S1	12	0	3	11	81
S2	12	0	3	12	74
S3	11	0	3	11	67
S4	11	1	3	7	72
S5	11	3	3	5	61

SEM 2	tutorial attendance out of 13	late arrival out of 13	assessments submitted out of 4	participation in on-line discussion out of 12	overall mark (%)
S1	13	0	4	7	70
S2	12	0	4	10	75
S3	13	0	4	8	68
S4	13	4	2	0	50
S5	10	6	2	0	34

At the end of each semester, students were able to provide feedback regarding the ILE Program. The following comments (spelling and grammatical errors untouched) were received at the completion of semester 1, during which Engineering Professional Practice was delivered :

S1 : *"I really liked doing this course. it is pretty cool too be starting my career as an engineer in year eleven, when some kids my age dont even know what they want to do yet. i liked the course and would change nothing about it, however if i was to change something, some of the leatures were abit boring (sorry richard, but truth hurts sometimes), i know it cant be helped but i was just giving my opinion. i cant wait to do the next course, and at the end of year twelve going to uni at USC. yay."*

S2 : "*This course has been a great privilege and opportunity to take part in and I have enjoyed all of the topics we have discussed in ENG 101. One improvement I would recommend would be to have more tute activities after we have finish each week's lectures. Other than I have enjoyed my studies in ENG 101 and it has been a great opportunity to study this course when I am only in year 11. Hopefully ENG 101 has lead me into the direction of potential studies in the engineering profession in the future."*

S3 : "*This course ENG101 has been a great opportunity to take part in and to get a head start on the other students that may be thinking about atteneding USC. I dont think there would be much to change in this course but the movies could be a little bit longer to break up the leacture. Other than that its been great and I have enjoyed studying ENG101 in year 11. It has given me an insighht into what to expect at uni. Thanks for this great opportunity."*

S4 : "*The course is a great opportunity for me because I enjoy doing most of the things that are involved with being an engineer in what they do and how. I still think that I will continue studying engineering after highschool at a university and try and take it up as my profession.*

The only thing that i would change is the length of the lecture mainly because the longest class at school is 1 hour and thats what im used to. Other than that its all good."

Student S5 did not provide any feed back.

At the end of semester 2, students were again offered the opportunity to provide feedback but as this was just two days before their school Term 4 also finished, no comments were received (perhaps comments should be sought well before holidays commence!).

A significant outcome of the ILE program in 2009 has been the expansion in both student numbers and participating schools in 2010. In 2009, a single school and just 5 students were involved in the ILE Program. In 2010, that initial school now has 19 students participating (including 4 students from another school who travel to attend). There are also two other schools who are hosting the ILE Program in 2010 : one school has 8 students participating, and another school has 15 students drawn from three separate schools. This means there are 42 students, from six schools, participating in the ILE Program in 2010.

This expansion of the program is the result of regional wide discussions amongst teaching staff from various schools, and visits by university staff to schools in the Sunshine Coast Region. Therefore, there is a greater awareness of the ILE Program in schools in the Sunshine Coast Region, and also in relevant professional organisations due to regional engagement activities by USC (e.g. Construction Skills Qld (CSQ, 2010) was very active in the establishment of the ILE teaching centre in Caboolture, south of USC, which has 15 students from three schools).

As the comments in the student's feedback show, ILE can provide secondary students with a sample experience of first year in higher education. Also, the rapid increase in student numbers suggests there are many secondary students who would like to participate in such a program if it was available to them. The extra schools that are now participating in the ILE Program also indicates that secondary school educators recognise this.

ILE Issues

Whilst it can be very rewarding to teach into a program such as ILE, there are some issues which university staff should consider before establishing an ILE-type program.

A major consideration is the time required to implement and then deliver such a program. Many meetings, initially with school staff (early involvement of senior staff, head of department, deputy-principal and principal, is critical) and then with students and parents, can be time consuming. These meetings set the scene for how the program will run and help all participants know what their responsibilities, costs and benefits will be.

Where the focus is on secondary schools at some distance to the university, travel by academic staff can take a large part of a day. This may impact on other academic duties and beneficial outcomes (such as increased enrolment in university programs) may not be realised for months or years.

The administrative requirements of formally enrolling students into university may be problematic, especially if there is no previous experience with these types of enrolments. It may be that the university IT systems are not set up for these requirements and so will need to be modified.

Significant difficulties can also be experience when attempting to match school and university timetables. Universities may make timetable arrangements for classes well in advance of schools. This may mean that university staff will have limited time available to travel and teach within the school timetable. This can be exacerbated by late changes in either timetable. It may be possible to overcome these issues by holding classes before or after school. However, students may have limited mobility (many may travel to and from school in buses at fixed school bus times) and the program becomes reliant upon the goodwill of parents to transport students. These extra-curricula activities may then impact on students' study time, part-time employment, and sporting commitments.

Another issue related to timetables is school holidays as these may not correspond to university semester breaks and holidays. Students may also be absent due to school camps, sporting events etc., and flexibility in delivery must be built into the program schedule. This flexibility must also incorporate Public Holidays, which may affect one school, but will not affect another school if the classes are delivered on different days.

The university academic delivering the program is not the students' regular teacher, but neither is the academic a one-off visitor who will hold the students' attention. This means the academic must establish control and authority over students whilst at the same time engaging them in higher level studies which are likely to be more demanding than their school studies. As Student S1 indicated : "*some of the lectures were a bit boring*". The academic must find ways of maintaining student interest throughout the content of the courses being taught. In the case of the ILE Program, this included having a brief movie clip shown at the completion of each lecture. The movie clips contained something that was relevant to the material presented in the lecture and the students did not know what movie was being shown until it began. This generated some interest and speculation as to which movie might be relevant to each topic.

There is also the question of what to do with students who do not meet the pass requirements of the university courses they are undertaking. As may be seen above, Student S5 did not pass the second semester course. It is administratively difficult to offer such students another attempt at an ILE Program course. For example, they may no longer be at school, or they may have a timetable that is incompatible with the ILE timetable. If a student does not pass the first ILE course attempted, this may indicate the student may not be able to manage the extra workload associated with normal school studies and the ILE Program. In such cases it may be appropriate for the student to withdraw from the ILE Program.

Conclusion

The ILE Program has successfully provided secondary students with a sample of what first year in higher education might be like. The implementation and delivery of such a program must be carefully managed to maximise outcomes to the stakeholders including the students, the schools and the university. Indicators of student effort and engagement with the program have been discussed and may be useful as possible identifiers of the need for intervention and support for students who may underperform in the program if not given extra or alternate, suitable support. In particular, on time arrival for ILE's classes, assessment submission and participation in on-line discussion were seen to be predictors of student success. The ILE Program has expanded to include more student and more schools and this will enable further examination of the usefulness of the indicators. The approach taken in the ILE Program could be applied to other disciplines and future work will consider this possibility.

Acknowledgements

This Project was funded by the Australian Government Department of Education, Employment and Workplace Relations (DEEWR) via the Collaboration and Structural Reform Fund (CASR). The Principal, Mr Darrin Edwards, and the Head of Technology, Mr Kerry Paige, at James Nash State High School in Gympie, were both very supportive of the project which could not have been conducted without their active involvement. Ms Sarah Windsor and other staff at the USC Regional Projects Management Hub provided vital assistance throughout the project.

References

Anderson, L. S., and Gilbride, K. A. (2003). Pre-university Outreach: Encouraging Students to Consider Engineering Careers. *Global Journal of Engineering Education*, (7), 87-93.

Boekaerts, M. and Corno, L. (2005). Self-regulation in the classroom : A perspective on assessment and intervention. *Applied Psychology : An International Review*, 54(2), 199 – 231

Construction Skills Queensland, (2010). Retrieved 9th February from http://www.csq.org.au/

Darvall, P. (1993). Towards World-Best Practice in Engineering Education. *Australian Journal of Public Administration, 52*(1), 53-64.

Department of Employment, Training, and the Arts, (2008). Next Step 2008 : Sunshine Coast Regional Report. Brisbane, Australia. p 13. Retrieved 9th February from http://education.qld.gov.au/nextstep/pdfs/2008pdfs/regions/sunshinecoast08.pdf

Garlick, S. (2005). Regional Growth, Enterprising Human Capital and Community Engagement. *Proceedings of International Conference on Engaging Communities*, Brisbane, Australia. Retrieved 9th February from http://www.engagingcommunities2005.org/abstracts/Garlick-Steve-final.pdf

Gerlich, R.N., Mills, L.H., and Sollosy, M. (2009). An Evaluation of predictors of Achievement on Selected Outcomes in a Self-Paced Online Course. *Research in Higher Education Journal*, 4, September 2009. Retrieved 9th April from http://www.aabri.com/manuscripts/09199.pdf

Gunasekara, C. (2004), The Third Role of Australian Universities in Human Capital Formation. *Journal of Higher Education Policy and Management, 26*(3), 329-343

King, R., and O'Kane, M. (2007). Rethinking Australian engineering education: the needs of future engineers will be at the heart of a new national review of tertiary engineering education supported by ATSE. *ATSE Focus*, (147), 7-9.

Queensland Studies Authority, (2007). Senior Syllabus : Technology Studies 2007. Retrieved 9th February from http://www.qsa.qld.edu.au/downloads/10-12/snr_tech_studies_07_syll.pdf

University of the Sunshine Coast (2010), Headstart Program, Retrieved 9th February from

http://www.usc.edu.au/Students/Future/Year10-12/Headstart/

Wilson, K., (2009). Success in First Year : The impact of institutional, programmable, and personnel interventions on an effective and sustainable first-year student experience. *12th Pacific Rim First Year in Higher Education Conference*, Townsville, 29th June – 1st July, 2009. Retrieved 9th April from http://www.fyhe.com.au/past_papers/papers09/ppts/Keithia_Wilson_paper.pdf

Wilson, K., and Lizzio, A. (2008). A "just in time intervention" to support the academic efficacy of at-risk first year students. *11th Pacific Rim First Year in Higher Education Conference*, Hobart, 30th June – 2nd July, 2008. Retrieved 9th April from http://www.fyhe.com.au/past_papers/papers08/FYHE2008/content/pdfs/6b.pdf