Using graduate attributes as a curriculum design tool

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Abstract
The paper describes the development of a research-based graduate attribute policy and how it was used to review the curriculum of the Bachelor of Engineering program at the University of Southern Queensland. The policy was developed from a set of principles defined after an extensive review of the relevant literature. It includes processes that are used, firstly, to develop a set of industry authenticated graduate attributes for a program and then to design the curriculum using those attributes. Finally, the policy defines processes that ensure that the graduate attributes are embedded and assessed in the courses in the program.

At least two sets of graduate attributes are defined for each program. Firstly, a set of attribute statements is developed so that they are appropriate for all of the graduates of the program. Secondly, a set of graduate attributes is defined for each of the specialisations, or majors, that may be studied in the program. Thus, civil engineering students would be expected to acquire both the program attributes and the civil engineering attributes while completing their program.

The paper concludes by describing the author's experience in using the policy to re-develop the curriculum for the Bachelor of Engineering program in 2006.

Keywords: Graduate attributes; Curriculum design; Quality; Stakeholder consultation.

1. INTRODUCTION

Barrie [1] suggests that '*… generic graduate attributes in Australia have come to be accepted as being the skills, knowledge and abilities of university graduates, beyond disciplinary content knowledge, which are applicable to a range of contexts.*' In other contexts, different words are used instead of the word *attribute*, for example, *ability, capability, competence, or skill* [2]. The term *discipline* is also used to describe the attributes that are common to graduates in a particular field, such as engineering. This approach recognises that the graduates from a specific specialisation, such as civil engineering, will have acquired a set of civil engineering attributes as well as the discipline attributes that are common for all engineers.

To avoid confusion the following terms are used in this paper:

- The term ***generic*** is used when discussing graduate attributes at a university level.
- The phrase ***discipline*** is used when discussing graduate attributes for a broad academic discipline, such as engineering.
- The term ***specialisation*** is used when discussing the graduate attributes for a field of practice, such as civil engineering.
- The term ***program*** is used to describe a structured collection of courses that leads to a qualification such as a Bachelors degree.
- The term ***course*** is used to describe a unit of study within a program.
- The term ***major*** is used to describe a group of courses within a program that enable a student to specialise in a field such as civil engineering.

1.1 Engineering graduate attributes

The 1995-1996 federal government funded review of engineering education in Australia was the catalyst for the development and widespread adoption of graduate attributes in engineering schools. The resulting report included the requirement that '*engineering schools should demonstrate that their graduates have achieved, to a*

substantial degree, a set of graduate attributes that were defined in the document' [3]. A decade on, a 2008 review of engineering education showed the success of this approach when it reported that: '*This set of attributes formed the basis of the revised accreditation process … and rapidly found specific expression in the statements of course and program outcomes of each engineering school*' [4].

In 2004 this set of generic attributes was transformed into the Engineers Australia National Generic Competency Standards – Stage 1 Competency Standard for Professional Engineer [5]. It provides a detailed description of the expected knowledge, capabilities and attributes expected of the graduate engineer.

1.2 USQ graduate attributes

The University of Southern Queensland (USQ) adopted its first policy on graduate attributes in 2000. The accompanying Guiding Statement stated: '*USQ aims to create and maintain a learning environment that provides the basis for students to develop as independent lifelong learners, become effective problem solvers, and gain knowledge and skills relevant to their future needs'* [6]. The accompanying regulations required Faculties to show the '*Means by which the program satisfies the attached Attributes of a USQ Graduate'* [6] when seeking accreditation for a program. The regulations did not, however, define how this was to be done.

1.3 The Faculty's response

The Faculty of Engineering reviewed its programs during the period 2000-2001 and addressed the USQ graduate attributes as well as those defined by Engineers Australia (EA) [7]. The Australian University Quality Agency (AUQA) audited the University in 2002 and commented on the quality of the Faculty's approach, and the outcomes, and included the following recommendation in its Audit Report [8] '*…that the approach used by the Faculty (of Engineering and Surveying) to embed and report on graduate attributes should be considered as a blueprint for implementation of USQ's graduate attribute policy across the university.'*

2. THE DEVELOPMENT OF USQ'S 2005 POLICY

The AUQA recommendation prompted the University to establish a Working Party to examine the University's curriculum design and implementation processes to ensure that all programs enable students to efficiently acquire, practise, and then be assessed on their achievement of the graduate attributes. The Working Party, which was chaired by the author, developed a new policy which was adopted in 2005. It was based on a conceptual model described in a discussion paper tabled at the November 2004 meeting of USQ's Academic Board [9]. Some elements of the model were based on research undertaken by Barrie [1] at the University of Sydney. The key elements of the *Qualities of a USQ Graduate* policy are described in the following sections.

2.1 Underlying principles

The policy is based on a conceptual model that defined all of the components that together formed a coherent framework that enabled the systematic implementation of the policy across the University. Five key principles underpinned the conceptual model:

- The attributes and capabilities of a graduate should be defined at the program level rather than at the university level. The rationale for this approach was that graduate attributes and capabilities would be more relevant if they were defined at that level.
- Graduate attributes and capabilities should be defined at both the program and major levels.
- The attribute and capability statements for a program should be developed by the Program Development Team in consultation with all stakeholders, including students, graduates, practitioners, and employers.
- A cascading system of linked statements should be used to define the qualities of a graduate at different levels, from the University level down to the level of the learning objectives in a course.
- A consistent approach should be used to implement the policy across the university.

2.2 The hierarchy of statements

Five levels of statements were defined in the policy:

2.2.1 Level 1: The Qualities of a USQ Graduate: These statements define the five overarching qualities of a USQ graduate [10]:

- *Discipline Expertise*: The level of knowledge, skills and emerging expertise required for them to commence practice in their chosen discipline.
- *Professional Practice*: A sound knowledge and understanding of the professional and contextual responsibilities appropriate for their practice.
- *Global Citizenship*: The ability, through their understanding and valuing of difference and diversity, to live and work in culturally diverse communities.
- *Scholarship:* The capability to make a scholarly contribution in their workplace and the wider community.

- *Lifelong Learning*: The information literacy and independent learning skills required for them to pursue personal and professional development throughout their lives.

2.2.2 Level 2: The attribute and capability statements. A set of statements define the attributes and capabilities of a graduate of a program and for each major in the program. The statements for the Bachelor of Engineering program are shown in Table 1. The same format is used for the statements for each major.

2.2.3 Level 3: The elements. Each attribute and capability statement may incorporate a number of elements, each of which must be addressed if a student is to demonstrate the attribute or capability. For example, attribute and capability statement number five, which defines a graduate's communication skills, has the following elements: written communications; oral communications, and inter-personal communications.

2.2.4 Level 4: The defining activities. One or more defining activities are developed for each element. These are statements of the typical activities that graduates of the program would be expected to undertake in their first year after graduation.

2.2.5 Level 5: The course learning objectives. One or more learning objectives are defined for each defining activity assessed in a course. These may be drawn from existing course specifications, or they may be newly defined and then allocated to an existing course or to a new course.

The statements at levels 2, 3, 4 and 5 are listed in a standard template which highlights the relationships between each level. Part of the template for graduate attribute and capability statement 5 is reproduced in Table 2.

No.	Statement
1	Understand and apply knowledge of engineering fundamentals and the basic sciences, including computing and mathematics.
2	Use a systems approach to understand and improve engineering outcomes.
3	Develop engineering designs.
4	Schedule, manage and complete engineering projects.
5	Communicate effectively in English in a variety of modes with members of the engineering team, allied professionals and with the community at large.
6	Make sound decisions based on open-mindedness, objectivity and reasoned analysis.
7	Function effectively in multi-disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as an effective team member.
8	Analyse, evaluate and synthesise data and information to construct a thesis.
9	Apply problem solving techniques including problem identification, formulation and solution, initiative, innovation and creativity.
10	Undertake research using the methodologies and skills appropriate for their discipline.
11	Manage work efficiently and effectively under time and resource constraints.
12	Adapt to changing circumstances and master new knowledge and techniques.
13	Learn independently and understand the need to undertake lifelong learning.
14	Gather, analyse and effectively use information from the range of sources relevant to their field.
15	Understand and operate effectively within the cultural environments in which professional engineers practice in local, national and global contexts.
16	Practice in a professional manner informed by a knowledge and acceptance of the economic, ethical, legal, professional, and workplace responsibilities of a professional engineer.
17	Understand and accept the social, cultural and environmental responsibilities of a professional engineer.

TABLE 1. Graduate Attribute and Capability Statements

3. DEVELOPING THE GRADUATE ATTRIBUTE AND CAPABILITY STATEMENTS

To ensure consistent outcomes were achieved across the university, a set of simple, efficient and sustainable processes was developed to implement the policy. This systematic implementation strategy was developed by a working party of the people who were charged with implementing the policy in one of the five Faculties. It included four phases, with each phase having three processes:

- *Development phase:* This phase begins with the formation of a Program Development Team (PDT), which then develops a new set of graduate attribute and capability (GAC) statements or, where there is an existing set, reviews the existing statements. The PDT then consults academic staff, students and other stakeholders, for example recent graduates and employers, about the content and level of the GAC statements. Following

the consultation process the PDT refines the graduate attribute and capability statements. This process ensures that the GAC statements are appropriate for a graduate of the program and, where appropriate, for each major in the program.

- *Design phase:* The GAC statements are then used to guide the curriculum development process. This ensures that all of the statements are embedded in the curriculum, and that students are provided with opportunities to acquire, practise and be assessed on their achievement of the attributes and capabilities defined for the program. The final process in this phase is the preparation of the documentation required for the accreditation of the program by the University and, where required, a professional organisation such as Engineers Australia.
- *Implementation phase*: The aim of the first process in this phase is to engage students in the learning process. When they attend their orientation program, commencing students are informed about the graduate attributes and capabilities of a graduate of their program. They are also encouraged to manage, and be responsible for, their learning to ensure that they acquire all of the attributes and capabilities defined for their program. The second process in this phase is the development of the teaching and learning strategies that will be used in each course. The final process in this phase is implementing the teaching strategies and facilitating student learning.
- *Evaluation phase*: The first process in this phase is the assessment of student learning outcomes in each of the courses they undertake in the program. The learning, teaching and assessment processes and outcomes of each course are then reviewed by the teaching team and a short report is compiled for the Faculty executives. Thus, the second process in this phase is an annual audit of the learning, teaching and assessment undertaken in the program. The final process of the evaluation phase is the annual evaluation of graduate attributes and capabilities. This data is collected by a third party using standard questionnaires to gain the views of the graduates of the program, and their employers.

This four phase process is cyclical, with the data gathered during the evaluation phase being used to monitor the success of the program. Then, if improvements are required, the cycle begins again with a review of the GAC statements. When a cyclical curriculum design process like this is used to develop and embed graduate attributes, the practitioner authenticated set of graduate attributes becomes a key component of the curriculum design process.

Program Outcomes			**Course Outcomes**		**Comments**
Graduate Attributes and Capabilities	**Elements**	**Defining activities**	**Course Code**	**Objectives**	
5 Communicate effectively in English in a variety of modes with members of the engineering team, allied professionals and with the community at large.	1 Speaking skills	a) Communicates effectively in spoken English b) Presents papers at professional development activities such as conferences, seminars and workshops c) Etc.	ENG4903	2 Plan, and present a substantial technical seminar in an appropriate professional manner 3 Make effective use of presentation aids 4 Present, defend and discuss the technical information, based on their own academic dissertation, in a professional forum	Students will normally present the seminar at the annual Project Conference where it will be assessed by Faculty staff.

TABLE 2. Extract from the template for graduate attribute and capability statement 5

4. QUALITY PROCESSES

Four key characteristics of the policy guarantee quality outcomes:

The *validity* of the policy is supported by Australian and international research [1] [9] that underpins the conceptual model used to develop the policy.

The *currency and relevance* of the program curriculum is assured when it is developed using an authenticated set of graduate attribute and capability statements developed in consultation with stakeholders.

The *integrity* of the policy is provided by the integrated strategies and processes that are used to systematically implement the policy across the university.

The *reliability* of the policy is based on the fact that when students successfully complete all of the assessment items in a program they have demonstrated they have acquired the graduate attributes and capabilities defined for that program.

5. APPLYING THE POLICY TO THE BACHELOR OF ENGINEERING PROGRAM

The aim of the Bachelor of Engineering program is to provide students with the knowledge and skills they require to commence practice as a professional engineer and to undertake further advanced level studies in engineering. Specifically, the program provides students with a core of basic generic and technical skills, common to all branches of engineering, and then permits students to undertake an in-depth study in either agricultural, civil, computer systems, electrical and electronic, environmental, instrumentation and control, mechanical, mechatronic, power systems, or software engineering. In addition, students are equipped with an understanding of the industrial and social environments in which they will function as professional engineers, and a capacity to communicate effectively and adapt to change.

The program is accredited by the University and by Engineers Australia. It is offered in both the on-campus and distance education modes, with approximately 70% of 930 students studying off-campus by distance education. The program requires four years of full-time study or eight years of part-time study.

5.1 Development of the graduate attribute and capability statements

The initial drafts of the generic *graduate attribute and capability statements*, together with their associated *elements* and *defining activities*, were developed by the members of the Program Development Team during 2005. They were based on the 2001 set of *discipline graduate attribute* statements. The initial drafts of the *graduate attribute and capability statements* for each of the specialisations (majors) in the program, together with the associated *elements* and *defining activities*, were developed by the relevant Head of Department, in consultation with the academic staff in the Department.

5.2 Stakeholder consultation

As the USQ policy did not define a stakeholder consultation process the Faculty developed its own processes. Employers, supervisors and recent USQ graduates were asked to complete a questionnaire based on the graduate attribute and capability tables defined for the program and for the major appropriate for their specialisation. The draft graduate attribute and capability tables were modified to develop the questionnaire, with the columns headed 'Course Codes' and 'Objectives' being replaced by a column headed 'Ranking, 1-5' (See Table 2). Stakeholders used this column to rank each defining activity (DA) after reflecting on **'***the activities that a graduate of the program should be able to undertake in the first year or two after graduation'*. They used the following five point scale:

5 – Essential for a graduate in this major

4 - Very important for a graduate in this major

3 – Important for a graduate in this major

2 – Useful for a graduate in this major

1 – Not relevant for a graduate in this major

The stakeholders were also asked to write any comments they had in the 'Comments' column. These could relate to a graduate attribute and capability statement, an element, or a defining activity. They could also propose a new defining activity, or comment on any other matter. Stakeholders were also able to use an additional page at the end of the questionnaire to record any comments about the policy, the approach, the process, or any other matter.

The questionnaire was sent to 224 stakeholders: 139 recent graduates; 40 employers and supervisors; and 45 USQ academic staff. The response rate for the questionnaires was disappointing, with only 36 completed questionnaires being received by the final date: 16 from USQ academic staff; and 20 from employers and graduates.

It is interesting to notes that in all but 3 cases the average rank allocated by academic staff for a DA was equal to, or higher than, the average employer/graduate rank for that DA. Because these staff had been involved in the development process their input was only used for comparison purposes. Thus, only the responses from the employers and graduates were used to refine the GAC tables.

The results for the 160 defining activities (DAs) in the six attribute and capability tables were analysed in detail to identify any changes that should be made. The key findings from the employer and graduate responses were:

- 155 of the 160 DAs received at least one rank of 5 from the employers and graduates.
- 139 of the DAs had a mean ranking of 3 or more, with 31 having an average of 4 or more.
- 21 of the DAs had a mean ranking less than 3. All of these were carefully reviewed by the Program Development Team.
- 53 DAs received at least one 'Not relevant for a graduate of this major' ranking, although 48 of those DAs also received at least one 'Essential for a graduate of this major' ranking.
- A total of 124 comments were made about elements or defining activities and ten overall comments were received.

The Program Development Team considered the results and decided that, because of the low response rate, only essential or clarifying changes should be made at that time. The Team considered each of the comments and, where appropriate, changed the relevant component of the tables. They also considered each of the 21 defining activities which received a mean rank of less than 3. A written response was developed for each of these items.

The last stage of the stakeholder consultation process was to refine the graduate attribute and capability tables.

5.3 Curriculum design

Once the tables were complete the Program Development Team identified the courses where student achievement of each of the defining activities would be assessed, and then each defining activity was linked to one or more learning objectives in the relevant course. This linking data was then entered into the graduate attribute and capability tables.

A number of gaps and inconsistencies were identified between the course objectives and the defining activities. These were resolved by the Associate Dean (Learning and Teaching) who either proposed changes that could be made to one or more of the existing objectives, or developed drafts of new objectives. The proposed changes were then discussed with the relevant Head of Department for a course in a major or, in the case of a core course, the relevant course examiner (leader). In most cases the changes to the objectives were adopted directly as they either clarified an existing objective, or better described a learning outcome that was already being assessed. Further discussion was required about the objectives in three courses before agreement could be reached over the proposed changes. This was because they would have required changes in the topics, and the teaching and assessment practices undertaken in those courses.

Once all parties had reached agreement on the changes, they were promulgated through the normal review and approval process undertaken to update course specifications for a new academic year. The changes were then implemented for the 2007 academic year.

5. CONCLUSION

This paper described the development of a research-based graduate attributes policy at the University of Southern Queensland. It also outlined the strategies that were used to implement the policy, and how the policy was used for a review of the Bachelor of Engineering program in 2006. The paper demonstrated how the four phase implementation strategy defined in the policy can be used as a powerful curriculum design tool.

6. REFERENCES

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