Diversity and longevity: a framework for graduate attribute development in engineering education

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***Abstract**: The phrase "Graduate Attributes" invokes many feelings; hope, fear, disappointment, and perhaps most commonly, confusion. The first key question "Do we want graduate attributes?", is largely decided with most Australian universities deciding that Graduate Attributes are important. Investigation of the second key question, "Which graduate attributes do students need?", is now well under way at these institutions. The third key question "How do we develop and document the development of graduate attributes?" is still in its infancy and this is the question addressed in this paper. After considering the problems associated with teaching graduate attributes, a framework is proposed. Within this framework the role of ePortfolios is discussed.*

Background

Australian universities often use the phrases "Graduate attributes", "Generic skills" and the increasingly unpopular "Soft skills" to describe those abilities that we know professionals require to succeed but we struggle to define and teach. Academics, industry and students generally agree that graduates must have these attributes (Higher Education Council, 1992), but details of the implementation needs further discussion (S. C. Barrie, 2004). Recent projects have attempted to categorise the attributes all engineers require. The project by Male et al (Male, Bush, & Chapman, 2011) surveyed established engineers, while Nair et al (Nair, Patil, & Mertova, 2009) surveyed employers but both came up with similar findings. Unsurprisingly communication, team work, self-management and problem solving were identified as being at the top of the list of important attributes. These traits also corresponds with the stage 1 competencies identified by Engineers Australia (Engineers Australia, 2011) and the findings of the Higher Education Council (Higher Education Council, 1992) and the Business, Industry and Higher Education Collaboration Council. Debuse and Lawley used the more novel approach of text analysis on online job advertisements (Debuse & Lawley, 2009). This research focused on the field of Information Communications Technology (ICT) and identified the concept of "Team" as significant among the "People Skills" but did not clearly identify other non-technical skills required by graduates.

After recognising key graduate attributes (GA), the next problem becomes how to teach them, and this appears to be a real issue for all educators (S. C. Barrie, 2007; Green, Hammer, & Star, 2009). The reasons for this are many, and can be split into two broad categories: those that are inherent to graduate attributes and problems that are a result of embedded university culture.

Inherent problems:

1. Conceptual clarity: GAs are difficult to define and there is a lack of conceptual clarity between practitioners and organisations.[1, 2, 3, 4, 5]
2. Assessment: GAs are problematic (almost impossible) to assess using traditional methods resulting in them not being assessed at all. Without assessment there can be no indication of development. [4, 5]
3. Time: GAs take years of learning rather than weeks. [4]
4. Expertise: Not all teaching staff have the capabilities to teach GAs. [1, 2, 5]

Cultural problems:

5. Isolation: Approaches to teaching GAs are often individualistic, relying upon the inspiration and experience of staff members who teach GAs in isolation from other staff. [2, 5]
6. Implicit teaching: GAs are often developed implicitly as part of a subject rather than explicitly taught. GA characteristics are usually applied to discipline specific assessments but without formal teaching. [4, 5]
7. Motivation: A lack of appropriate reward schemes results in staff that are not motivated to effectively incorporate the development of graduate attribute in their subjects. [1, 5]

[1] (Green, et al., 2009) [2] (S. C. Barrie, 2006) [3] (Male, et al., 2011) [4] (Hughes & Barrie, 2010) [5] (S. Barrie, Hughes, & Smith, 2009)

While these are not the only problems, they are significant ones that need to be considered when creating a framework for teaching graduate attributes.

Teaching graduate attributes

Barrie (S. C. Barrie, 2007) proposes 6 categories of how graduate attributes can be taught at university based upon a previous study of common university staff perceptions (S. C. Barrie, 2006):

1. Remedial: GAs are taught to bridge gaps between student capabilities and what is expected at university.
2. Associated: GAs are taught to all students as a secondary and quite separate function of the university through supplementary teaching.
3. Teaching Content: GAs are taught within discipline subjects as a part of the subject.
4. Teaching Process: GAs are learnt by students as a result of how discipline material is taught.
5. Engagement: GAs are learnt by students as a result of how students engage with a course (as a series of subjects).
6. Participatory: GAs are learnt by students as a result of how students engage with university life as a whole.

These categories are ordered in increasing complexity, and Barrie infers increasing value. While a direct comparison of how Barrie's categories address the identified problems is not practical, it's clear that the more valued categories place more emphasis on student learning. However, it is questionable as to how well the student can learn without formal guidance.

One typical approach to teach GAs is to mandate that subjects integrate graduate attributes. An example of this is Griffith University who have adopted this approach and has created a graduate skills toolkit which supports the requirement of all subjects to develop graduate attributes. This tool kit supports ten graduate attributes and includes ten sets of resources; each resource being available on CD-ROM and online. The resources focus on a single skill and include background documents, guides on how to assess and teach the skill, handouts as well as other resources(BIHECC, 2007). While the Business, Industry and Higher Education Council report approves of the materials and the approach, it does point out the limitation that without a cohesive approach a student could cover the same attributes in multiple subjects, while possibly not covering others at all. Other universities who have performed

graduate attribute mapping and may have similar intentions include Curtin University and Monash University.

Referring to Barrie's categorisation system, the subject mandated approach could only be considered to come under the category of "Teaching Content" or if a subject is particularly well designed "Teaching Process". It is also unlikely that this approach would be considered to be within the "Engagement" or "Participatory" categories as the primary development of GAs is left up to the individual subjects without the cohesive approach. In terms of the identified problems it only addresses the issues of conceptual clarity, assessment, expertise, and to a limited extent motivation, but in all these respects it depends on the individual, a better supported individual than in many other cases, but still the individual.

Another popular approach is Work Integrated Learning (WIL) which blends workplace programs with formal teaching often within a single subject (BIHECC, 2007). These kinds of programs naturally develop graduate attributes, improve motivation, increase networking and have a host of other benefits. The downside is the difficulty in finding industry partners and the extra coordination required, although RMIT has a program that avoids the problem of finding an industry partner by simulating this kind of environment, specifically trading in the money and foreign exchange markets, within its School of Economics and Finance. Once again considering Barrie's categorisation system, WIL would be in the "Teaching Process" or "Engagement" classification, but in terms of the problems it addresses, by itself it does not address any of the inherent problems except possibly "Expertise". Similarly for the cultural problems it really only addresses the issue of "Motivation". A variation is the UNSW Co-op Program that targets the top performing students in a mix of scholarship program and work experience that spans a student's entire study career. In addition to the benefits of the WIL, it also addresses the problems of "Time" and "Isolation" and would be considered in the categories of "Engagement" or "Participatory". The downside of this program is the limited reach as it only affects a small proportion of students.

The requirements of a graduate attribute development program

The following assumptions form the basis of the suggested framework:

1. Upon graduation students are required to posses at least a moderate level of expertise in the Graduate Attributes being developed.
2. The identified inherent and cultural problems associated with developing GAs need to be addressed.
3. The framework should operate at highest levels of Barrie's categories.

This leads to the following requirements:

1. The program must specifically assess Graduate Attribute development as a consequence of assumption 1 and to address the problem of "Implicit Teaching". It must also contain a significant amount of assessment, such that a student must not be allowed to complete their studies without first fulfilling the assessment requirements.
2. A second requirement that derives from assumption 1 is that GAs need to be assessed individually to avoid some being developed at the cost of others.
3. The program needs to be implemented in at least the faculty level to address the problem of "Isolation".
4. The program needs dedicated and specialised staff to address problems of "Assessment", "Expertise" and "Motivation". This may also address the issues of "Conceptual Clarity" to a certain extent.
5. The program needs to span years, ideally an entire course, to address the issue of "Time".
6. The program must be student focused and allow assessment of a diverse range of learning sources. Combined with the other requirements, this should allow the program to be categorised as "Participatory".

A possible model based upon the four year engineering degree that addresses these requirements is given in Table 1.

Table 1 : Possible four year Graduate Attributes development program

Assessment	All GAs to be developed are assessed individually. Assessment is based upon whether or not listed activities have been completed with specific activities being assessed for quality. Different assessments will be established for both basic attainment and intermediate attainment of GAs. Any GA can be assessed at any year level at the end of any year.
Year 1	The requirements for graduation in terms of GAs is disseminated again to students through a lecture or other means. Specialised workshops that teach the foundation skills of Graduate Attributes are available to students. These workshops teach the basics of the GAs and explain the assessments for that GA. An assessment cycle for any GAs that students believe they qualify for occurs at the end of the year. Students receive a report on what they have qualified for.
Years 2 and 3	The requirements for graduation is disseminated again and presented in the context of job application. Workshops designed to further develop graduate attributes are made available with more emphasis on personal development. These workshops are open to students who have attained basic levels of particular GAs. Students who did not successfully complete the basic level of particular GAs may repeat the first year workshops and assessments. An assessment cycle for any GAs that students believe they qualify for occurs again at the end of each year. Students receive a report on what they have qualified for.
Final Year	All workshops are still available to students. A course hurdle requires all students to have developed the identified GAs to an intermediate level. An assessment cycle in the middle of the year is made available to allow for graduation at the end of the year.

Tracking the development of Graduate Attributes

In order for students to track their development of Graduate Attributes, they could use an ePortfolio. An ePortfolio is a digitized collection of artifacts that demonstrates an individual's ability in a range of areas (Lorenzo & Ittelson, 2005). Artifacts can be documents, presentations or any other electronic media that demonstrates the development or capacity of a particular skill, often skills that are considered "soft" or "generic" and are typically hard to test directly. They are often displayed as web pages but can also be used for constructing resumes or exported as digital archives. Artifacts are usually accompanied by a reflection of their work, and it is in this reflection that much of the learning occurs(Prpic & Moore, 2009).

Self reflection involves looking inwards and understanding the assumptions that underlie the way a student learns. The goal is to identify problems that hold you back, and then overcome them. It is an inherently difficult process, analogous to trying to look at the back of your head in a mirror (Brookfield, 1998). Brookfield goes on to say though that repeated attempts at self reflection can help the process by identifying patterns of behaviour; a practitioner can identify what they excel at and what they naturally avoid, which signifies areas that need to be addressed; correct behaviour being a key element in developing attributes such as team work and leadership. This repeated self reflection

can conceivably be achieved with an ePortfolio. The desire is that self reflection sets up a "self-oriented feedback" loop, where future learning builds upon an understanding of past learning (Barry J. Zimmerman, 1990). The ePortfolio can be used to demonstrate skills and experiences to potential employers or organistions. Creating the ePortfolio can help students develop their understanding of the "big picture". It can build a student's confidence in their skills, and it can help them understand the process of their learning (AeP, 2009; James & Harris, 2008). There are also advantages for the institution; they can help in monitoring student learning, assist in evaluating a course and through these processes they can be used to support accreditation (Terheggen, Prabhu, & Lubinescu, 2000).

Cambra-Fierro and Cambra-Berdun propose and validate a model which suggests that self-evaluation contributes to academic performance and self-evaluation is encouraged by "advice, self-motivation, responsibility and self-concept" (Cambra-Fierro & Cambra-Berdún, 2007a, 2007b). This appears to agree with the premise that a tool such as an ePortfolio that is implemented and supported correctly could give students an opportunity to build their capacity for self-evaluation. Cassidy(Cassidy, 2006) also reinforces the idea that self-evaluation (combined with a deep approach to learning) has a positive correlation with academic success. Cassidy's study was based upon first year students, supporting the idea that starting an ePortfolio with students of this year level is appropriate.

While there is the possibility of self-reflection through the use of ePortfolios, a preliminary investigation at the Melbourne School of Engineering, at the University of Melbourne suggests that work is required to make this happen. A small sample of students were surveyed and asked "What is self reflection?". Of the few definitions provided, most were primarily observational such as "[Self reflection is] A look at how you have learnt over the course", without including the important development and change component of self reflection (Barry J. Zimmerman, 1990). This suggests that first year students are not well versed in self-reflection and that as such it is not likely that they would engage with it effectively on their own. Supporting this is the trend for the literature to discuss how to develop self-reflection in students rather than how best to make use of it (Cambra-Fierro & Cambra-Berdún, 2007b; Huntly & Donovan, 2009; Willey & Gardner, 2010; Yang, 2010; Barry J Zimmerman & Kitsantas, 1997), and also the trend to connect high achieving, deep approach students with self reflection (Cassidy, 2006; Rodriguez, 2009; Barry J. Zimmerman, 1990). One significant point that both Cambra-Fierro et al. and Cassidy agree on is that motivation is an important factor in making self-evaluation happen and in a program that is consistent with Barrie's categories of "Participatory" or "Engagement" this could be achieved through the student's engagement with the course or university life as a whole. The lower categories could achieve motivation through specific assessments, however, with too strong a focus on assessment it would be likely that the majority of students would not feel responsible for continually developing their ePortfolios, nor would it be likely that assessment would motivate them past the assessment date. The research of Kitsantas et al. (Kitsantas, Reiser, & Doster, 2004; Barry J Zimmerman & Kitsantas, 1997) also discourages the use of assessment as being the sole motivator, their findings indicating that a focus on the process of the learning activity (once again, consistent with the highest of Barrie's categories) is more productive in terms of self-efficacy, satisfaction and performance than focusing on the outcome during the learning phase.

Conclusion

The varied issues arising with the teaching of graduate attributes have been considered in this paper and a framework proposed that intends to address some of the key difficulties. Within this framework the role of ePortfolios is identified as an important tool in the demonstration of the development of graduate attributes over a student's entire degree program. While graduate attribute development within specific subjects might be easier to implement in some ways, for proper development a program needs to span an entire course. In this way the benefits of Barrie's categories of "Participatory" and "Engagement" can be achieved, with key inherent and cultural problems being overcome. Such a program can meet the need of students to feel responsible for and capable of shaping their self development; after this occurs they will best be able to achieve self-regulation and demonstrate attainment of the graduate attributes that tertiary institutions are now requiring.

References

(HEC), H. E. C. (1992). *Achieving quality, higher education / Higher Education Council, National Board of Employment, Education and Training*: Canberra : Australian Govt. Pub. Service, c1992.

AeP. (2009). ePortfolio Concepts for Learners. Retrieved from http://www.eportfoliopractice.qut.edu.au/docs/AeP_conceptguide_learners.pdf

Barrie, S., Hughes, C., & Smith, C. (2009). National Graduate Attribute Project (GAP) Final Report.

Barrie, S. C. (2004). A research-based approach to generic graduate attributes policy. [Article]. *Higher Education Research & Development, 23*(3), 261-275. doi: 10.1080/0729436042000235391

Barrie, S. C. (2006). Understanding What We Mean by the Generic Attributes of Graduates. *Higher Education, 51*(2), 215-241.

Barrie, S. C. (2007). A conceptual framework for the teaching and learning of generic graduate attributes. [Article]. *Studies in Higher Education, 32*(4), 439-458. doi: 10.1080/03075070701476100

BIHECC. (2007). Graduate Employability Skills: The Business, Industry and Higher Education Collaboration Council.

Brookfield, S. (1998). Critically reflective practice. *Journal of Continuing Education in the Health Professions, 18*(4), 197-205.

Cambra-Fierro, J., & Cambra-Berdún, J. (2007a). Students' self-evaluation and reflection (part 1): measurement. *Education + Training, 49*(1), 36-44.

Cambra-Fierro, J., & Cambra-Berdún, J. (2007b). Students' self-evaluation and reflection (part 2): an empirical study. *Education + Training, 49*(2), 103-111.

Cassidy, S. (2006). Learning style and student self-assessment skill. *Education + Training, 48*(2), 170-177.

Debuse, J., & Lawley, M. (2009). Desirable ICT Graduate Attributes: Theory vs. Practice. [Article]. *Journal of Information Systems Education, 20*(3), 313-323.

Engineers Australia, E. (2011). Stage 1 Competency Standard for Professional Engineer. Retrieved from http://www.engineersaustralia.org.au/shadomx/apps/fms/fmsdownload.cfm?file_uuid=DBA27A80-95B2-94BD-5BE8-A105DEDDED21&siteName=ieaust

Green, W., Hammer, S., & Star, C. (2009). Facing up to the challenge: why is it so hard to develop graduate attributes? [Article]. *Higher Education Research & Development, 28*(1), 17-29. doi: 10.1080/07294360802444339

Higher Education Council, H. (1992). *Achieving quality, higher education / Higher Education Council, National Board of Employment, Education and Training*: Canberra : Australian Govt. Pub. Service, c1992.

Hughes, C., & Barrie, S. (2010). Influences on the assessment of graduate attributes in higher education. [Article]. *Assessment & Evaluation in Higher Education, 35*(3), 325-334. doi: 10.1080/02602930903221485

Huntly, H., & Donovan, J. (2009). Developing academic persistence in first year tertiary students : a case study. *Studies in Learning, Evaluation, Innovation and Development, 6*(1), 1-14.

James, R., & Harris, K.-L. (2008). The use of e-Portfolios in teaching and learning at the University of Melbourne (T. a. L. D. Committee, Trans.) (pp. 6): Centre for the Study of Higher Education, the University of Melbourne.

Kitsantas, A., Reiser, R. A., & Doster, J. (2004). Developing Self-Regulated Learners: Goal Setting, Self-Evaluation, and Organizational Signals during Acquisition of Procedural Skills. *The Journal of Experimental Education, 72*(4), 269-287.

Lorenzo, G., & Ittelson, J. (2005). An Overview of E-Portfolios. Retrieved from http://www.educause.edu/ELI/AnOverviewofEPortfolios/156761

Male, S. A., Bush, M. B., & Chapman, E. S. (2011). An Australian study of generic competencies required by engineers. [Article]. *European Journal of Engineering Education, 36*(2), 151-163. doi: 10.1080/03043797.2011.569703

Nair, C. S., Patil, A., & Mertova, P. (2009). Re-engineering graduate skills : a case study. *European Journal of Engineering Education, 34*(2), 131-139.

Prpic, K., & Moore, G. (2009). *iCrescam - growing attributes of University of Melbourne engineering graduands.* Paper presented at the AaeE Conference 2009, Adelaide, Australia.

Rodriguez, C. M. (2009). The impact of academic self-concept, expectations and the choice of learning strategy on academic achievement : the case of business students. *Higher Education Research and Development, 28*(5), 523-539.

Terheggen, S. L., Prabhu, R. P., & Lubinescu, E. S. (2000). From Product to Process: Enhancing Learning through the Use of Student Electronic Portfolios.

Willey, K., & Gardner, A. (2010). Investigating the capacity of self and peer assessment activities to engage students and promote learning. *European Journal of Engineering Education, 35*(4), 429-443.

Yang, Y.-F. (2010). Students' reflection on online self-correction and peer review to improve writing. *Computers & Education, 55*(3), 1202-1210.

Zimmerman, B. J. (1990). Self-Regulated Learning and Academic Achievement: An Overview. *Educational Psychologist, 25*(1).

Zimmerman, B. J., & Kitsantas, A. (1997). Developmental phases in self-regulation: Shifting from process goals to outcome goals. *Journal of Educational Psychology, 89*(1), 29.