AUSTRALIAN LEARNING & TEACHING COUNCIL

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FELLOWSHIP REPORT

Bridging the gap: Matching students and staff through discipline-based self-evaluation and co-creation of more appropriate pedagogies in engineering

http://www.altcexchange.edu.au/group/bridging-gap-between-learning-and-teaching-engineering

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Executive Summary

The broad aims of this fellowship were to enhance the learning experience and learning outcomes of engineering students, and to embed enabling strategies and processes for engaging engineering students and academics, systematically. It was motivated by the demand for engineers and the critical need to increase enrollment and retention rates of students in engineering programs.

A case study approach was designed in accordance with best practice to explore the proposition that a mismatch between learning styles, teaching styles and institutional norms impedes student commitment to and success in learning. It involved current students and academics across three universities; Queensland University of Technology (QUT), CQUniversity and The University of Melbourne (UoM). The chosen sites reflect a range of institutions whose cultures could be expected to have an impact on students' success rates and learning outcomes.

Learning styles of participating students and academics were assessed using Felder and Silverman's online survey tool, Index of Learning Styles (ILS) Questionnaire, developed in an engineering context. To identify the major features of various approaches to teaching, teaching styles were assessed using Grasha's Teaching Style Survey.

The case studies included class observations, focus groups with students and interviews with volunteering academics. The data acquired from these activities were then compared with the learning and teaching styles survey results to triangulate on the phenomenon. Feedback was provided to participating academics through written personalized analyses, and to a wider audience via a series of workshops. Barriers to learning were explored in student focus groups and a thorough critical review of the literature.

To disseminate the case study results, three workshops were conducted at the three participating universities. To engage more academics, two national level workshops were also conducted at the annual conference of the Australasian Association for Engineering Education (AaeE).

The main outcomes of this fellowship can be summarized as follows:

- Engagement of students and academics from the participating universities in the case studies;
- Engagement of academics from various other universities in workshops and follow up communications;
- Engagement of a network of colleagues (Program Evaluator and Reference Group) with proven track records in teaching performance, leadership, and the scholarship of teaching;
- Direct engagement of nineteen volunteering academics in interviews and class observations, one hundred and fifty six students in learning styles surveys, around one hundred students in nine focus groups spanning twenty four hours of discussion and rich data collection;
- Engagement of more than eighty participants in five workshops, two of which were held nationally, and about seventy participants at a QUT ALTC special Fellows seminar;
- Dissemination of findings as an invited keynote presentation at the 2009 CDIO International Conference;
- Development of the following resources: (a) four guides for academics on connecting teaching with learning and addressing barriers to learning, (b) ten resources as papers, workshop materials and workbook, slides, etc. (c) eight reports, (d) three documents on the processes used for planning and running this fellowship program, (e) two protocols for interviewing academic staff and conducting student focus groups, and (f) data (transcripts of student focus group discussions, and learning styles assessment results of participating students and academics.)
- Two co-authored conference papers and one journal paper presenting findings of the case studies;

The fellowship provided an insight into factors affecting the learning-teaching nexus and indentified gaps between teaching objectives and classroom practice, suggesting ways of addressing them. It also provided an in-depth treatment of the barriers to student learning and suggestions for dealing with some of them. Further, it provided a number of guides including a self-evaluation and reflection model for enriching academics' teaching performance and enhancing students' learning experience.

Details of the program, its processes, collected data and outcomes are accessible from the ALTC Exchange site at: bridging-gap-between-learning-and-teaching-engineering.

1. Project plan

1.1 Rationale

There is demand for engineering skills that is not matched by student demand for engineering programs. The demand for engineers is expected to increase even further, as the global economy recovers from its present downturn. For example, a recent report on the Future of US Automotive Human Resources (CAR, 2008), has anticipated this increased demand for that industry in the USA. This highlights the importance of maximising retention rates of students in engineering programs. Nationally, the likelihood of successful graduation from a bachelor level engineering program is about 52% for male Australian engineering students, and 60% for female students, on average (King, 2008). Can we do better?

To support and facilitate student success rates and engender active learning, there is a need to have a commitment to identify and respond to any weaknesses in teaching strategies and in the learning environment in an integrated way. To retain students and to evaluate the success or otherwise of their programs, universities routinely conduct surveys and collect data. However, it is vital to have sophisticated program evaluations that are well documented and supported by thorough data analysis. It has been observed that in data collected via the Course Experience Questionnaire (CEQ), students may rate all aspects of teaching as being of high quality, yet they score the whole course/program's experience as being poor. Such a dichotomy highlights the need to have a closer look at survey questions, and other feedback and data collection mechanisms to gain insights into factors affecting engineering students' perceptions of quality teaching and to discover the reasons that contribute to their success. There is also a need to share research results in order to assist in stimulating a productive discussion on the matter.

1.2 Objectives

This fellowship aimed to address the following interdependent critical educational issues:

- Enhancing the learning experience and learning outcomes of engineering students, and
- Embedding enabling strategies and processes for engaging engineering students and staff, systematically.

Of specific relevance to addressing these educational issues was the Fellow's previous work in (a) utilising students' preferred cognitive styles (Boles and Pillay, 1999 and Boles et al., 1999) and active learning strategies in designing and delivering their learning activities, in the classroom and on line, and (b) curriculum design (Boles, 2001), assessment and staff development. In pursuing these issues, the Fellow started by his experience as an engineering educator and leader for more than two decades, working with students, fellow academics, and university administration in the USA and Australia. This was greatly supported by program collaborators, researchers, program evaluator, and a reference group comprising experts and leading educators.

The intended outcomes of this program concentrated on enhancing engineering students' learning experience and outcomes by:

- embedding systematic approaches for creating synergies between students' learning styles and academics' teaching styles,
- devising and using a collaborative problem-solving process which involves both students and academics in self-evaluation and co-creation of more relevant and appropriate pedagogies,
- providing resources and mechanisms for enabling individual academics to work collaboratively with colleagues to access and utilise their collective strength at the discipline level, across universities, and
- identifying barriers to learning, and devising systematic ways for addressing them through the examination of student evaluation of teaching surveys and the assumptions underlying them, with specific focus on the engineering discipline.

While these outcomes have been largely achieved, there have been some changes in emphasis on some of them, as outlined in the following sections.

2. Approach and methodology

The fellowship program was implemented using a case study approach. A project officer, a project researcher and a program evaluator were appointed to work with and assist the Fellow and the program Collaborators at CQUniversity and The University of Melbourne.

A number of workshops and activities were planned and designed to ensure continued engagement and were used as a vehicle for dissemination during the program.

The case studies were used to gather and organize a wide range of information and then analyse the contents by seeking patterns and themes in the data. A case study protocol (Yin, 2001) containing a set of procedures and general rules was devised and followed. The case study protocol considered the objectives and issues to be investigated and the research questions to be addressed. Procedures for identifying and gathering information were also put in place to support the conduct of the program and achieving its intended objectives.

As part of the case studies, field work was carried out at the three universities; QUT, CQUniversity and The University of Melbourne. The sites chosen for the case studies reflect a range of institutions whose cultures and demographics could be expected to have an impact on students' abilities to learn how to learn in order to achieve the intended learning outcomes. At each university, a call for participation of academics was made via information sheets, discussions and presentations to staff. These varied depending on the circumstance at each institution. The timing for the conduct of the studies was largely determined by semester schedules and academics' and students' timetables.

At CQUniversity, the Project Collaborator (Prue Howard) led the efforts of recruiting participants and organising academic staff interviews as well as class observation schedules. A parallel process was followed at The University of Melbourne, led by the Project Collaborator there (Roger Hadgraft). While leading the program, the ALTC Associate Fellow (Wageeh Boles) was in direct communication with colleagues at QUT via formal and informal meetings and discussions. In all cases, the Project Officer (Hilary Beck) communicated with all involved and organised and kept track of activities. The Project Researcher (Lesley Jolly) was in charge of conducting the class observations and academic staff interviews. In addition, at each institution, the Project Researcher conducted focus groups with volunteering students at different stages of completing their engineering programs.

The case studies had a primary focus on the learners (students), the teachers (academics) and the learning environment (institutional norms). They were designed to explore the proposition that a mismatch between learning styles, teaching styles and institutional norms may impede student commitment and success in learning. By institutional norms we mean such factors as the prestige attached to research, the dominant model of delivery, whether it be lecture, online, project etc., and the amount of support offered to students in adjusting to university culture.

Engineering education literature includes studies that suggest that in engineering programs, learning can be optimised by addressing the students' different learning styles or preferences. However, most engineering academics tend to, at least implicitly, assume not only that all students adopt similar learning styles, they expect the same learning style to be applied to all areas of engineering studies (Mills et al., 2005).

Considering how students prefer to learn, research shows that students are characterized by significantly different learning styles: they preferentially focus on different types of information, tend to operate on perceived information in different ways, and achieve understanding at different rates. The work of Felder and Silverman (Felder and Silverman, 1988) on learning and teaching styles is a relevant example of the value-adding the discipline-based approach continues to deliver for engineering. Students whose learning styles are compatible with the teaching style of an academic staff member tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/teaching style mismatches (Felder, 1993). The work in this program has taken into consideration the recent work of Coffield et al (2004). They published a study on the various learning styles and questioned the validity and reliability of the learning styles construct and assessment instruments. However, in discussing the implications for pedagogy, they state that: "A knowledge of learning styles can be used to increase the self-awareness of students and tutors about their strengths and weaknesses as learners. In other words, all the advantages claimed for metacognition (i.e. being aware of one's own thoughts and learning processes) can be gained by encouraging all learners to become knowledgeable about their own learning and that of others". The same publication refers to Apter's work (2001) who suggests that an understanding of the various factors that affect or result in different motivational levels, given the possibly different contexts, can 'allow people to become more in control' of their own motivation and of their learning; as a result. Coffield et al. (2004) relate that Apter continues to state that; "Learners can become more effective as learners if they are made aware of the important qualities which they and other learners possess. Such knowledge is likely to improve their self-confidence, to give them more control over their learning, and to prevent them attributing learning difficulties to their own inadequacies". Through the case studies, this Fellowship program provided an opportunity for participating students and academics to engage in meaningful discussions about learning and teaching styles and preferences.

When Grasha (1994) started his investigation into teaching styles, he made the assumption that a teaching style represented a pattern of needs, beliefs, and behaviours that academics demonstrated in their classroom. He also envisaged that style was multidimensional and affected how lecturers presented information, interacted with students, managed classroom tasks, supervised coursework, introduced students to the study area or profession, and mentored students.

The interaction between the students' learning styles and preferences, academics' learning styles, teaching styles and philosophies provide a rich field for investigation and holds a great potential for enhancing the learning environment and students' learning outcomes. This fellowship endeavored to tap into the literature and combine it with the expertise of the Fellow, the program collaborators, program evaluator, and reference group, to gain an insight into factors affecting the learning-teaching nexus.

2.1 Case studies

At each site, two major activities were implemented, one with students and the other with volunteering academic staff. The program worked with current students and staff across the three universities, to study interactions between students and lecturers in a process of investigation, analysis, problem-solving, pedagogical design and implementation that develops a culture of shared responsibility between students and staff for enhancing learning outcomes.

Students were asked to complete an on-line questionnaire to assess their Learning Styles, and participated in focus groups. Volunteering academics were asked to complete a learning styles survey and a teaching styles inventory. In addition, an instance of their teaching was observed and they were also interviewed. The student focus groups and lecturers' interviews assisted in obtaining important details about the effects of the institutional culture.

The learning styles instrument chosen was Felder and Silverman's Index of Learning Styles (ILS) Questionnaire (Felder, 1999), since it was developed for engineering students and was used in previous studies such as the one reported by Mills et al. (2005). The ILS uses four dimensions to describe learning preferences. Each preference is rated on a scale from 1 to 11, with 11 being the strongest preference.

The four dimensions can be described as in Mills et al. (2005):

- Active/Reflective: This dimension refers to processing of information. Active learners prefer trying things out and working with others. Reflective learners prefer to think things out and work alone.
- Sensing/Intuitive: This dimension refers to ways of receiving information. Sensors like learning facts and using tried methods in practical settings. Intuitive learners are innovative and enjoy abstract concepts and new situations with untried methods.
- Visual/Verbal: This dimension refers to ways of perceiving sensory information. Visual learners relate well to graphs, pictures, diagrams etc. Verbal learners enjoy reading and lectures.
- Sequential/Global: This dimension refers to progress towards understanding. Sequential learners prefer taking logical steps towards an outcome. Global learners grasp the big picture quickly and work out the steps later.

The teaching styles assessment instrument used was the Grasha-Riechmann teaching styles survey. This has five categories of styles, namely: Expert, Formal Authority, Personal Model, Facilitator, and Delegator, as given in table 1:

Table 1: Teaching Styles

Type	Definition
Expert	Transmitter of information
Formal Authority	Sets standards and defines acceptable ways of doing things
Personal Model	Teaches by illustration and direct example
Facilitator	Guides and directs by asking questions, exploring options, suggesting alternatives
Delegator	Develops student's ability to function autonomously

However, Grasha (1996) claims that all teachers possess each of the qualities of the five styles to varying degrees. In a thematic analysis of his experiences, he found that four combinations, or clusters, of styles were evident. Teachers use some styles more often than others or use styles in combination. He further identified the four clusters shown in Table 2 below.

Table 2: Teaching methods

Cluster	Primary Styles	Secondary Styles
1	Expert/Formal authority	Personal model/Facilitator/Delegator
2	Expert/Personal model/Formal authority	Facilitator/Delegator
3	Expert/Facilitator/Personal model	Formal authority/Delegator
4	Expert/Facilitator/Delegator	Formal authority/Personal model

In addition to the learning and teaching instruments, academic staff were invited to use Angelo and Cross' Teaching Goals Inventory (Angelo and Cross, 1993) to help them reflect on their self-assessments of teaching styles and actual interactions with students in the classroom.

Discussions of the immediate findings of the case studies formed the kernel of the workshops conducted at each of the participating institutions. Since the literature suggests that outcomes can be enhanced by making the learning process and its potential barriers explicit, the workshops were designed to encourage participants to work together towards this goal.

Feedback to participants and the discipline formed an important part of the program. Individual academic staff participants were presented with a summary reflecting on their survey and interview results and the findings of the observations. Where possible, this was offered with some pointers and suggestions on how to move forward and create a better understanding of their students and also themselves, in order to enhance their teaching.

2.2 Workshops

Workshops for academic staff were held at the three participating universities and also at the 2008 Australasian Association for Engineering Education (AaeE) Conference at Yeppoon.

The objective of the workshops was to stimulate thinking about the need to be aware of the variety of preferred learning styles of students, and to attempt to focus on how academics could modify their teaching styles to facilitate improved learning and consequently retention in their classes. Many participants had completed Grasha-Riechmann's Teaching Style Inventory: (http://www.longleaf.net/teachingstyle.html) and Felder and Soloman's Index of Learning Styles Questionnaire: (http://www.engr.ncsu.edu/learningstyles/ilsweb.html) and were also volunteers in the observations and interview phases of the studies. Others had completed Angelo and Cross' Teaching Goals Inventory (http://fm.iowa.uiowa.edu/fmi/xsl/tgi/data_entry.xsl?-db=tgi_data&layout01&-view).

2.2.1 Workshop feedback analysis

Workshop Evaluation forms were handed out at the end of each workshop. Participants were asked to respond to three questions. The first focused on whether the workshop prompted participants to think in new ways about their teaching. The response to this question indicated that almost all academics had been prompted to think in new ways about their teaching styles. The only dissenter was a participant who had extensively studied teaching and learning styles previously and who, therefore, was perhaps less likely to be stimulated by the workshop to consider new ways of teaching and learning.

The next question examined if the time duration of the workshop was adequate. The response indicated two issues:

- The four-workshops at each of the three universities appeared sufficient for most participants' needs.
- The AaeE Conference workshop time of two hours was not sufficient for the majority of participants.

The shortage of time allocation at, in particular, CQUniversity was due to the lively discussion that often ensued at various points of the workshop. Because of the value of these discussions to the study, they were not actively stemmed.

The third question was regarding the adequacy and usefulness of the workshop materials provided (workbook and other resources). The response to this question showed that the workshop materials were adequate for their purpose. Workbooks were distributed at each workshop that contained several exercises that participants were requested to complete to enhance their understanding of teaching and learning styles, and how to set goals that enabled academics to make changes where necessary. Useful links to websites and journal articles on learning and teaching styles, particularly in Engineering, were also provided.

2.2.2 Follow up postcards

One of the resources provided was a postcard, which participants were requested to complete, that encapsulated their thinking and the goals they would take away from the workshops. As a result of the workshop, academics were asked to list three things they would do to advance their understanding of teaching and learning styles, and how they would incorporate ideas on this topic in their day-to-day planning and teaching. The postcards were then placed in envelopes (provided) and self-addressed by participants. Those who were open to sharing their ideas were asked not to seal the envelopes, while others chose not to reveal their thinking. These postcards were collected and mailed to the participants approximately one month after each workshop to remind participants to 'keep going' with their plans and ideas that evolved during the workshops.

These are summarized as follows:

Teaching and Learning Styles

Of all the postcards available to the study, the majority indicated that participants would take a more active interest in developing their knowledge of teaching and learning styles. Some indicated that they would review their own teaching and learning styles, while others sought to determine the styles of colleagues and students. One sought to develop an awareness of students' learning styles when they ask questions, but only two academics would make awareness of learning styles an essential aim for all students.

Interactive classes

A large number of responses indicated that more interactive classes would be planned. While one sought to raise the rates of pre-reading before classes, the majority took the view that problem based and project based learning would enhance student learning. Others would initiate more interactive lessons generally some by demonstration or labs instead of lectures, develop collaborative learning, provide more engineering examples, and develop teamwork skills. One was interested to determine ways to access content retention.

Lectures

Dealt with as a separate category, respondents indicated they would initiate greater visual stimulus and contextualized learning in lectures. A number indicated they would modify course plans or lecture materials, mostly in unidentified ways, although one leant more towards the role of facilitator and delegator, while another two sought to reduce the number of lectures and to increase contact with students. Two respondents would undertake to plan more in the future.

Other outcomes

Participants would undertake to engage with and assist other staff in their institution and would arrange workshops among staff to heighten awareness of the learning and teaching styles issues. An approach has been made by one university for materials used in the workshops for this purpose.

Some five respondents enjoyed the functionality of the SMART (Specific, Measurable, Achievable, Realistic, and Timed) plan matrix and would use this in professional and personal planning in the future.

2.2.3 Overall Outcomes of the Workshops

Workshop participants were asked to provide feedback on the most relevant outcomes of the sessions, but regrettably, this section was left blank on several forms. However, overwhelmingly, academics indicated that the main point they were taking away from the workshop was the need to understand more about learning and teaching styles and to re-design lectures to accommodate all learners. Clearly, it was a revelation to many participants that different people responded to different learning styles, and how variation in teaching styles can stimulate learning for students. This revelation prompted a large number to consider improving their teaching practice with learning and teaching styles in mind, particularly given the shocking attrition rate from engineering programs. A few participants were motivated to share their experiences with other colleagues and to help them to develop better understanding of learning and teaching styles.
(Refer to Appendix A13 for further details.)

2.3 Student focus group data analysis

The Fellowship research proposal was entitled "Bridging the gap: Matching students and staff through discipline-based self-evaluation and co-creation of more appropriate pedagogies in Engineering" and assumed that closer attention to the match and mismatch between learning styles and teaching styles and institutional norms could lead to better learning outcomes. The research reported here has been undertaken to identify what the relevant matches and mismatches might be and what could be done

about them. A major source of this investigation was the analysis of student focus group data (Refer to Appendix A5 for details). We have found that:

- Students' understandings of their own learning do not map directly onto the dimensions of the learning styles inventory we used. Students are prepared to be and indeed prefer to be flexible in their approaches to learning.
- Teaching style is so often subject to the requirements of the style of class (lecture vs. lab for instance) or curriculum paradigm (e.g. Project Based Learning) that many lecturers do not seem to have a clear preference/strategy for a specific teaching style cluster. While they may exhibit characteristics of a certain teaching style cluster in one teaching setup, they may adopt a different one in another class. However, based on the comments of participating academics (during the interviews), they may be able to describe their teaching styles in terms that are parallel to those described by the Grasha survey instrument we used.
- Students who participated in our focus groups never discussed their teachers in terms that could be matched to specific teaching style clusters, but talked instead about their enthusiasm, helpfulness and organisation.
- It appears that the constraints on the academics' classroom performance, and what style they may prefer to adopt when they can, are less visible aspects to students. Students will respond positively as long as attention is paid to enthusiasm, helpfulness and organisation.
- Systematic barriers to learning still exist arising from the educational environment, the personal attributes of students and aspects of their behaviour. These barriers tend to be intertwined and mutually reinforcing and some of them lie outside of the control of any teacher or institution. For a more detailed treatment of the barriers to student learning, the reader is referred to the resources and guides sections of the ALTC Exchange site, created as part of this fellowship program: http://www.altcexchange.edu.au/group/bridging-gap-between-learning-and-teaching-engineering

2.3.1 How Students Learn

Many students told us that they were unable to complete the Learning Styles Inventory because it was asking them to make choices between alternatives when in fact they felt both choices to be true. This does not come to us as a surprise, and the instructions accompanying the survey instruments, asked for a response that is more frequent or more likely to be entered. Instead, students' discussions of learning seemed to us to discriminate between three primary impacts: the form in which information was delivered, the ways in which that information was organised and their own habitual modes of working with the information. These primary impacts are not totally different from the four dimensions of the learning styles instrument used here, and can be seen as some sort of regrouping of the factors affecting learning preferences.

There is a clear preference for visual **forms of information** but this does not necessarily mean pictures only and certainly does not equate to the use of PowerPoint slides. Watching a demonstration or watching a teacher developing a solution or equation on the board were forms that rated highly with students. One of the best examples of this that we saw was an online tutorial on thermodynamics which began with video footage inside the engine room of a steam tug and passed through animated diagrams of the operations of the engine to animated graphs of the values involved. This was visual in a number of ways, including footage of an actual engine and the demonstration of the steps by which an engineer translates the actions of the machine into equations. Students like to meet their course material through hands-on practical experience with equipment but this is not always logistically possible. Step by step demonstration may be a plausible practical option.

The most obvious ways in which the **organisation of information** impacts on student learning has to do with the way teachers structure and organise the material. This can be seen as a link between learning preferences and teaching practices. Structure relates to clarity of aims and objectives and students commented that good structure allowed them to go to whatever they needed in the course in a flexible way. A disorganised presentation was possible even with well structured material and students found this hard to cope with, even where the lecturer was enthusiastic about their subject.

Organising information so that it has obvious real world relevance was also important to students. This encompassed large scale relevance such as the students' preference for project based learning down to the use of currently relevant examples even in theoretical discussions. Any technique that allowed

students to relate new information to what they knew already (as in the judicious choice of examples) and to what they conceived their ultimate profession to be (as in the use of industry-linked projects) was considered helpful to learning.

The final organisational issue was the integration of detail with the global understanding of a problem or body of knowledge. The learning styles inventory treated these as oppositional learning style preferences but it was in this area more than any other that students claimed to need both approaches. While they like to work through well-organised material to a well-defined conclusion, they would like more of the 'big picture' to help them make sense of the details. There is a clear parallel here with their preference for real-world connections, as these provide another way to situate the detail.

Students' primary preferred **modes of working** were active and collaborative. In this case active modes of working did not refer just to hands-on lab or project work but more often to the repetitive solving of example problems. There was a preference to do this in company with peers, sometimes to reduce the workload by sharing out problems but more frequently as a way of checking understanding and reinforcing learning. Students working together can be hypothesised to produce better understanding due, in part, to exposure to a variety of teaching styles (as provided by peers). Another strategy for coping with a heavy workload that most students reported was end-of-semester cramming. They acknowledge that this leads to problems with retention of learning and that the structure and timing of assessment drive them to cramming (even if there is sometimes some procrastination on their part). The big end-of-semester effort is perhaps not significant learning.

2.3.2 How Academics Teach

Our student focus group data did not provide strong evidence that students are able to characterise academic's teaching styles, in terms of the categories of Grasha's survey instrument used. This may be in part due to lecturers adopting various strategies (and hence displaying characteristics of different teaching style clusters) in different teaching situations. This should not be surprising since Grasha (1994) states that: "While many people have argued that style is important in teaching, identifying the elements of our styles as teachers has proved to be difficult."

Students participating in the focus groups were not exclusively those taught by the participating academics, whose teaching styles have been assessed. This meant that it was not possible to provide a direct link between students' comments on learning preferences on the one hand, and the teaching styles of their lecturers, on the other, even if students have been able to articulate aspects styles as defined in this study. The lack of evidence of a strong link between teaching styles and students' learning preferences (in our data), may have resulted in academics often appearing to be unsure about their performance.

Our evidence, from the limited data acquired, suggests that students value, and can see evidence of, well articulated course materials that are delivered in an organised way, with enthusiasm. When this is the case, students will take it as their responsibility to succeed in that course. This seems to be valid even when the teaching approaches employed may cause students to exert more effort or supplement the teacher's work by peer support.

Of course, this is not to say that teaching approaches do not matter or that they cannot be designed to maximise student learning. In fact, organisation and enthusiasm can complement, and form part of, a successful teaching strategy, that takes into consideration students' characteristics, including learning styles or preferences.

2.3.3 The gap between teaching objectives and observed actions

During interviews with volunteering academics, and as part of the fieldwork protocol, participants were asked to talk about their teaching objectives. The reported objectives were compared with the observed actions/behavior of the same academics in the classroom. It was noted that, in our data with a limited number of participants, there were gaps of varying widths between the intentions and the reality. The diagram of figure 1 provides a sample of such gaps.

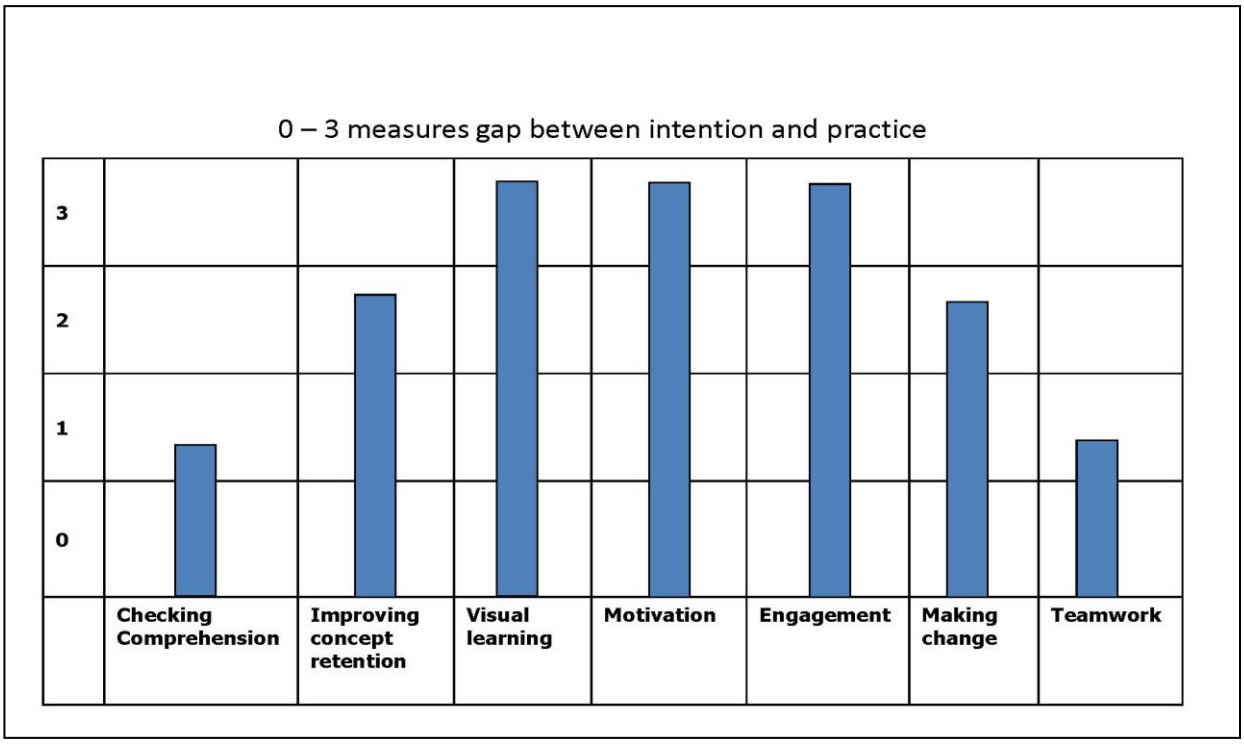

Figure 1: Gap between intention and practice.

Regardless of where the gaps occurred or how wide these were, this highlighted the critical importance of using a process of self (and peer) evaluation of teaching practice, coupled with reflection and action. That is to have a teaching quality assessment cycle, that can be carried out by individuals and teaching teams. (Refer to Appendix A4 for details.)

2.4 Barriers to student learning

In this fellowship program, the issue of the barriers to student learning was addressed in two ways. One investigation was conducted as part of the case studies and was based on the analysis of student focus group data (*Refer to Appendix A5 for details*). In the second line of investigation of the barriers to student learning, we turned to the literature, with a view to build a model for describing these barriers. This model can be used as a framework for discussions as well as devising ways of addressing those barriers. In addition to the model, this investigation produced a list of annotated bibliographies (*Refer to Appendix A6 for details*) with concise descriptions of the main contributions of the articles and brief commentary on its relationship with the learning issues of this fellowship. Further, this investigation also produced a guide to academics (*Refer to Appendix A2 for details*) for addressing some of the learning barriers. The guide included fictitious scenarios and possible ways for addressing them, with pointers to the relevant literature.

2.4.1 Analysis of student views

There has recently been increasing awareness of the widening gulf between the assumptions of higher education institutions and the culture and aspirations of students (Markwell, 2007; Pike, & Kuh, 2005). Some in the universities attribute this gulf to changes in the student population, sometimes lumped together under the label 'Generation Y', which the institutions are struggling to cope with. The barriers to learning therefore arise from an educational environment needing to change, the kind of persons entering as students and the behaviours they exhibit.

The **educational environment** includes not only the physical environment but also the social one. Providing collaborative learning spaces is the kind of issue which combines both. Students spoke enthusiastically of the need to have such spaces and that is understandable given their reliance on peer support for effective learning. But they also complained sometimes that such spaces were noisy and too social for meaningful work to get done. The aspect of educational environment which was most regularly identified as a barrier by students is disorganised and unclear courses and programs. In one of our case study institutions repeated curriculum redesign and the associated adoption and dropping of courses was found to be very discouraging by some students, particularly those who, in typical 'Generation Y' style, want to study part-time. They ran the risk of having to do advanced courses before basic ones, not being able to complete majors because of a course being removed and so on.

Technologies designed to help students including web pages or electronic learning systems such as Blackboard were subject to similar comments. Where they were clearly set out and logically organised they were helpful but where that did not happen they constituted major barriers for students. Formal learning support such as Maths Learning Centres and other generic tuition services were not valued by some students, but where targeted services such as Maths bridging courses were offered, they were perceived to be helpful by those who needed them. It would appear that providing options when designing learning spaces and student support is a key element for enhanced learning for larger proportions of students.

The original research design in this investigation presumed that there would be regular differences between institutions on the basis of contrasts such as sandstone/regional, theoretical/practical and so on. This turned out to be significant only insofar as it directly affected student learning. Thus the programs with a heavy practical component either in project based work, co-op organisation, or Problem Based Learning pedagogy were rated as helpful environments by their students, in line with student preference for visual, practical and active learning.

The **attributes of students as individuals (or Personal attributes)** that are sometimes perceived as being problematic for "Generation Y" learners include lack of motivation and academic aspiration. In fact, the students in our sample had high aspirations and were eager to do well in their courses. Although they were usually working as well as studying they did not see this as indicating a lack of commitment to studies. It did however lead to some **behaviors** which academics sometimes found problematic. For instance, with wage earning being so important to students they were prepared to cut classes if they felt that their time spent there was wasted or could be made up by independent study or study with peers.

For a more in-depth treatment of the barriers to student learning, the reader is referred to our work as presented on the ALTC Exchange under "Resources" or "Guides":
http://www.altcexchange.edu.au/group/bridging-gap-between-learning-and-teaching-engineering

2.4.2 A model for describing the barriers

The investigations on learning preferences, teaching styles and influences of institutional cultures on student learning, as carried out in this fellowship program, were informed by the literature, as well as the experiences of the project team and participants. However, a specific focus of the literature review conducted in this program was given to barriers to student learning. This literature review resulted in a proposed model for describing those barriers. It aimed to isolate those elements that can be addressed by academics and academic institutions. The review also provided a set of brief conclusions and recommendations for future investigations. The full details are given in Appendix A7.

Much research on student persistence and retention in engineering starts from the premise that completion rates for engineering degrees are quite low. In the Australian context, King suggests that estimations of graduation success rates for domestic students enrolling in bachelors degrees in engineering from 1994 to 2005 are in the range 48 to 66% with females having a higher graduation rate than males (King, 2008). In terms of success rates (percentage of students who pass all courses) and retention rate there is again a variation between males and females with the success rate varying between 73 and 90% and the retention rate varying between 68 and 91% for domestic students. The lowest success and retention rates are for male students enrolled part time (King, 2008). Markwell (2007) reports that, for students who go from high school to university, completion rates in Engineering

and related fields are lower than other discipline areas (83.2% as compared with 96.7% for Medicine, Dentistry, Vet Science and Law) but higher than for others (70.2% for Information Technology).

There has been substantial research conducted on persistence and retention in engineering. One of the consistent findings across that research is that there is no single indicator which might be used to determine whether a student will succeed or fail in engineering. As a result of this review, a **model of barriers to learning** in engineering that reflects the complexity of the student experience of engineering education was developed. Barriers to learning may be understood to fall into three broad, but intersecting categories. They are:

(a) Educational Environment – external influences on the student due to the educational environment
(b) Behaviours and Actions – what behaviours and actions the student demonstrates or adopts in a learning situation, and
(c) Individual Attributes – both the internal and external attributes that the student brings to their learning and which may be influenced by their environment and actions.

These categories are not independent – the environment that a student experiences, can influence their behaviour and their perceptions of themselves and their capabilities (e.g. receiving no feedback on their learning can lead students to assume that they are doing well when the reality is otherwise, leading to failure and a drop in academic confidence).

2.4.3 Key messages for dealing with barriers to learning

The review has highlighted that while there are many complex reasons for student success or lack of success, teachers do have the power to create a teaching-learning environment that supports more students to persist with their study and perform to the best of their ability. Some of the key messages are:

- Students must be engaged in their learning to be successful. Active, collaborative and cooperative learning activities can help this engagement.
- The quality of interactions between teachers and students both inside and outside the classroom has a significant impact on student experience and student success.
- There are outside influences beyond the control of the academic environment (e.g. hours in paid work, financial pressures) that will impact on the quality of effort that students can give, which means that the quality of classroom experiences is very important in at least providing the opportunity for student success

The literature review identified a number of areas needing further investigation, in order to a) better understand those elements affecting engineering students, in the Australian context, and b) identify possible actions to address this complicated problem. The review also added confidence to our convection that **teachers make a difference** – an empowering thought for those involved in educating the engineers of the future.

2.5 Design of the Fellowship Group site on the ALTC Exchange

Prior to utilizing the ALTC Exchange as the portal for disseminating the outcomes of this fellowship program, an investigation of the possible alternatives to do so was carried out. This had two objectives, namely (a) to explore the best portal for communication between those directly involved in the implementation of the fellowship program (eg. project leader, project officer, participating and academics, program evaluator and program researchers) and (b) to design the final dissemination portal. (*Refer to Appendix A22 for further details*.)

The final Fellowship group site was designed to maximize usability and ease of access to the provided resources. One major issue to address was the narrow screen space available for content (Enhanced in the recently released ALTC Exchange2.0) and the lack of a mechanism to create a visual overview using an image map, for example, of the contents of the site. These problems were addressed using the editing tools of the ALTC Exchange portal to create a coloured table with links to the various categories of the group site. The opening page is shown in figure 2.

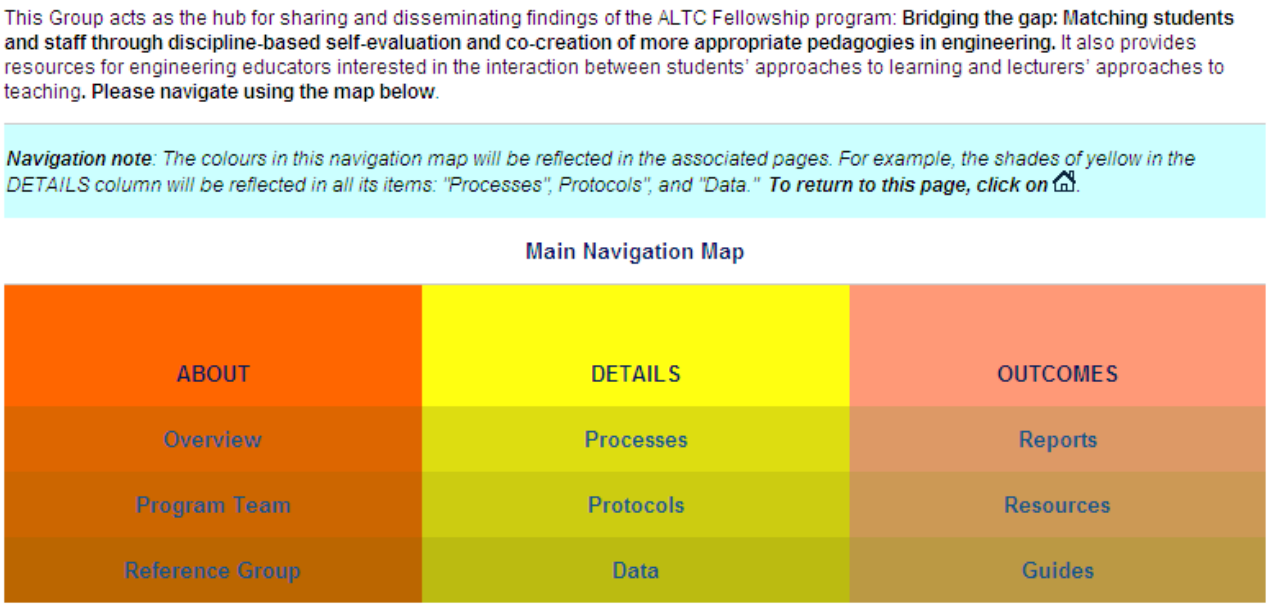

Figure 2: Main ALTC Exchange page

Each cell in the navigation map links to a separate page with the same colour. Figure 3 shows a sample of such pages.

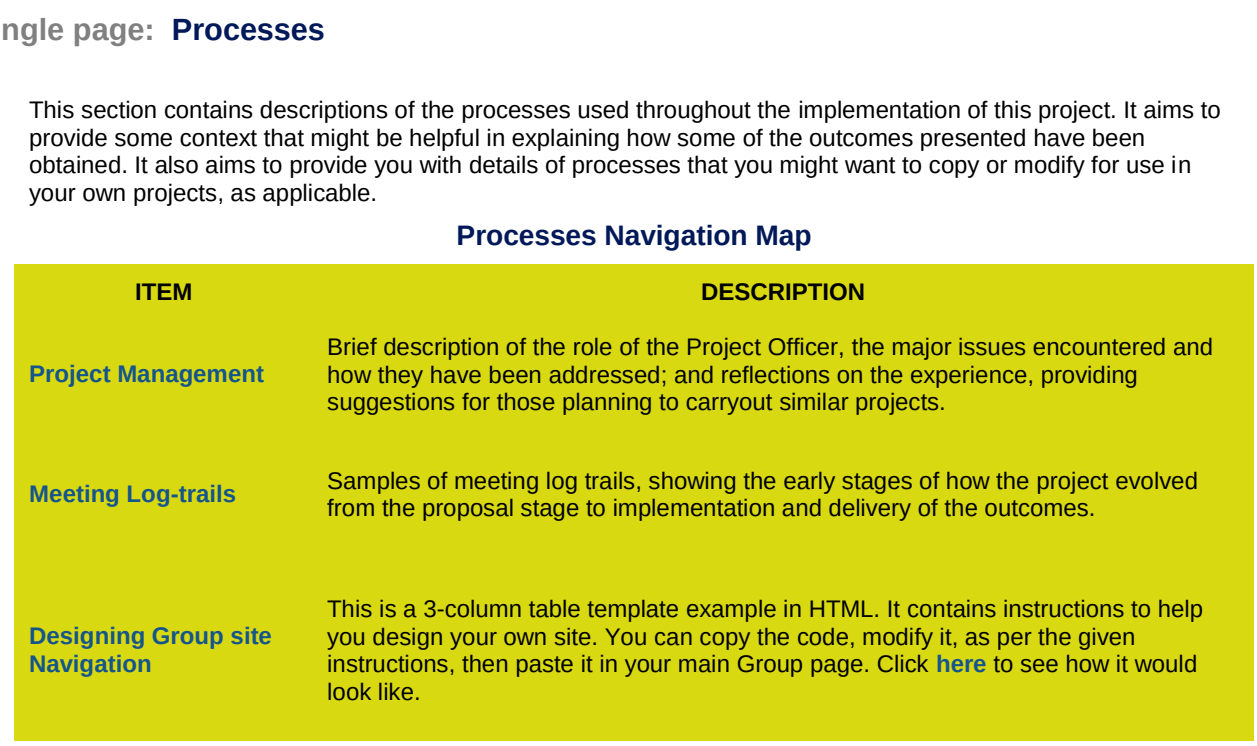

Figure 3 : Sample content page

3. Project impact

3.1 How the Fellowship used and advanced existing knowledge

The literature is very rich with publications and studies, models and critiques of learning styles or preferences. Varying views on validity and reliability have recently been an extra source for enriching the discussions in this area and associated actions in classrooms.

In this fellowship program, links between the students' learning preferences, those of the academics, the teaching styles of academics and institutional norms and cultures have been explored, using a case study approach. This process and its outcomes can be used as a model for reflection and action towards teaching enhancements, and ultimately better learning outcomes for students.

The results of the conducted investigations and the collection and analysis of very rich data have contributed, and are expected to contribute, to the knowledge pool in this area, as well as the practical aspects of the learning-teaching nexus.

A fresh look at, and review of, the literature on barriers to student learning is another specific contribution in advancing our understanding of engineering students and the factors affecting the progress of their studies. Some of these are extendable to students in other disciplines and fields of study.

A sub-set of the barriers to student learning which are under the control of the academics and the institutions has been identified, at least partially. Examples, in the form of scenarios, have been heighted and ways of addressing them have been suggested. These suggestions were made based on published research, and references to that research have been provided. This is supported by a detailed annotated bibliography that can be used to gain a quick but valuable awareness of the issues considered by researchers on this topic.

The much focused annotated bibliography on barriers to student learning, produced as part of this program, can be used as a foundation for both research and application, not only by academics in the engineering education area, but also in the wider-sense of higher education.

The data gathered from discussions with students in focus groups has supplied this program with vey valuable insights into student perspectives, in various institutions. This data is available for other researchers to use and investigate.

The processes of self and peer evaluation of teaching objectives against teaching practice, developed in this program, provided a systematic way of enhancing teaching performance and learning outcomes.

These contributions address, some of the recommendations of the recently conducted review of Engineering Education (King 2008), thus making their impact both relevant and timely.

3.2 Factors contributing to the success or impediment of the project

An essential requirement for the success of collaborative programs, such as this one, is the leadership, commitment and enthusiasm of all involved. Together with the success factors, there were some difficulties and challenges. The impact of these challenges was minimized through the dedicated work of the project officer, the project researcher, and the cooperation of colleagues at the three universities, but specially the program collaborators at CQUniversity and The University of Melbourne. In addition to face to face meetings and frequent communications by e-mail and phone, two video conferences were organized and conducted, which helped iron out problems and address the progress of the program to ensure alignment of activities with objectives.

The following is a brief account of the main success factors and the challenges faced during the course of this program. Comments on how some of the difficulties have been dealt with are also provided.

3.2.1 Success factors

One of the major factors contributing to the success of this program is the commitment and enthusiasm of a number of key personnel involved. To start, the program collaborators from CQUniversity and The University of Melbourne have been critical to ensuring that the case studies could be replicated at their institutions. The main point here is that without the commitment and support of collaborators it becomes difficult or even impossible to achieve objectives that required such collaboration.

The next factor that contributed to the success of the project is the appointment of staff and colleagues who have the right expertise and attitudes to support the implementation of the project. The importance of the expertise is obvious in complementing and strengthening those of the project leader. The shared sense of importance of the topic under investigation and the willingness to invest time working on it, are also critical. Of those, this program had an excellent group consisting of the project officer, the project researcher, the program evaluator, the members of the reference group, and research assistants.

Another contributor to success is the support from the ALTC staff, but specifically, the encouragement and collegiality of the leadership. This was manifested in providing opportunities for fruitful discussions, but also fostered an environment conducive to building a strong and very valuable network with other ALTC Fellows.

This program worked directly with a number of academics and many students which required time commitment and active participation in various ways. The cooperation of those students and volunteering academics was vital for the completion of learning and teaching preferences surveys, and observation of classes. Sharing views and ideas and even issues and problems in interviews with volunteering academics, and also discussions on focus groups with students were very critical. Another important factor in making all this possible is the support of the leadership in each of the three institutions. The support of Deans and Heads of schools/departments was very vital for encouraging participation.

The support of the Fellow's home institution, QUT, has been a vital success factor for the program. While this was provided by academic and administrative colleagues, the support of the Senior Staff at the School, Faculty and University levels was critically important.

Having engagement and dissemination strategies built-into the program, from the proposal stage, and following this up in communications opportunities, making clear how the fellowship program has direct relevance and potential for practical implementation was also a positive contributing factor.

There is also the valuable effect of having a clearly planned evaluation strategy that helped keep the project on-track. An important part of this strategy is the role played by the reference group, but specifically the project evaluator. In this project, the program evaluator was involved throughout the implementation providing guidance and support, along the way, rather than just at the end.

3.2.2 Challenges faced

The first challenge encountered was the much longer-than-anticipated time it took to finalise and sign the Fellowship contract between the ALTC and QUT. This was due to negotiations entered into between the two institutions. The issues subject of the negotiations were subsequently addressed satisfactorily, and the contract was signed, but not before the 18 March 2008. As a result, the funds were released and made available to the program only at the start of April, a two-month delay from the proposed start of February 2008.

Next, the need for obtaining ethical clearance from all three universities involved (QUT, CQUniversity and The University of Melbourne) was not anticipated at the time of writing the Fellowship proposal. It was not until 16 May 2008 that QUT's ethical clearance was granted. CQUniversity's ethical clearance was granted on 16 June 2008. Official ethical clearance from The University of Melbourne was obtained prior to the commencement of the data collection activities which commenced there on 15 September 2008.

There was also the challenge of the logistics of working across three institutions with different systems, processes, and management structures. For example, time tabling of activities at the three universities was another source of difficulty. The case studies included classroom observations, academic staff interviews and student focus groups. All these needed to be scheduled around each university's academic calendar, availability of academic staff for interviews, and availability of students for focus group discussions. The case studies were designed to gather data about teaching styles with various instruction formats such as lectures, tutorials, laboratories, etc. However, due to the need to conduct all these activities within a short time (about one week at each site), the majority of observations were conducted for lectures. This difficulty was compounded by the un-availability of the project officer and project researcher for short periods of time during the project (due to prior commitments), thus presenting another time constraint to deal with.

While the ALTC Exchange became available for use as a means of dissemination and communications during the implementation stage of this program, finding a suitable way of publication and sharing information between all participants (project team, the reference group and others) was not quite obvious. Given that this Fellowship program was dealing with learning preferences, including the presentation of information, the limited screen "real estate" posed a problem. Presenting materials as one long string, without a visual overview was not supportive of those interested in seeing the "big picture", prior to going into the details. However, after some investigations, a visual representation of the Fellowship Group site was designed, using the available editing and presenting facilities on the ALTC Exchange. See section 2.5 for details.

3.3 How the outcomes are amenable to implementation at various institutions

In what follows, the outcomes and resources created through this Fellowship program are described. For each category, comments are provided to give details of the extent of their applicability at other institutions. It may be postulated that, since the Fellowship program was conducted across three different "types" of institutions, its outcomes would be amenable to implementation at various institutions.

3.3.1 Guides for academics

(i) Connecting Learning and Teaching (Appendix A1): This guide aims to help academics utilise what is known about student learning, your teaching and the effects of the educational institution on student learning.

(ii) Overcoming Barriers to Student Learning (Appendix A2): This guide is designed to help academics with practical suggestions to use in their classroom to try to overcome certain barriers to student learning.

(iii) Learning from others (Appendix A3): This resource can be used as a guide to addressing academics' specific learning and teaching issues, which have been encountered by those participating in the case studies.

(iv) Self evaluation and appropriate pedagogy (Appendix A4): This guide describes a process of self evaluation of the appropriateness of an academic's teaching strategies, in achieving their intended teaching goals. It provides a systematic way of assessing the success of the adopted teaching styles and strategies in achieving those goals or intentions. It is also a means for comparing intention to action, as evidenced by observed actual interactions with students, and achieved learning outcomes. In other words, this process provides a means of comparing one's intention with reality, as a first step of a continuous improvement cycle of identifying issues, making changes to address them, evaluating the extent of success, and so on.

All these guides are directly useable in any institution, where student-academic interactions take place, such interactions being in the form of lectures, tutorials, laboratory classes, etc.

3.3.2 Papers and other resources

(i) Student Focus Group analysis (Appendix A5): This resource presents analysis of student focus group discussions conducted at the three participating universities. This addresses the research questions of the ALTC Fellowship application. They cover issues of learning and teaching styles and barriers to student learning.

(ii) Linking Teaching Goals with Practice (Appendix A3): This resource is designed to help academics find parallels between what study participants encountered in their teaching, and the aspects that interest the users of this resource in their practice.

(iii) Annotated bibliography on barriers to student learning (Appendix A6): This is an annotated bibliography of selected articles/references addressing various aspects of the barriers to student learning. It contains complete details of each reference, an introduction or overview of the reference, its scope, aims, and research methods used. The resource also describes each reference's usefulness and/or relevance to this ALTC Fellowship project, and a short critique identifying any limitations or shortcomings.

(iv) Barriers to student learning: A literature review (Appendix A7): This resource is a critical literature review of the barriers to student learning. It includes an extensive list of references that can be used for bringing the readers up to date on the topic. The resource could also serve as a starting point for further investigation on this important topic.

(v) AJEE Journal paper pre-print (Appendix A8): "Influences on student learning in Engineering: Some results from case study fieldwork." To appear in the Australasian Journal of Engineering Education.

(vi) AaeE'08 Paper (Appendix A9): Invited paper presented at the Australasian Association for Engineering Education (AaeE) conference, Yeppoon, Queensland, December 2008.

(vii) AaeE'08 Paper slides (Appendix A10): Paper presentation slides, contains concept maps for the case study protocols.

(viii) Workshop Slides (Appendix A11): This is a sample of the workshop slides used in conjunction with the workshop workbook, see item below.

(ix) Workshop Workbook (Appendix A12): This workbook accompanies the workshop on learning and teaching styles. It is useful, even without the workshop, for creating self awareness about one's learning and teaching styles. It can serve as a guide for starting a process of reflection and enhancement of teaching approaches.

(x) Workshop evaluation analysis (Appendix A13): Workshop Evaluation forms and follow up post cards were handed out at the end of each workshop. Evaluation forms aimed at gathering feedback on workshop effectiveness and to get participants' comments. The postcards aimed at encouraging participants to follow actions planned at the workshops. The data has been analyzed and a summary is presented here.
(xi) Poster (Appendix A14): Poster presented at the ALTC Fellows forum -February 2009.

The papers are published in the relevant conference proceedings or journals; thus they are accessible and open for use, not only by engineering academics, but also by those working in a wider range of science and technology education. The workshop booklet and resources can be modified to suit the specific needs of institutions, or groups of academics.

3.3.3 Reports

(i) Reports to the Reference Group (Appendix A15): These reports were prepared to provide details of the progress of the program to the Reference Group and Program Evaluator, and to request their feedback and comments. Three such reports were posted on the ALTC Exchange, and can be used as examples of formal communications with program collaborators and support groups.
(ii) Interim Report to ALTC (Appendix A16): Interim Report to ALTC outlining progress to date (August 2008).
(iii) Case Study Report (CQ University) (Appendix A17): Case study investigations at CQUniversity, reporting on teaching and learning survey data, classroom observations, academics' interviews and student focus groups.
(iv) Case Study Report (U of Melbourne) (Appendix A18): Case study investigations at The University of Melbourne, reporting on teaching and learning survey data, classroom observations, academics' interviews and student focus groups.
(v) Case Study Report (QUT) (Appendix A19): Case study investigations at QUT, reporting on teaching and learning survey data, classroom observations, academics' interviews and student focus groups.

These reports, in addition to their content which gives details of the issues at hand, provide an insight into the success factors or impediments, as they occurred. Although specific to this fellowship program, the issues have many aspects that can be shared among those working in related areas of investigations.

3.3.4 Program processes and planning

(i) Project Management (Appendix A20): Brief description of the role of the Project Officer, the major issues encountered and how they have been addressed; and reflections on the experience, providing suggestions for those planning to carryout similar projects.
(ii) Meeting Log-trails (Appendix A21): Samples of meeting log trails, showing the early stages of how the project evolved from the proposal stage to implementation and delivery of the outcomes.
(iii) Designing Group site Navigation (Appendix A22): This is a 3-column table template example in HTML. It contains instructions to help users of the ALTC Exchange design their own site. This code can be copied, modified, as per the given instructions, and then pasted on the ALTC Exchange Group page. An example of how this code might look like is provided.

The descriptions of how the project was managed and how records were kept for action and follow-up, provide details of the approach taken in this program. These details can be adapted to a wide range of learning and teaching projects, and would not necessarily be dependent on the institution.

3.3.5 Protocols

(i) Protocol for interviewing academic staff (Appendix A23): This defines the specific areas for investigation to ensure for consistency during academic staff interviews.
(ii) Protocol for conducting student focus groups (Appendix A24): This defines the specific areas for investigation to ensure for consistency, when conducting student focus group discussions.

These protocols were specifically designed to achieve the requirements of this Fellowship's case studies. Therefore, they may not be directly applicable to other projects. However, they may provide ideas on how such protocols are designed to link with the objectives of the investigation at hand.

3.3.6 Data

(i) Transcripts of student focus group discussions (Appendix A25): This presents the verbatim statements of students participating in the focus groups, identifying data have been removed.
(ii) Learning styles assessment results (Appendix A26) of participating students and academics: This gives numbers of participating students and academics and the collected learning styles data, from each of the participating institutions.

The data provided here can be used by those investigating learning and teaching preferences in engineering education, regardless of their institution. In fact, there is excellent potential not only to draw on what this data have to offer for engineering education research, but it can also be used for benchmarking investigations.

3.4 Ways of disseminating the outcomes

During the program, dissemination took place through engagement with academics and students at the three participating institutions, as well as at the national level, in conference workshops. Papers published in the journal and conference proceedings are available for access by all. At the conclusion of the program, all the other resources will continue to be available from the ALTC Exchange Group site. Further dissemination opportunities are arising, as a result of this work. One such opportunity was through a keynote presentation at the CDIO International conference held in Singapore, in June 2009. Invitations to present within my institution and in other institutions, such as RMIT, Melbourne, are currently being followed up.

3.5 Links with other projects

The Fellowship program was motivated by, among other things, the national demand for engineering skills. It aimed to address issues affecting student demand for engineering programs as well as retention rates of those already enrolled in such programs. The fellowship program was developed and implemented at a time when the Australian Council of Engineering Deans (ACED) sought and received funding from the ALTC for the project: "Addressing the Supply and Quality of Engineers for the New Century," (King, 2008.) Strong connections between these two programs are continuing. These connections are developing further with the outcomes of the fellowship program, informed by, and feeding into, the implementation of King's (King, 2008) recommendations.

There are four project areas being undertaken within the ACED's program: "Curriculum Specification and Support Systems for Engineering Education that Address Revised Qualification Standards," (King et al., 2008) in response to some of King's (King, 2008) recommendations. A clear connection between this program and the outcomes of the fellowship could be exploited in the implementation of recommendation 3: implementing best-practice engineering education. There is need to investigate current experiences, practice, ideas, paradigms and explore others, with a view to translate these into everyday practice in every modality of interaction between academics and students, in pursuit of achieving best learning outcomes.

The Senior Fellowship program, "Engineering Science and Practice: alignment and synergies in curriculum innovation," (Cameron, 2008) has informed the investigations of this program. The key point is how our knowledge about the development stages of graduating engineers, and the learning they acquire in practice; influence our thinking of, and application to curriculum design. While Cameron (Cameron, 2008) provided a framework for the progression from study time frames between university and practice, this fellowship has focused more on the learners' and teachers' characteristics in order to create synergies between the two groups, and attempt to identify and bridge gaps.

The fellowship program outcomes present a component of a bigger picture of aspects affecting engineering education and the characteristics of engineering students, academics and graduates. A number of projects have been identified as complementary components of that picture. While there may not be direct connections between the Fellowship program and these projects, there are strong synergies between its outcomes and those of the following projects:

Koppi T, and Naghdy F (2009), *Managing Educational Change in the ICT discipline at the tertiary education level*, ALTC discipline-based scoping project.
Broadbridge P, and Henderson, S (2008), *Mathematics Education for 21st Century Engineering Students*, ALTC discipline-based scoping project.
Lowe D, et al. (2008) *Remotely Accessible Laboratories: enhancing learning outcomes*.
Reidsema C et al., *Design based Curriculum Reform within Engineering Education*.
Mills J, et al., *Gender Inclusive Curriculum in Engineering and Construction Management*.
McCarthy T, *A pro-active approach to addressing student learning diversity in Engineering Mechanics*.

The outcomes of this Fellowship program are now being considered in the formulation of the ***Engineering and Technology discipline strategy***. In recent discussions at the ACED meetings, it was noted that the current plans will be incorporating some of the ideas and findings, presented as part of the outcomes of this fellowship program, on building and adapting curricula and pedagogy using knew knowledge of the changing nature of students.

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5. Appendices

Appendix A1 : Connecting Learning and Teaching
Appendix A2 : Overcoming Barriers to Student Learning
Appendix A3 : Linking teaching goals with practice – learning from others
Appendix A4 : Self evaluation and appropriate pedagogy
Appendix A5 : Student Focus Group analysis-fieldwork report
Appendix A6 : Annotated bibliography on barriers to student learning
Appendix A7 : Literature review of the barriers to student learning
Appendix A8 : AJEE Journal paper pre-print
Appendix A9 : AaeE'08 Paper
Appendix A10 : AaeE'08 Paper slides
Appendix A11 : Workshop Slides
Appendix A12 : Workshop Workbook
Appendix A13 : Workshop evaluation analysis
Appendix A14 : Poster – ALTC Fellows Forum February 2009
Appendix A15 : Reports to the Reference Group: Issue 1, Issue 2, Issue 3
Appendix A16 : Interim Report to ALTC (August 2008)
Appendix A17 : Case Study Report (CQUniversity)
Appendix A18 : Case Study Report (University of Melbourne)
Appendix A19 : Case Study Report (QUT)
Appendix A20 : Project Management: Experience and reflections
Appendix A21 : Meeting Log-trails
Appendix A22 : Designing Group site Navigation
Appendix A23 : Protocol for interviewing academic staff
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Appendix A25 : Data -Transcripts of student focus group discussions
Appendix A26 : Data -Learning styles assessment results