Conducting Successful Studies in Materials Science and Engineering with Consideration to a Multiplicity of Student Cohorts and Delivery Modes

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Abstract

Second year students undertaking their studies in Materials Science and Engineering within the Bachelor of Engineering at CQUniversity, Australia, are a diverse group requiring a variety of approaches to enable them to undertake their studies. The university, whilst having a strong regional focussed approach, conducts its Engineering degree offerings over three campuses, at Mackay, Rockhampton and Gladstone, in Queensland, Australia and by flexible mode throughout Australia and internationally. Lecturers are located on each of the campuses and it is their role to oversee the cohort of on-campus students on that particular campus. On-campus, full-time students are traditionally secondary students who have continued with their studies into tertiary education or mature learners who have been in the workforce for some time and return to study to re-skill, up-skill or update their knowledge and skill base. While students who study by a part-time, external (ie. flexible or distance) study mode are practitioners who have a trade qualification or are university graduates wishing to re-skill, up-skill or update their knowledge and skill base and continue working throughout their study. All students have access to course materials, video-streams of lectures, student-student and student-lecturer communication channels via a dedicated course Moodle™ website.

Index Terms – distance education, materials science, lecturer-centric, residential schools

BACKGROUND

CQUniversity is a regional Australian university operating ten campuses across Australia. Six campuses are located in Queensland area; Rockhampton, Mackay, Gladstone, Bundaberg, Emerald and Noosa. These campuses deliver undergraduate and postgraduate academic programs and research opportunities to domestic students. There are a further four campuses (Sydney, Melbourne, Brisbane and the Gold Coast) focusing upon conducting academic programs to meet the needs of international students. In particular the School of Engineering and Built Environment, within the Faculty of Sciences, Engineering and Health, operates its undergraduate engineering programs, in the coal-rich mining area of Central Queensland through the three campuses of Rockhampton, Mackay and Gladstone. The School's undergraduate co-operative engineering program consists of a combination of Project Based Learning (PBL), lecturer-centric instruction, industry placement, and professional practice education. The first two years of the program are available on a face-to-face basis on the Rockhampton, Gladstone and Mackay campuses. Gladstone and Mackay are separated by one hour and three hours travel by road respectively from Rockhampton. The second year Materials Science and Engineering course is conducted in a lecturer-centric mode of delivery. The course uses a diverse range of approaches to engage students in learning and both on-campus, face-to-face (or internal mode) and off-campus, distance cohorts of students are enrolled in the program.

CROSS CAMPUS MANAGEMENT

With teaching staff dispersed over three campuses regular communication between these staff is problematic but not insurmountable. The distances encountered create financial and logistical problems for travel, accommodation and physical and human resource allocation. Prior to the commencement of the teaching term the teaching team have met by teleconference or face-to-face to discuss the teaching resources and requirements (physical and virtual) and generated updated assessment items and formulated the course profile for the forthcoming offering. Once the twelve week teaching term begins

regular hourly meetings are conducted, from one week to the next, to review and plan to ensure student enquiries, encountered problems are addressed and organisation of planned events are reviewed and enacted where necessary. The two hour, weekly lectures are conducted by videoconferencing across the three campuses and this provides a further access mode for the teaching staff to confer and discuss issues on top of teleconferencing and emailing as communication channels.
Overall responsibility for decisions relating to the course and its conduction, student issues and resource management is made by a course co-ordinator. This role is one that is negotiated between individual staff and the program director and the academic staff member's line supervisor, the Head of School. There is a quotient of an individual's work allocation that is assigned for accepting the responsibility of the course co-ordinator position. Even with the formality of the designated course co-ordinator's role the current teaching team works as a successful unit as decisions are made by the group through a strong consultative and collaborative approach.

The course: materials science and engineering

The course, ENEG12005 Materials Science and Engineering, at CQUniversity Engineering is a 6 credit point course, which was re-developed from a previous 12 credit point course, the ENEG12002 Materials and Processes. The purposes are to provide the basic knowledge in materials science and engineering and associated skills to the students in the programs of Bachelor of Engineering and Bachelor of Engineering Co-op Degrees for their later endeavours in both studies and careers. The main course contents include (1) the properties and classifications of engineering materials; (2) the internal (often micro-) structures and structure-property relations of engineering materials; (3) the techniques/methods to modify the internal structures and therefore, to manipulate the material properties; (4) standards and/or codes for material testing and evaluation; (5) the failure mechanisms, failure analysis and preventions of engineering materials; and (6) material selection for engineering design and repairs.

Owing to its importance as the basis for all four engineering streams offered at CQUniversity Engineering, (i.e. mechanical, civil, electrical engineering and mining), this course is delivered in the second semester of year two under the umbrella of the first two year component of the program known as 'engineering foundations'. The students from different disciplines possess varying levels of pre-requested knowledge basis for this course and so the aim is to accommodate this by the different emphasises within the course content. It is particularly challenging to balance the different needs and backgrounds of the students, and the transition of the course from a 12 credit point course to a 6 one has added further difficulties to the delivery because it means that less contact hours are allocated. To tackle the challenges, a multi-phase approach including lectures, tutorials, group project, laboratory practicals, and various online forums is employed. The student learning is assessed through quizzes, group laboratory reports, a group project report and a formal examination.

Furthermore, the students enrolled in this course include both on- and off-campus cohorts. On-campus students are located in three campuses, i.e. Rockhampton, Mackay and Gladstone campuses, and off-campus students can be anywhere in Australia. It has been proven to increase the difficulties of the delivery because of the enrolments of off-campus students in a course with laboratory component [1-6]. The lectures are delivered in pre-set time slots to all three campuses through videoconferencing, and these are recorded so that the video streams can be posted on the dedicated Moodle™ [7] course website so that any student (internal or distance study mode) can view the lectures asynchronously. Also various forums and discussions about relevant problems and reports are hosted in the Moodle™ website so that students have equal access and ability to contribute, synchronously or asynchronously, no matter whether they are a student on one of the three campuses or an off-campus student. A compulsory residential school is also required of the off-campus students.

The Moodle™ platform is the Learning Management System used to deliver the course. There has been a transition from Blackboard™ to the Moodle™ platform in the past two years. This approach is another strategy for bridging the geographical distances for student and academic alike. It has meant an improvement in the digital literacy of academics and students in order to facilitate and enhance e-

learning and teaching. Management of the site is shared between the teaching team with all having the protocols to upload or download files or for making changes to the site itself.

RESIDENTIAL SCHOOLS

The implementation of residential schools as part of the learning experience for students enrolled in distance education has been implemented at CQUniversity for almost 30 years; especially for science courses. In the past three years the practice has been adopted for undergraduate engineering courses and this is the case for the course of Materials Science and Engineering which includes a compulsory laboratory-practical element, consisting of four laboratories, a formal quiz and tutorial sessions. In the case of engaging with distance students to ensure they are acquiring or refining laboratory skills, this is critical for the student to gain comprehensive understanding of the course contents because laboratory-practicals are an important element for the development of engineering technical skills [1]. While the on-campus students are scheduled within ten weeks to complete the laboratory sessions, it is a challenge to provide the laboratory sessions to the off-campus students given their diversified geographic locations [2, 3]. To satisfy the need of the off-campus students of laboratory-practical, various techniques have been considered, including on-campus sessions, movie clips, home experiments, computer simulations and the internet-controlled remote laboratories [2, 4, 6]. Among the five methods, the on-campus session or residential school is chosen because it is the best method to ensure the students have the real "hands-on" experience [2, 5].

The residential school is designed for students enrolled in distance mode to participate in intensive interactions with teaching staff and their peers. Internal students do not attend the residential school because laboratory sessions for them are conducted throughout the term on all campuses to accommodate their need. The primary objective of the residential school is to allow distance students to participate in the laboratory-practical components, which are compulsory for this course.

In order to ensure distance students are fully conversant with the relevant content and required standard for the laboratory work submissions, a number of sessions are designated for them to produce a draft of their first laboratory submission, seek advice and ask questions. In particular, emphasis is placed on providing worthwhile sessions so that students get the most out of the residential school experience so they can complete as much as possible while at the residential school. This is a deliberate strategy to enable the students to capitalise upon the availability of academic staff and complete their study commitments so they are able to slot back into their work commitments without onerous tasks to still needed to be completed from their residential school experience.

The students studying by distance mode consist of people who live and operate their working lives in urban, rural and even remote (rural) areas. The people living in geographically rural and remote areas are self employed or are employed by large agricultural companies or multinational mining corporations. The majority of our distance students, in the rural and remote category of working, are employed in the mining industry. In an Australian context, geographically remote means that the industry is based in a 'company-owned' town which exists only because of the industrial activity being conducted there. People are living in areas where they need to travel vast distances (6 to 10 hours by road) to reach urban areas.

The nature of these students' work-life is to conduct a 12 hour work shift, operating over a 9 day fortnight and then they have four days leave before returning to the same work cycle. A large number of these students operate on a 'fly-in/fly-out or a drive in/drive out' basis and so can be living and working an urban/rural or urban//remote (rural) existence with them being absent from their family during the work period. So in conducting the residential school, time is of the essence. Consequently, it is paramount that in bringing students from throughout Australia that the learning experiences and interactions are worthwhile, focussed and meaningful.

The residential school program has lately been developed into a three day event, which consists of all phases of learning activities including quizzes, laboratory-practicals, tutorials and the discussion of

course content. This is one way the off-campus students can gain an equivalent experience as their on-campus peers.

Like [8] it is our experience the residential school is considered a significant opportunity by students enrolled in distance mode for students and lecturers to make contact and develop a working relationship. Students were appreciative of the skills that they developed as well as the sense of community embodied in the residential school. Our experience concurs with comments made by students surveyed by [8],

> *'Residential schools are almost essential for distance students for clarification of ideas and concepts, finding compatible fellow students for mutual help, study and support and brief social and academic contacts with other students and lecturers.'*

and further by [9]:

> *'I also think that an important part of a degree is the contact with other students which for distance education students only comes during residentials.'*

The schedule for the residential school ensures the attendees are on tasks over the whole period. In this way, the off-campus students can use the three valuable days more effectively to maximize their learning experience. In particular, the program has been so designed to that the student cohort is not absent from their workplace more than is necessary. As practitioners they have varied managerial responsibilities on-site to oversee the daily operational functions of their workplace and some need to travel vast distances to attend the residential school. Furthermore the sessions are carefully planned as attendees are practitioners who are skilled people who are working in industry and may be conversant with techniques or have a far more in-depth knowledge than secondary students (typical internal student) – so they need to be challenge in order to provide an environment for them further develop their technical knowledge and skill acquisition. So our experience correlates well with that of the observations made by lecturers in [10] who appreciate that:

> *'The external students are very knowledgeable and demanding. They are highly motivated and curious, so you have to teach your subject well and present A Class material.'*

> *'The students are professionals and my peers. There is no teacher delivery, instead they each engage in reflective practice, both in the teaching and learning.'*

> *'The practical work that the internals and externals do is not greatly different but the students do differ, the internals are not as confident or rapid in their work, whereas the externals are experts.'*

> *'In the theoretical subjects the distance education students are not as good but*

in technical subjects they are better.'

An added advantage of the residential school is that it is an avenue by which academic staff can pursue direct feedback from students enrolled in distance mode, who are practitioners working in industry. The teaching team see this as a significant opportunity to gain insight into current industry practices as well as provides relevant and indirect input to the content of the course. Both cohorts of students (distance and internal) have the opportunity to provide informal feedback at any time during the conduction of the course and there is also a formal questionnaire towards the end of the academic term. In order to evaluate the effectiveness of residential school program, an anonymous feedback survey was conducted in term 2 (2010) at the completion of the 3-day residential school. The questionnaire consisted of two parts. The first part consisted of four sections with 11 items. These sections were:

- Facilitator (Attitude and Practices)
- Laboratory Sessions
- Class Quiz, and
- the Least Appealing Features

Section one focused upon the Facilitator's attitude and practices and consisted of a set of 5 items as listed in Table 1. Students were requested to respond to each item in the questionnaire using a five point Likert scale; Very Poor, Poor, Average, Very Good, Excellent and Unable to Comment. The second section comprised open ended questions for students to comment upon their experiences at the residential school.

Table 1: A list of questions/items used in the survey for students' feedback.

No	Items
1	Facilitators' enthusiasm on the course.
2	Facilitators' encouragement for me to do my best work.
3	Facilitators' helpfulness in answering my questions and queries.
4	Facilitators' sensitivity to an individual's way of learning.
5	Facilitators' preparation/organisation of residential school.

The response rate was 100% (N=18). The overall results obtained from the survey were very positive as discussed in the following sections. Table 2 [11] presents a response summary of the collected data. The survey results suggest that students attending the course's residential school were extremely happy with the facilitators' overall attitude and practice in handling the residential school activities. The chart in Figure 1 gives a graphical presentation of the survey results [3].

The outstanding feedback on the facilitators is probably due to the excellent teaching strategies applied by the facilitators during the 3-day event.

LEARNING OUTCOMES, GRADUATE ATTRIBUTES AND FORMS OF ASSESSMENT

The course's learning outcomes [12] have been mapped to the undergraduate programs learning outcomes in order for the course and program to conform to Engineer Australia's competencies required of a graduate engineer; Table 3. The Engineers Australia graduate attribute categories are indicated in Table 4.

Table 2: Presents a response summary of the collected data [11].

Item	Very Poor	Poor	Average	Very Good	Excellent	Unable to comment	Rating Average
1	0.0% (0)	0.0% (0)	5.6% (1)	**66.7% (12)**	27.8% (5)	0.0% (0)	4.22
2	0.0% (0)	0.0% (0)	22.2% (4)	**61.1% (11)**	16.7% (3)	0.0% (0)	3.94
3	0.0% (0)	0.0% (0)	5.6% (1)	**66.7% (12)**	27.8% (5)	0.0% (0)	4.22
4	0.0% (0)	0.0% (0)	33.3% (6)	**44.4% (8)**	5.6% (1)	16.7% (3)	3.67
5	0.0% (0)	5.6% (1)	**38.9% (7)**	**38.9% (7)**	16.7% (3)	0.0% (0)	3.67

In order to assess the knowledge and skills acquired and the level of proficiency the course has three forms of assessment which covers all the desired learning outcomes incorporated in the course.

Assessment item 1—Practicals

There are four (4) laboratory sessions for this course. These are:

1. Investigation of Ductility and Brittleness in Wire Demonstration
2. Investigation of Cast Iron Structure
3. Tensile and Hardness Tests
4. Charpy Tests

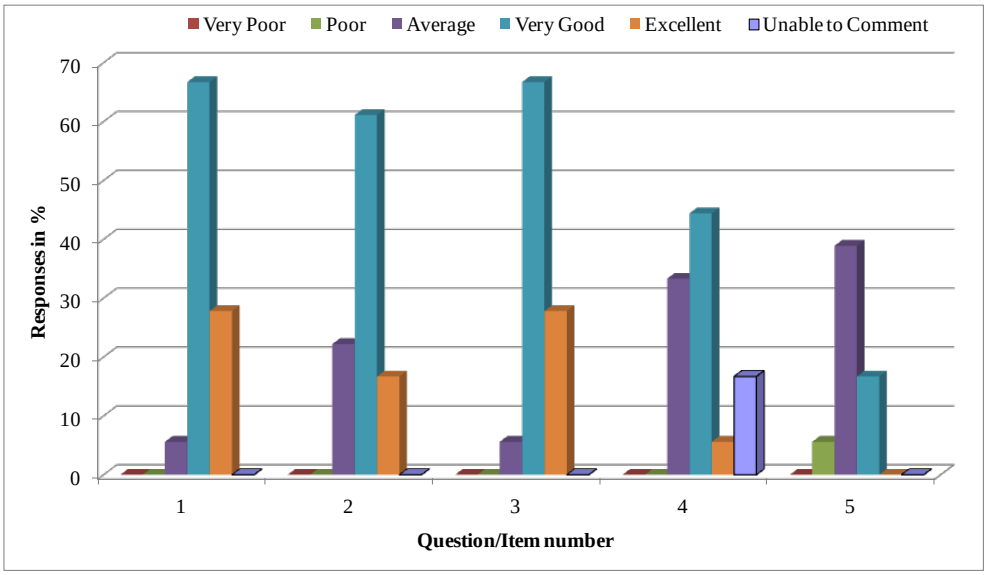

Figure 1: Chart showing survey results on the effectiveness of residential school in the course. (N=18) [11]**.**

These laboratory sessions are compulsory for all students (internal and flexible). A student must achieve at least 50% of the marks allocated to the lab work to obtain a grade of Pass (P) or Credit (C) and at least 75% of the marks allocated to the lab work to obtain a grade of Distinction (D) or High Distinction (HD).

Assessment item 2—Classroom Quizzes

Classroom quizzes are very effective in assessing technical understanding and is used as a summative assessment item as students progress through the term. The format is 'open book' but no discussions are allowed. Internal students are given questions relating to the contents discussed in the previous weeks during the tutorial sessions. The first quiz is done under formal examination processes. The remaining quizzes are accessed by students by the Moodle™ course site and all students have the weekend to complete and upload their solutions. For the later quizzes, we recommend students attempt the questions in a session of a maximum 2 hrs. The reason is help them acquaint themselves with examination conditions as some students in the cohort have not been involved with formal examinations for some time.

A student must attempt at least 75% of the questions to achieve a passing grade. A question deemed to have been completed if the student has shown correct procedure and sound understanding of the work.

Assessment item 3—Team Project

The team project is generally completed by a group of 4 to 6 students, and the total marks of 15% allocated to this project consists of 10% for group project report and 5% for self and peer assessments. The current project is on determining the best material to be used for a chisel which can be used to for a brick and mortar application. The students have to select steels among the four plain carbon steels and design a procedure to manufacture the chisels. They are also required to draw up a plan for the quality testing of these chisels. Upon the completion of the materials selection and manufacturing process design as well as the testing plan, a report is required, which must also include self assessment (1%), peer assessment on team members(1%) and team members assessments on individual student.

Assessment item 4—Examination (written)

The examination is conducted as a formal, invigilated open book assessment with a weighting of 40% and is conducted over a three hour duration. All these assessment items described above show that this course gives students equitable and diverse assessment experiences and procedures in the form of Quizzes (individual), Project (Team), Laboratories (Team but separate write up) and Examination (Individual).

Table 3: Course learning outcomes and correlated Engineers Australia graduate attribute categories

Course Learning Outcomes	Engineers Australia Graduate Attributes Category Correlation
1. Discuss and identify the principal properties of common engineering materials.	1, 2, 3
2. Classify engineering materials and explain the reasons for such classification.	1, 2, 3
3. Select engineering materials for given applications.	1, 3, 4
4. Explain the processes used to control the microstructure and macrostructure of materials and their properties in engineering use.	1, 2, 3
5. Analyse the effects of the environment on materials and the failure of engineering materials during service, and explain causes and mechanisms of failure.	1, 3, 4, 5
6. Demonstrate an effective, professional level of teamwork and communication and support collaborative peer group learning.	2, 6, 9, 10
7. Identify appropriate sources of information about engineering materials required for given applications.	4, 10

Table 4: Engineers Australia graduate attribute categories

Engineers Australia Graduate Attributes Categories
1. Science and engineering 2. Communicate effectively 3. Technical support competence 4. Simple problem resolution 5. Standards and codes of practice 6. Function as a team member 7. Social, cultural, global and environmental 8. Sustainable design and development 9. Professionalism and ethics 10. Lifelong learning

Since timely feedback is a key factor in students' learning the assessment submission timeline has developed in such a way that students receive feedback on their assessment submission on time. For example, students have to submit their laboratory reports for all four laboratories however, their first submission is marked and returned with feedback and advice which assists them to reflect on and improve upon their first submission and then they are asked to submit other laboratories.

The course structure follows a comprehensive quality assurance mechanism with respect to contents, delivery and assessment. As indicated clearly in the assessment details, lots of opportunities are provided for group work/team work and so to ensure examining individual student knowledge acquisition. This practice is followed for both internal and flexible students.

Another important feature is the facilitators of this course make sure that an equity of marking (and workload) is achieved by assigning different lecturers to mark the whole cohort of a particular assessment item; quiz, laboratory.

QUALITY ASSURANCE PROCESSES

As previously discussed, in order to facilitate and manage staff, across multiple campuses, so that students are provided with equitable, credible and comparable learning experiences it is important that the teaching team operate as a cohesive group. Shared information and resources are crucial to achieving success. It is important that decisions concerning learning experiences and teaching strategies are discussed both before and during the teaching term so that all students will be provided with equitable learning environments and that academic staff have teaching opportunities regardless of their campus location.

It is paramount that students across the campuses and the students enrolled as distance students are treated equitably and have access to staff and resources. In regards to the cohort of internal student on individual campuses it is important that staff on specific campuses do not bias their student cohort by under- or over-servicing or compromise other groups on other campuses by being unduly influenced by local campus allegiances. In order to address this and to provide a mechanism for more efficient task assignment for the lecturing team it was negotiated that specific assessment items are managed and corrected by the one academic and all answering of enquiries, advice, marking, feedback and follow up is undertaken by the one academic. This mechanism provides consistency as any alterations or modifications are dealt with by the one person and this should result in equitable actions taken for all students, no matter what campus or form of study mode (internal or distance).

CONCLUSION

CQUniversity offers educational opportunities for students choosing to study in the discipline of engineering in distance mode and in a face-to-face learning environment. Engineering courses are delivered across multiple campuses which are geographically separated by large distances and this creates challenging scenarios of the manner in which students are treated equitably when participating in lectures and in the processes adopted to assess assessment items. With multiplicity comes complexity. The manner in which staff management and student learning is successfully achieved requires a robust quality assurance process and is underpinned by nurturing a collaborative and consultative teaching team.

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