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# THE EFFECT OF INTEGRATING GA'S INTO THE CURRICULUM ON THE DESIGN OF A NEW 3-YEAR MECHANICAL ENGINEERING DEGREE AT DUT

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## Abstract

The introduction of the South Africa Higher Education Qualification Sub Framework (HEQSF) in 2014 necessitated the replacement or alignment of all existing Higher Education qualifications. The Department of Mechanical Engineering at the Durban University of Technology (DUT) chose to replace the old National Diploma in Mechanical Engineering with a Bachelor of Engineering Technology degree (BEngTech, or "BET"), which was first offered in 2018.

The BET was structured such that it met the requirements of various stakeholders and statutory bodies, including the Engineering Council of South (ECSA). ECSA is designated by the Engineering Profession Act of 2000 as the statutory body responsible for quality assurance and accreditation of engineering programmes. In this role ECSA developed a small bouquet of qualification standards, including the new BET degree, which was selected by DUT. Included in these standards are prescriptions such as credit values, NQF levels, knowledge areas and 11 Graduate Attributes (GAs), all of which must be embedded in the programme. The ECSA qualification standards for the HEQSF aligned programmes are accredited according to an outcomes-based framework, as opposed to the content-based accreditation of the old programmes. The outcomes-based accreditation is focused on the GAs which must be developed and accessed.

ECSA stipulates that a student should not graduate unless they have passed an assessment of each GA. While the development of each GA occurs in several modules (taught exclusively by the department), it was decided that the assessment of them should only take place in exit-level modules. In addition, it was also decided that a student would fail a module that included the assessment of a GA if they failed the GA assessment. This would prevent graduation.

This paper briefly describes the process that was used to design the new BET and focuses on how the development and assessment of the GAs was embedded in the modules, as well as the quality assurance issues around that. Some preliminary analysis will also be presented to indicate the effect of the GAs on the success and graduation rates. The authors of this research adhere to a pragmatic paradigm where quantitative methods will be used, guided by the Grounded Theory Method.

***Keywords:*** *Engineering, engineering education, graduate attributes, success rates, analysis*.

## 1. Introduction

This paper describes the effects of integrating Graduate Attributes (GAs) into the curriculum of the Bachelor of Engineering Technology (BET) in Mechanical Engineering, at the Durban University of Technology. This paper will also describe a preliminary investigation, conducted to determine if the assessments used to measure competence in the GAs, would have an effect on student success, and hence throughput.

The study described above forms part of a larger project exploring the success of mechanical engineering students in this programme. The purpose of this larger project is to identify key factors leading to, or impeding, student success. It will also analyse the curriculum design, and implementation thereof, in order to test its conduciveness for student success. Several studies, all relating to student success will be undertaken, namely

- To determine if the entrance requirements are appropriate
- To identify factors leading to student success
- To identify factors leading to poor throughput rates
- To identify 'bottleneck' modules and propose interventions
- To investigate the effect of 'back-to-back' offerings of modules on student progression
- Investigate the effect of integrating GAs into the curriculum

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## 2. Background

The Higher Education Act of 1997 laid the groundwork for South Africa's new higher education institutions, mandating the creation of a unified, coordinated higher education system. The goal of reforming higher education and its institutions was to fulfil the requirements of a society that is becoming increasingly technology oriented. (Mtshali and Sooryamoorthy 2019) It was also implied that via a process of amalgamation, the number of universities and technikons (which were similar to polytechs in the UK) would be reduced. In 2003 technikons were renamed Universities of Technology (UoTs) (Mtshali and Sooryamoorthy 2019) and the Durban University of Technology (DUT) was formed by the merger of ML Sultan Technikon and Technikon Natal.

The Higher Education Qualifications Sub-Framework Act No. 67 of 2007 (HEQSF Act) (South African Qualifications Authority 2013) established a single qualification framework for higher education institutions, as envisioned in the Department of Education's 1997 strategy. This was to hasten the creation of a single nationwide coordinated higher education system, with course harmonisation across programmes and student movement between higher education institutions. (Kapp 2019). All existing programmes needed to be aligned to the HEQSF, and any new programmes developed were similarly required to comply with the HEQSF.

The Faculty of Engineering and the Built Environment (FEBE) at DUT had previously offered three-year National Diplomas (NDip), followed by a one-year bachelor's degree in technology (BTech). Postgraduate qualifications, in the form of a Master of Engineering Technology, and a Doctor of Engineering Technology were also offered. The NDip and the BTech were not HEQSF compliant (and could not be aligned) and had to be replaced by entirely new programmes, whilst the postgraduate programmes could be aligned easily.

In developing these new programmes, the requirements of a number of stakeholders and statutory bodies needed to be met, particularly those of the Engineering Council of South Africa (ECSA), along with the (new) Department of Higher Education and Training (DHET), the Council of Higher Education (CHE), and the South African Qualification Authority (SAQA). The CHE is an independent statutory quality council for higher education in South Africa. Quality assurance is led and managed by them. Trends and developments are researched and monitored. The CHE initiates a critical conversation about current concerns in higher education and provides strategic and policy assistance to the DHET Minister. DHET is responsible for providing national strategic leadership in support of the Post-School Education and Training system for improved quality of life of South Africans. ECSAs' core functions are the registration of professionals, accreditation of programmes and the development of standards for educational qualifications.

The three main categories of professional registration administered by ECSA are Professional Engineers, Professional Engineering Technologists, and Professional Engineering Technicians. The category of registration is primarily dependant on the academic qualifications of the applicants. In order to align with the HEQSF, ECSA developed a suite of qualification standards, providing the academic requirements for registration in the various categories (Engineering Council of South Africa 2020). These standards all incorporate 11 *Graduate Attributes*, which must be embedded into the curricula, developed, and assessed (and in order to graduate a student must be considered competent in all 11 GAs). The 11 GAs are described in the first reference.

After consultation with its stakeholders, the engineering departments within FEBE chose to offer the three-year Bachelor of Engineering Technology (BET) followed by a Bachelor of Engineering Technology Honours (BEngTechHons).

Before the BET could be offered, a number of approval process were required. Firstly, a skeletal curriculum structure is presented to ECSA, and if it meets the requirements of the relevant standard, their endorsement is given. Subsequently university Senate approval is sought for an application to DHET for PQM (Programme and Qualification Mix) clearance. Once this is obtained a full curriculum, inclusive of module programme structure, prerequisite, module descriptors, entrance requirements etc, is submitted to CHE for approval. Finally, SAQA adds the qualification to its database of approved qualifications. It is only after this last stage is complete that a new qualification may be offered formally.

## 3. Integrating the GAS

A number of decisions were taken at the faculty level to ensure that the GAs would be developed, assessed and documented in a consistent manner. The assessment of GAs should only be conducted in 3rd year, exit level modules, offered by the department. Due to the importance placed on GAs, in relation to programme accreditation by ECSA, it was decided that only modules offered directly by the department, as opposed to serviced modules would be used to assess GAs.

In addition to the ECSA GAs, DUT has its own GAs. In order to avoid duplication, the university GAs were mapped against the ECSA GAs, and thus only assessment of the ECSA GAs is necessary.

Further it was decided, that passing the embedded GA assessment would be one of the requirements to pass the module. In other words, if a student failed the GA assessment, which may have been unrelated to the module content, they would not be able to pass the module. The rationale for this was to eliminate that the contradiction of a student passing a module, but not being able to graduate, as all GAs had not been achieved.

The GAs were to be assessed by using a competency scale, where students would need to demonstrate competence in all of the assessment criteria, as detailed in the assessment marking rubric. In the event of a student failing the assignment, or not demonstrating competence, they would be permitted to correct inadequacies in the work and resubmit. If the resubmission again fell below the required standard, the student would fail GA, and hence also the module

Once a GA had been assessed, the outcome was to be recorded as either 0 or 1 on the Universities Management Information System (MIS), where 0 denotes *not competent* and 1 *competent.* In addition to providing proof of competence on the student's academic record, the MIS is also set such that a subminimum of 1 is one of the requirements to pass the module. This effectively prevents the contradiction mentioned earlier.

By their nature, the GAs may not be directly related to the content of the module in which they are embedded. For example, *Graduate Attribute 9*: *Independent Learning*, is embedded in the module Fluid Mechanics 3. Its associated assessment criteria, shown below, have no direct link to the content taught in *Fluid Mechanics 3*. In order to assess this GA, the students are given a self-study assignment relating to pipe networks, a section of the module, which is not covered in lectures. They are then required to produce a report separated into two distinct sections, namely *Learning Strategy* and *Pipe Networks.* The *Learning Strategy* section is used to assess the GA and consists of the following:

- Introduction Strategy/plans
- Detailed comments on where/how information was sourced and well as the appropriateness of said sources
- Reflections on the success of the strategy employed, or comments on how the strategy was changed if the original strategy was unsuccessful
- References

Conversely in *Environmental Engineering* where, *Graduate Attribute 7: Impact of Engineering Activity* is assessed, the, the case study used for the assessment is directly related to the module content.

In subjects such as *Fluid Mechanics 3*, where the GA assessment is not related to the content taught in the module, there was concern regarding the possibility of students passing all the content related assessments but still failing the module due to a failed GA assessment.

As previously stated, all students in their third year of study must pass the GA assessments embedded in the modules. There was concern that the implementation of GA assessments could have negative success and hence throughput implications Specifically, the programme contains no electives, so if a student fails even one module, they would be delayed from graduating for at least a year. If a significant number of students were failing modules due to failing the GA assessments, this could be problematic.

In the event of a student not demonstrating competence in a GA assessment, it was decided that they would be given a second opportunity. It was hoped that this would mitigate the potential negative consequences to throughput. As of 2022, two cohorts had already finished their final year of study, and as such, it is an opportunistic time to investigate whether the GA assessments were affecting success and throughput.

## 4. Investigation method

Quantitative methods guided by the Grounded Theory Method (GT) were utilised in this, and the larger investigation mentioned in the introduction. GT is a collection of tools and processes that allow researchers to find concepts and construct theories from data using a systematic approach. In the theory-generating process, GT is predominantly inductive, which implies that researchers travel from the particular to the general to explain occurrences (Corbin and Strauss 2014) . In developing theory, deduction and abduction play a part. The GT approach to these concerns is distinguished by its willingness to consider numerous answers, all of which are developed "from the ground up" from the information (Foley and Timonen 2015).

The Universities MIS system is used to record student outcomes, such as individual assessment grades, and final grades. As mentioned previously, each students' GA assessment result is recorded with a 0 or 1. As mentioned, ŧ any student with a 0 recorded for the GA assessment has failed the module. What is not immediately clear to the casual observer is whether the student has failed the module because of this GA assessment result.

Although a comprehensive analysis could not be carried out, the authors looked at the success rate (and failure rate) of the modules as a whole, as well as the success rate (and failure rate) of the GA assessment, in order to ascertain if a significant proportion of students are failing the modules due to the GA assessments.

Simplistically, if a student passed all assessments, in a module, except the GA assessment, it could be deduced that the GA was the sole cause of failure. Conversely, if the GA assessment results are removed from the final mark, and final mark remains a fail, we can conclude that the GA assessment is not the sole cause of failure.

For the years in question, class lists containing all assessment results were downloaded from the MIS for each module containing a GA assessment. Two modules, namely Strength of Materials 3, and Capstone Design Project were found to have incomplete information captured on the class lists. *Capstone Design Project* had no explicit information regarding the GA assessment for 2020, and *Strength of Material 3* had no information for either year - the lecturers involved were unsure, at the time, on how to record the GA outcome on the MIS. This has since been rectified.

Fortunately, in these two modules, the embedded GAs were in alignment with the module content to such an extent that it is not likely that a student would fail the GA assessment, yet pass the module. For example, Graduate Attribute 1: *Problem Solving* is assessed in Strength of Materials 3. In this GA, students are required to show competence in the application of engineering principles, to systematically diagnose and solve broadly-defined engineering problems. The content-based assessments typically consist of the types of problem solving illustrated above, so it is likely that the student would have passed the GA assessments as well.

Where a student failed a module, the final mark was recalculated, with the mark obtained for the GA assessment removed. If the final mark, after the recalculation, was a pass, the student would have been deemed to have failed the module due to the GA assessment.

*Table 1. Failures due to gas in 2020 and 2021.*

| **Module** | **Number of Students** | **Failed GA** | **% Failed GA** | **Failed module due to GA** | **Failed module** | **% Failed module** |
|---|---|---|---|---|---|---|
| Capstone Design Project* | 56 | 2 | 3.6% | 0 | 2 | 3.6% |
| Environmental Engineering | 146 | 5 | 3.4% | 0 | 6 | 4.1% |
| Fluid Mechanics 3 | 104 | 3 | 2.9% | 0 | 4 | 3.8% |
| Mechanics of Machines 3 | 136 | 8 | 5.9% | 0 | 27 | 19.9% |
| Principals of Management | 149 | 4 | 2.7% | 0 | 10 | 6.7% |
| Thermodynamics 3 | 101 | 1 | 1.0% | 1 | 4 | 4.0% |

*Data only available for 2021

## 5. Results

Given that the BET was only implemented in 2018, the earliest possibility for students to be in their third year would be 2020. For this reason, the years 2020 and 2021 were the only possibilities for this preliminary investigation. This study will be repeated, as more data becomes available.

Table 1 above shows aggregated results for both years, and each of the assessed modules, including the number of students enrolled in the module, the number of students who failed the module, the number of students who failed the GA, and the number of students who failed the module primarily due to failing the GA assessment.

## 6. Discussion

In the two-year period investigated, a total of 23 students failed GA assessments. Of these, 22 would have failed the module even if they had passed the GA assessment. In these 22 cases, it is obvious then, that the introduction of a GA assessment did not contribute toward the student failing the module.

*Thermodynamics 3* is the only module where a student passed all assessments yet failed the GA assessment.

*Graduate Attribute 4: Investigations, experiments and data analysis* is embedded in *Thermodynamics 3*. This is a GA that is not directly related to the module content and is assessed via a laboratory/practical investigation and report. Considering that in the two-year period, 101 students were registered for this module, this one failure is an outlier and cannot be considered significant.

We can conclude that the GAs assessments have not had a significant negative effect on success and throughput in the years investigated. This investigation should be expanded to include further cohorts as the years progress.

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