Embedding and Assessing Graduate Attributes in Engineering Curricula at UCT

Jenni Case & Brandon Collier-Reed

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Engineering programmes across South Africa are accredited by the Engineering Council of South Africa (ECSA), a statutory body which represents the profession. In 1998, ECSA adopted an outcomes-based framework for accreditation, in line with the Washington Accord, a system of mutual accreditation across similar professional bodies in a range of countries including the USA, UK, Australia and Canada. Accreditation takes place on a 5 yearly cycle, and UCT underwent its first outcomes-based accreditation in 2000, followed by 2005. Preparation is currently underway for the 2010 accreditation due to take place later this year. In the 2000 accreditation, ECSA was still ‘feeling its way’ through this new system and thus much of the accreditation followed the traditional content-based mode. In 2005 there was an intensified demand for us to demonstrate that our courses and programmes were structured along outcomes-based lines. In 2010 there will be a strong requirement for us to show that our assessment systems are able to ensure that each graduate meets the prescribed outcomes.

The programme-level outcomes central to ECSA’s accreditation process can be seen as analogous to graduate attributes in so far as they are the “qualities, skills and understandings ... students would desirably develop during their time at [an] institution and, consequently, shape the contribution they are able to make to their profession and as a citizen” (Bowden, Hart, King, Trigwell, & Watts, 2000). ECSA describe these capabilities in terms of Exit Level Outcomes (ELOs). Neither content nor structure of a programme is prescribed and it is satisfying these generic ELOs which form the cornerstone around which engineering programmes develop their own unique curricula.

In a 2001 article our colleague Jeff Jawitz (CHED) argued that the ECSA shift to outcomes-based accreditation offered unique opportunities for engineering educators, which he summarised as follows:

- It has brought key educational issues, namely the relationship between learning objectives, the learning process and assessment, to the fore for discussion in engineering departments.
- It allows much greater freedom for programmes to define their own content as the emphasis has shifted from what students know to how students can use what they know.
- It is focussing attention on how we assess our students.
- It requires that our programmes have in place systems of continuous evaluation and improvement, a healthy change from the ad-hoc approach that we currently depend on, and one that will force us to apply in our educational design the same principles that we teach our students to adopt in their engineering design.

(Jawitz, 2001, pp. 175-176)

In this reflective piece we consider the ways in which the UCT engineering curricula have developed over the last decade in order to be able to more clearly develop and assess our desired graduate attributes. Engineering curricula have traditionally been focused on problem-solving, application of scientific and engineering knowledge, engineering design, laboratory work, and engineering tools. There has also been a focus on professional and technical communication. In this piece we will thus focus particularly on those attributes which have traditionally been less emphasized in engineering programmes, viz. 1. impact of engineering activity, 2. individual, team and multidisciplinary working, 3. independent learning ability, and 4. professionalism. Although we might have always thought that our programmes in at least a serendipitous manner would have developed these competencies, we are now required to show explicitly that we do develop them across a programme, and moreover that we are able to assess them – a considerable challenge for each programme. In this short piece we are not able to cover the full range of curriculum modifications that we have made; rather we highlight in each instance exemplar innovations from the programmes where we have been most closely involved. We particularly focus on the assessment of what ECSA terms ‘Exit Level Outcomes’.

Impact of engineering activity
This outcome requires that graduates are able to ‘demonstrate critical awareness of the impact of the engineering activity on the social, industrial and physical environment’. This broad-ranging statement includes those aspects of engineering curricula that have traditionally focused on safety and risk assessment, but now also includes an engagement with environmental and social impacts.
In the Mechanical Engineering, a triad of activities have been integrated into the fourth-year “capstone” project course where students are required to critically engage with this outcome. Firstly, each student must complete an ethics questionnaire which must be approved before they collect any data for their project. This compels a student to consider the ethical implications of the work that they are doing and the impact of what they are doing may have on a community. Secondly, a risk assessment form must be completed by each student for any new activity related to the practical aspect of their project. In this way students are made to consider the occupational and public health and safety requirements for any activity that they are involved in during their project. Finally, students are required to write a short essay that critically considers the impact of their project on society. Assessment is conducted by examiners (including an external examiner) using their professional judgement as to whether a student has satisfactorily managed to demonstrate satisfactory performance in this outcome.

In a final year course in Chemical Engineering, students have to analyse and describe the social and environmental considerations in a new process industry project. They have to discuss approaches for engaging with the conflicting interests of multiple stakeholders. They also need to demonstrate that they appreciate the role of the process engineer in responsible value-creation and preventing harm.

Individual, team and multidisciplinary working

This outcome requires that graduates are able to ‘work effectively as an individual, in teams and in multi-disciplinary environments’.

In Chemical Engineering there is a strong emphasis on group work throughout the programme. The final year Design Project takes place in a randomly assigned group of 6 students while the Research Project is conducted in a self-selected pair. The assessment of the Design Project includes both individual and group submissions. Both courses make extensive use of individual oral presentations to also assess individual competence. In Mechanical Engineering, multidisciplinary working has been integrated into the final-year design course as there are typically both mechanical as well as electro-mechanical students in each project team. Students are able to work across disciplinary boundaries (the mechanical/electrical boundary) in the development of the solution to their design problem.

Independent learning ability

Here graduates are required to be able to ‘engage in independent learning through well developed learning skills’.

In Mechanical Engineering this outcome is assessed in, amongst others, the fourth-year project. Here, students are given the opportunity to demonstrate that they are effective learners by showing that they can determine learning requirements and strategies by sourcing and evaluating information. Furthermore, projects are constructed in such a way as to require students to access, comprehend and apply knowledge acquired outside formal instruction, and then critically challenge assumptions they may have and embrace new thinking.

Chemical Engineering uses problem-based learning in one final year course to provide students with the opportunity to demonstrate their ability to learn independently. In this case, the mode of learning is limited lecturer input, with students learning through engagement with real-world problems. The assessment of problem-based learning activities takes place through the monitoring of performance in regular examinations, as well as through the reflective learning journals that students submit for assessment. In these journals, students are required to evaluate what they have learned and how they have learned it.

Professionalism

ECSA requires that graduates are able to ‘demonstrate critical awareness of the need to act professionally and ethically and to exercise judgment and take responsibility within own limits of competence’.

Throughout their final year Mechanical Engineering project, students are required to behave in a professional manner in their relations not only with the technical and workshop staff, but also their supervisor and peers. This outcome is assessed by the supervisor (the internal examiner) qualitatively in the form of a report they compile of a student’s performance. In this report, the supervisor is required to give evidence to what extent they believe that a student has accepted responsibility for their actions, displayed judgment in decision making, limited their decision making to their area of current competence, and discerned their boundary of competence in their project. Similarly, in the Chemical Engineering Research Project, students are explicitly assessed on their professionalism by the course coordinator as well as their supervisors.
Jeff Jawitz (2001) highlighted some specific opportunities afforded to engineering departments as ECSA moved to formally accrediting programmes in terms of what they refer to Exit Level Outcomes – and what we argue are notionally equivalent to the graduate attributes developed through an engineering programme. The exemplars presented above have hopefully illustrated how two departments have made use of this opportunity by ensuring the articulation between course-level learning objectives, programme level outcomes, and assessment. A focus on ‘educational design’ has emerged as an integral part of our programme planning and the ‘ad hoc’ approach referred to by Jawitz is slowly having less of an influence on the way we operate. What remains is to recognise that what ECSA (and thus industry) may require and what UCT may view as important generic graduate attributes are not necessarily a perfect match. Our programmes will continue to evolve to ensure that every student graduating not only meets ECSA’s Exit Level Outcome requirements, but also the generic graduate attributes that emerge from within the University’s structures.

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