EMAP: Outcomes from Regional Forums on Graduate Attributes in Engineering

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***Abstract**: The teaching, learning and assessment of graduate attributes in engineering offers challenges at both the classroom and curriculum level. In this paper we report on three recent regional forums that promoted the sharing of good practice in teaching, learning and embedding graduate attributes. During the Forums we sought participants' views on what specific problems and constraints hinder their efforts to embed graduate attribute learning across Engineering programs. We found engineering academics and academic managers experienced a series of hurdles that included: strong incentives to concentrate on activities other than teaching; lack of individual skills and knowledge related to graduate attributes and their teaching; colleagues and students who undervalued 'soft skills'; lack of time and resources to develop new teaching approaches; shifting institutional policies; and ongoing debate about the terminology and philosophy of graduate attributes and engineering. The research was initiated by the Engineering Meta-Attributes Project (EMAP) Team and funded by the Carrick Institute for Teaching and Learning in Higher Education (CG623).*

Introduction – About EMAP

The Engineering Meta-Attributes Project (EMAP) is funded by the Carrick Institute for Teaching and Learning in Higher Education to investigate and disseminate good practice in teaching, learning and assessing graduate attributes in Engineering. Engineering faculties across Australia are experiencing substantial pressure from industry, the professional body and their home higher education institutions to contextualise and embed graduate attributes in undergraduate programs. Responding to this pressure is proving challenging with three inter-related problems evident in the Australian engineering education literature:

- **Innovation tends to be isolated and shortlived.**

Much innovation in teaching engineering graduate attributes is at the level of subject, and driven by lone academics facing a number of obstacles (see Sargison *et al*., 2005; Nightingale, 1997; Turner, 2001; Carew, 2005; Goricanec and Hadgraft, 2003), such as working in isolation from peers and the pertinent literature. This means good practice rarely benefits from the insights and critique of interested others, existing graduate attribute research and T&L theory.

- **Rigorous evaluation is rare.**

Few reported innovations in teaching engineering graduate attributes are evaluated in terms of their impact on student learning, and assessment of graduate attributes is considered problematic in the engineering education literature (Male and Chapman, 2005; Brophy, 2005; Froyd, 2005; Rollins, 2005; Hendy and Hadgraft, 2002; Lindsay and Good, 2002). The current approach to quality assurance in HE is outcome focussed, and so these problems with evaluation and assessment undermine engineering educators' capacity to define, gather evidence on and discuss what really works in teaching and learning graduate attributes in engineering.

- **Contextualisation is limited.**
  The engineering graduate attributes described in the literature tend to be disproportionately aligned with generic institutional lists, and poorly aligned with the realities of engineering practice, particularly with design, which is central to engineering work (Barrie *et al.*, 2003; Kosse and Hargreaves, 2003). Discourse, research and development are needed to embed design-relevant meta-attributes (e.g. reflective practice, systems thinking) in undergraduate engineering.

In response to these apparent problems, a team of engineering educators and others has come together to propose and guide the project under discussion: EMAP. EMAP is committed to researching good practice in the teaching, learning and assessment of graduate attributes in engineering. We have an interest in both classroom-level innovation and in the mapping and tracking of graduate attribute learning across degree programs. The EMAP Project is lead by Dr Anna L Carew (University of Wollongong) with input from the EMAP Leadership Team (Prof Radcliffe previously UQ, now Purdue University, USA; A/Prof Hadgraft UMelb; Mr John Currie & Dr Barrie USyd; A/Prof Nightingale, Prof McCarthy, A/Prof Cooper UoW; E/Prof Alan Bradley, Engineers Australia) and the Project Postdoctoral Researcher, Dr Sandrine A Therese (UoW). Further information about the project and outcomes to-date is available in the *EMAP Progress Report CG623 Teaching and Assessing Meta-Attributes in Engineering: Identifying, Developing and Disseminating Good Practice* available on request from Dr Anna L Carew (carew@uow.edu.au).

Regional Forums

During March and April 2007, EMAP convened three regional forums (Sydney, Brisbane, Melbourne) that attracted ~60 participants in total. The participants were ~ 45 engineering academics or faculty leaders (e.g. sub-Deans T&L, Heads of School), ~10 academic developers and several interested others (e.g. Engineers Australia, Carrick Institute). The academic participants represented 17 universities, mostly from Eastern Australia. The intended Forum outcomes were that participants would leave the Forum with:

1. One or two new techniques for teaching graduate attributes in the engineering classroom;
2. Ideas for solving a problem of teaching, learning or assessing graduate attributes in engineering;
3. Ideas for curriculum renewal or structural reform to embed graduate attributes across engineering programs.

Participants were invited to share their own teaching and curriculum analysis practice. This included practice in teaching and assessing graduate attributes in undergraduate engineering subjects ('classroom focus') and practices for mapping, tracking and embedding graduate attributes across degree programs ('curriculum focus'). In each of the Forums, participants were also invited to comment on the main problems and constraints they perceived as hindering the teaching, learning, assessment and embedding of graduate attribute learning in engineering. Table 1 is a teaching plan for the Melbourne Forum that illustrates the structure of the one-day Forums. Each of the Forums was formally evaluated and participants expressed general agreement that the Forum content and structure were satisfactory (average rating 6/7).

Table 1: Teaching Plan for EMAP Melbourne Regional Forum

TIME	SECTION	DETAIL (*instructions*)
9.30 – 10.00	**Welcome** **Intro & order**	Welcome What we are here for (brief overview) & running order
10.00 – 10.30	**Focus problem** **Info exchange demo & prep**	Quiet time to identify focus problem for the day *What is the main problem associated with teaching & assessing GAs in Eng that you would like to work on today?* Report back on problems and clustering of problems Formal presentations of one idea for teaching GAs (x2) Please prepare to: *Explain one idea for teaching GAs in less than 3min*
10.30 – 11.00	**Info exchange** **Reflective time**	Pairs – *take 3 min to explain an idea, 2 min for questions, then swap* (x3). Observer role – observe/collect/critique process or products. Individually – *What would you need to do to adapt one of these ideas for your teaching?*
	BREAK	
11.15 – 11.35	**Group formation & problem analysis**	*Form clusters around general problem areas, and define the problem (area/field of problem, evidence/impressions/experiences of problem, clear problem definition).* *Avoid naming the cause of the problem!*
11.35- 11.50	**Interim report** **Open forum**	Clusters report evidence of problem and problem definition. Questions, comment and discussion of interim reports.
11.50 – 12.20	**Group work** **Report back**	Clusters continue work to advance problem area '*What could be causing the problem? Possible solutions – direct action and info needed*'.
12.20 – 1.00	**Constraints** **Open forum**	Brainstorm. *What stops us from embedding/distributing GAs throughout the curriculum?* Questions, comments and discussion.
	LUNCH	
1.45	**Welcome back (5')**	Shift in focus
1.50 – 2.50	**Curriculum review** **Open forum**	Formal presentations on processes and outcomes of curriculum level review (x2) *What works in embedding/distributing GAs throughout the curriculum? What do/did you do in your Faculty?* Questions, comments and discussion.
	BREAK	
3.05 – 3.45	**Curriculum review** **Open forum**	Formal presentations on processes and outcomes of curriculum level review (x2)
4.00 – 4.30	**Where next** **Evaluation**	What next and how EMAP/others could help Workshop evaluation

Participant Presentations

Several participants were invited to make brief formal presentations of their own practice in teaching and assessing graduate attributes in the classroom ('classroom focus'), or on their experiences and approaches to mapping, tracking and restructuring curriculum in their own institutions ('curriculum focus'). There were 6-7 formal presentations at each of the Forums (19 in total) and the purpose of these presentations was to share good ideas and to generate discussion amongst Forum participants.

During the classroom level formal presentations and the related 'information exchange' activity, many different forms of teaching and assessment were shared, for example: scaffolding and assessing reflective practice; developing information literacy, research and formal presentation skills through student conferences; structured approach to note taking and summarizing; and inductive learning on occupational health and safety in labs. A spectrum of different views and approaches to curriculum mapping and renewal were presented at the Forums. Some of these tales of curriculum renewal appeared to be more policy driven approaches (e.g. USQ, UniSA) while others were strongly grass roots and consultative (e.g. UoW, RMIT). One was driven by university-wide restructure of course delivery (UMelb). Many were organic having evolved over many years (e.g. UCQ, USQ, UniSA, RMIT, QUT), and others relied on database driven auditing/support for mapping where graduate attributes were taught (e.g. USyd, UoW). Four presenters provided views of embedding graduate attributes that rested on strong research, conceptual or analytical frameworks (USyd, Griffith, UQ, ACED).

The upshot of these presentations was clear evidence that all of the thinking and ideas required for innovative delivery of engineering graduate attributes learning at classroom- and curriculum-level are already in existence. Dissemination, uptake and adaptation are the key.

Key Problems & Constraints

The general sense from the Forums was that there are not one or two central or monumental constraints to the teaching, learning and embedding of graduate attributes in undergraduate engineering. Rather, individual engineering academics and academic managers experienced this challenge as a series of hurdles. These hurdles included, for example: strong rewards and incentives to concentrate on activities other than teaching; lack of individual skills and knowledge related to graduate attributes and graduate attribute teaching; cultural attitudes amongst colleagues and students that undervalue 'soft' skills; lack of time and resources to develop and deliver new approaches to teaching; shifting institutional policies; and ongoing debate and confusion about the terminology and philosophy of graduate attributes. The 'hurdles' analogy indicates that those academics and academic managers who tackled the challenge of embedding graduate attributes in engineering curriculum faced multiple barriers and needed singular vision/commitment. There is an implied need for substantial stamina and support to clear such a succession of hurdles and implement changed teaching and assessment, or new curriculum structures.

The raw problem and constraint lists for each forum make for interesting reading (these are available in *CG623 EMAP Summary of Outcomes from Regional Forums Report* available on request from Dr Anna L Carew). The raw list demonstrated that, while there was a great deal of overlap/agreement in what problems and constraints were hindering graduate attributes in engineering, each Forum produced unique insights or perspectives. The problems and constraints identified by Forum participants have been reviewed and clustered into three broad problem areas with specific sub-problems. We present a summary of these below in an order that might give shape to the succession and inter-relatedness of hurdles an engineering educator might face in taking action on the teaching, learning, assessing and embedding graduate attributes:

1. **Educator, subject, curriculum focus**

   a. Academics lack the time and resources to improve the quality of learning activities and assessment. Nominated constraints included: larger cohorts of students and limited individual face-to-face time, unrealistic workload allocations, and the need to adequately resource for a 'whole of curriculum focus'.

   b. Perverse reward/incentive schemes tend to preferentially reward academics for research, winning grants and writing papers, rather than teaching well.

   c. Old habits, subjects and curricula die hard. Constraints included 'procedural ruts' (the inclination to teach the same subject in the same way for years) and 'brownfields curriculum' (degrees that are well established, owned by many and often strongly defended).

   d. How to enthuse engineering educators? Ownership of the whole curriculum is required rather than just individual subjects; broader agreement that graduate attributes are legitimate and need to be taught in engineering is needed; the university-led, top-down approach hasn't worked, need staff buy-in; and EA accreditation drives the process (i.e. interest in graduate attributes peaks for accreditation and the intent is compliance rather than excellence).

   e. What is 'good' teaching and assessment for engineering graduate attributes? Engineering academics are generally not researching graduate attributes or trained to teach graduate attributes. What (content/skills) should be taught? How and in what order should graduate attributes be taught? How are they fairly/validly assessed? Should they be assessed? Is fair/valid assessment possible given large classes?

2. **Graduate attribute definitions/balance**

   a. Engineering education stakeholders define graduate attributes in a range of ways. Stakeholders suggest various explicit and implicit lists/statements/positions on graduate attributes, each with individual wording/terminology, such as those from Engineers Australia, discipline-based professional bodies (ASCE, IChemE), employers, industry and industry groups (e.g. Henley Report, 2006), and individual universities. These various groups favour some graduate attributes more highly than others.

   b. Spectrum of skills, balance between graduate attributes and technical skills. A balance is needed in the spectrum of skills – from technical to fuzzy, from 'hard' to 'soft' to global.

   c. What is engineering? Preferences for particular graduate attributes, and particular balances between GAs and tech skill are premised on underpinning philosophies of engineering/ engineering practice.

3. **Student focus**

   a. Inspiring students for authentic, deep graduate attribute learning. Problems/constraints include stimulating independent thought and broader reading; breaking the Google dependency; convincing students to engage authentically with graduate attribute learning and deeper intellectual inquiry; encouraging development of conceptual skills rather than imitation; and ensuring student enthusiasm for graduate attributes T&L throughout their programs.

   b. Valid, robust means to assess student graduate attribute learning. How to check that individual students have developed these skills? How to ascertain whether students have internalized the graduate attributes?

Where to from here?

As is clear from the preceding account, the EMAP Team has undertaken a thorough stakeholder consultation. Several broad problem areas in teaching, learning, assessing and embedding graduate

attributes in undergraduate engineering were identified at the three regional forums. In addition, insights and priorities were nominated by the EMAP Leadership Group at the inaugural team meeting (see Progress Report CG623), and direction was provided by Prof David Dowling (USQ) (External Evaluation Report).

Given this thorough review of the perspectives of the key stakeholders in the EMAP project, we have proposed and commenced the following research as phase 2 of the project. The first activity is aimed at identifying and disseminating exemplars of good practice at classroom level. The second underpins the first. The third is aimed at developing a culture of good practice in curriculum renewal for graduate attributes in engineering:

1. **How do engineering academics currently teach graduate attributes? What approaches to teaching GAs do undergraduate students perceive as effective for developing graduate attributes? How do/should we assess student attainment of graduate attribute learning?:**

   These questions will be answered by targeted research on two meta-attributes (i.e. fuzzy graduate attributes of reflective practice and systems thinking). The research will be undertaken in two Australian Engineering Faculties. EMAP will undertake surveys and focus groups with engineering students (2 x year groups, 2 x disciplines) in these two Faculties. Concurrent in-depth interviews will be conducted with the engineering educators who teach the students surveyed. Exemplars identified during this research will be written up and disseminated to Forum participants and interested others. EMAP will also seek additional exemplars through informal networks, and alternative avenues for dissemination (e.g. conferences, academic development units).

2. **What are the different definitions of reflective practice and systems thinking, as engineering graduate attributes, that are held by engineering educators and undergraduates?**: These questions will be addressed, prior to and during the research mentioned above, by surveying and interviewing engineering academics and students and comparing the identified definitions with those held by industry/employer stakeholders (via searches of existing data/literature) and in the theoretical literature. Two extensive literature reviews have already been undertaken on these topics. This research will underpin and inform the aforementioned research.

3. **How do we best map, review, renew, restructure engineering curriculum for graduate attribute development?:**

   This activity will focus on identification, explication and academic development structured around exemplars of curriculum mapping, review and reform. A resource booklet which compiles a range of examples of curriculum mapping/review/reform approaches will be produced based on the exemplary approaches that were presented by various participants at the three Forums. Additional exemplars will be sought where necessary (possibly via recommendation from Engineers Australia's Associate Director of Accreditation, E/Prof Alan Bradley). This booklet will be launched via an interactive academic development workshop at a suitable venue (ie. the annual conference of the Australasian Association of Engineering Educators, Melbourne, December 2007).

Conclusion

The multiple hurdles and constraints identified during the Regional Forums suggest a multiplicity of ways that various individuals and bodies might support greater graduate attribute teaching and learning in engineering. There is a clear message for academic developers to concentrate on capacity building at the individual level (i.e. seeding new ideas and supporting engineering academics to try new approaches to teaching 'soft' skills), and in creating time-efficient linkage between academics who are already effectively teaching these skills and those who would like to. This is a realm of

academia where plagiarism (of good approaches to teaching) might be encouraged!

For faculty management, the findings suggest continued attention to the reward structure (i.e. promotion, awards, grants) and the incentives it offers for individual academics to allocate time to quality teaching and to the teaching of skills outside the traditional engineering remit. There are also some strong messages that the current overstuffing of engineering courses with (largely) technical content should be reviewed. It would appear that curriculum cramming offers a profound barrier for introducing soft skills and allowing students the time to master them by experience and reflection.

The outcomes of the Regional Forums suggest action that might be taken by national bodies with an interest in propagation of graduate attribute teaching and learning in engineering (e.g. Engineers Australia, the Carrick Institute for Teaching and Learning in Higher Education, Australian Council of Engineering Deans). These groups could put forward exemplars of good practice in the program or curriculum-level embedding, mapping and tracking of graduate attributes. Also, a clear position and recommendation of processes that encouraged Faculties to research, name, own and commit to their own graduate attributes should be made. Clarity on this point would allay some of the confusion and hesitation that appears to result from the multiplicity of generic lists, terminologies and reporting requirements that befuddle the contextualisation of graduate attributes in Engineering.

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