# Investigation of completion rates of Engineering students.

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Abstract: The completion and retention rates of the 2002 first year engineering cohort at the Queensland University of Technology are investigated to the end of 2006. Engineering degrees are four years fulltime and double degrees with engineering are five years fulltime. After considering completions, course changes and discontinuations in this time for the two streams of first year engineering maths, this paper also considers the progression of those students who chose to use the optional extra support available for first year engineering maths. Students who used this service were twice as likely to complete their course compared to those who did not.

*Keywords:* Engineering, Completion rates, mathematics support, retention.

## 1 Introduction

The issue of completion rates and retention of students at tertiary level is an ongoing challenge. Tomkinson et al [1} says of the UK "With wastage rates in science and engineering often in excess of 20%, for many of us the issue of student retention is of future viability. For others the main issue is of the human cost of so many students missing out on an opportunity." In the United States colleges of engineering are finding that they loose up to 50% of engineering students during the first two years, with women more likely to stay within the course than men [2]. There is a tension between government pressure to allow more students the opportunity of tertiary education and the reduction in proportions of quality students who are genuinely attracted to, and prepared for, certain university courses including engineering. To accommodate these tensions many institutions have started programs of learning support in mathematics and statistics at either the local course level or through university wide learning support centres or both. In the UK, such learning support is considered of such importance and priority that one of the four national Centres of Excellence in Teaching and Learning (CETL) is Sigma: The UK's Centre for Excellence in Teaching and Learning in Mathematics and Statistics Support, see [3].

At the Queensland University of Technology (QUT), as in most universities, all students who are enrolled in an Engineering Degree are required to take units of Engineering Mathematics in their first year. These units provide the foundation for all their engineering units. They therefore must also help the students with the transition from high school mathematics to the mathematics that they will need in their future units of engineering. In Queensland the secondary curriculum allows students to do up to two subjects in mathematics. For engineering students the appropriate subjects are Maths B and Maths C. Maths B is the core algebraic and introductory calculus subject, and Maths C is the extension subject that extends Maths B. About half of the students entering engineering have completed both Maths B and Maths C, the other students have completed Maths B only or enter with other mathematics background adjudged equivalent to Maths B by some authority. Students with Maths B only, do the Engineering Maths 1B (MAB180), while those who have both Maths B and C do the Engineering Maths 1A (MAB131). MAB131 is more in depth with more problem-solving than MAB180 as it takes into account the extra content, experience and mathematical

confidence these students bring from Maths C in school. This streaming continues into the second semester of first year.

This paper considers those students who entered engineering at QUT in Semester 1 2002 and explores what has happened to them in their course since then. Students who are in a regular full time degree program should have completed their engineering degree by the end 2005. Students in a full time double degree program should have finished at the end of 2006. Some students decide in the first semester that engineering was not the most appropriate course choice for them and discontinue the program early. Others discontinue at later stages of the program, sometimes changing to another degree, while some students change to another type of engineering speciality. Part-time study is also permitted, and a number of students do at least part of their degree part-time due to a variety of reasons, including obtaining course-related work or family reasons. Such students do not therefore complete the course in four or five years. Because the analysis of this paper is a forward analysis (that is, following students forward from their commencement in 2002), it cannot take into account the students who changed from another degree or another university into an engineering program at QUT and who received credit for the first engineering maths unit based on their prior studies. (It is not uncommon for students to change from another university to QUT.)

## 2. The QUT Maths Access Centre (QUTMAC)

It was in 2002 that the Queensland University of Technology's Maths Access Centre (QUTMAC) commenced operation, see [4]. With a modest annual budget and extensive in-kind support from the School of Mathematical Sciences, the Centre has had far-reaching impact on student learning at QUT. Despite its youth and limited budget it is rapidly becoming a leading model of university-wide support in mathematics and statistics learning, helping undergraduates, postgraduates and staff across disciplines, and with established UK linkages.

Engineering courses are highly vulnerable to diversities or weaknesses in mathematics backgrounds because these courses require the widest variety of both specific and generic mathematical skills as quickly as possible. Mathematical thinking is the lifeblood of engineering, feeding its full range of skills, from the most creative to the most technological and theoretical. This causes a raft of difficulties for engineering teaching staff and curriculum designers. Many engineers, both academic and professional, are aware of the many roles of mathematical thinking in engineering, but for others, mathematical thinking has become so much a part of them that they have forgotten how they acquired it. The increasing diversity of mathematical abilities and backgrounds amongst engineering students, and the mathematical needs of modern engineering within course structures that tend to have the least flexibility where flexibility is most needed (namely, in first year), is a formidable combination of challenges for all staff involved in teaching and supporting engineering students. The QUTMAC has a deep understanding of all these challenges for engineering students and staff, and its data and analysis provide much valuable information, see [5] and [6].

Operational objectives of the Centre include:

a. support for skills and understanding, and in developing student confidence and lifelong learning across all mathematics and statistics service and core units
b. provision and fostering of an environment of partnership and openness in mathematical learning – within and between all student cohorts and staff

c. development of diagnostic testing and associated support strategies in any unit in which student difficulties in basic mathematics are causing problems, or have the potential to cause significant difficulties in later units
d. consultation, collaboration, advice and support for staff on learning and teaching matters involving quantitative skills
e. data collection and analysis on quantitative aspects of learning and teaching
f. pursuit of scholarship of teaching in tertiary learning that involves mathematical and statistical thinking across disciplines.

Components of the QUTMAC's program include:

a. weekly student-driven, unit-specific support sessions
b. a drop-in centre/student work area with extensive specific-purpose paper resources, wireless facilities, and a schedule of duty tutors
c. sessions on mathematical problem-tackling, including test/exam preparation
d. roles in mentored tutor training
e. development and implementation of diagnostic tests and associated student support in units in Science, Nursing, Engineering and Information Technology courses
f. data analysis of student performance and progression with respect to a range of possible predictors, and associated advice and strategies for staff and management
g. statistical thinking symposia for postgraduate students across all disciplines
h. development and implementation of data collection and analysis strategies for monitoring and evaluation of QUTMAC programs

The components that are used in analysis in this paper are those aspects that relate to engineering programs, that is the weekly support session and the exam preparation workshops .

**Weekly support sessions:** These are unit-specific, optional but scheduled sessions driven by student questions and requests, that focus on building students' confidence, self-help and study skills, and on tackling their holes and weaknesses in the underpinning mathematical concepts and skills needed for current and future learning. The QUTMAC does not provide units for students without the official assumed knowledge for their program of study because such prerequisites are available in units in which students can enrol. The purpose of the QUTMAC's support sessions is to help students who officially have the prerequisite background for their program. There are many reasons why students with the official assumed background find that their skills and operational knowledge are insufficient; these range from inadequate identification of skills and knowledge that are assumed to the many problems and challenges described in the introductory overview.

Although they are optional, the support sessions are scheduled to ensure that students' timetables allow their inclusion in appropriate programs of study. The nature of the sessions varies from unit to unit, and the sessions adapt in response to students' needs. The principles, however, are always the same - to provide a supportive, friendly, open environment in which no question or difficulty is too small, and which provides the utmost encouragement for students to own their learning and to turn weaknesses into opportunities to learn and to grow.

Up to three weekly support sessions are provided in each of the first year engineering mathematics units.

**Exam preparation workshops:** These are specific to first year Engineering Mathematics units and a small number of other units. They are held at key stages during the semester and aim to help students develop study and problem-solving skills. For engineering students, similarly to the support sessions, these have been held

since 2002 and have become increasingly popular, often requiring extra repeated sessions to meet demand. These typically would last for one day with 3 two hour sessions. Again these are student driven with the tutor responding to the needs of the students.

## 3 Data and analysis

### 3.1 Data from student records

The information in this section was partially provided by QUT Student Records System 'Callista' by the Senior Client Services Officer, Student Systems, and partially obtained through research. The central records indicate all students that had discontinued the course including those who may have changed courses within the engineering faculty. Research was done on the individual records of all students who were recorded as discontinued to determine whether they had changed to other courses within engineering, or changed to other courses within the university, or had left the university. Table 1 provides a summary of these findings including the number of discontinued students who did the engineering mathematics units MAB180 or MAB131 and also indicates students that discontinued during the mathematics units.

Table 1
Destination of discontinued students

| Table 1: Destination of discontinued students | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **MAB180** | | | **MAB131** | | | **All Eng. Students** |
| | Completed MAB180 | Discont-inued MAB180 | Total Discont-inued | Completed MAB131 | Discont-inued MAB131 | Total Discont-inued | Discont-inued |
| Left QUT | 77 | 48 | 125 | 63 | 22 | 85 | 210 |
| Diff Eng course | 12 | 2 | 14 | 18 | 2 | 20 | 34 |
| Diff Course QUT | 23 | 10 | 33[m1] | 23 | 2 | 25 | 58 |
| total | 112 | 60 | 172 | 104 | 26 | 130 | 302 |

Some students left QUT completely (Left QUT) , others have changed to a different strand within engineering (Diff Eng course) , while others have remained at QUT but changed to a non-engineering degree (Diff Course QUT) (11. The discontinued MAB180, MAB131 columns indicate students who officially left the engineering course and their Engineering Mathematics unit before the end of the semester 1 2002.

Taking into account the above information, Table 2 provides data on the number of students entering the engineering degree program and the numbers and percentages of those who completed or discontinued by the end of 2006. About 15% of students are still enrolled and this includes those who are part time, or have failed some units and need to repeat them. At the start of the course only about 10% enrol as part time and during the course an unknown number change to part time and some temporarily discontinue and return later.

It is of concern to note that nearly 50% of students discontinue their engineering program, but this appears to compare favourably with the 20% retention rate quoted for the UK [1]. The rate of attrition from engineering programs is higher for those who did MAB180 (58%) while for those who did MAB131 it is close to 42%. It is also of interest that for those who did MAB180, the rates of completion within 5 years for both single and double degrees are the same (about 23%), while for MAB131, the rates are 37% (single degree) and 30% (double degree). This provides further evidence that those students who enter with both Maths B and Maths C have a greater chance of not only completing their engineering course, but also doing so in the minimum time.

Table 2.
Enrolments and Completion or discontinuation of course[m2]

| Table 2. Enrolments and Completion or discontinuation of course | | | | | |
|---|---|---|---|---|---|
| **Unit** | **Enrolled 2002** | **Completed before the end of 2006** | **% completed their course by the end of 2006** | **Discontinued by end of 2006** | **% discontinued** |
| MAB180 (single degree) | 254 | 58 | 22.83% | 148 | 58.27% |
| MAB180 (double degree) | 22 | 5 | 22.73% | 8 | 36.36% |
| MAB180 (all) | 276 | 63 | 22.83% | 156 | 56.52% |
| MAB131 (single degree) | 215 | 80 | 37.21% | 92 | 42.79% |
| MAB131 (double degree) | 46 | 14 | 30.43% | 18 | 39.13% |
| MAB131 (all) | 261 | 94 | 36.02% | 110 | 42.15% |
| All Engineering | 537 | 157 | 29.24% | 266 | 49.53% |

It is of interest to know if students' grades in their first attempt at their first Engineering Mathematics unit have some affect on their completion or discontinuation from an engineering program. Table 3 provides information on engineering grades and completion and discontinuation from an engineering program by the end of 2006. The scale of grade is 1 to 7 with 7 being the highest and greater than 4 a pass, 3 is a conceded pass. A grade of W or K indicates either a withdrawal from or incompletion of the unit.

Table 3
By grade in mathematics unit completed/discontinued
(Includes double degree)

| Table 3: By grade in mathematics unit completed/discontinued (Includes double degree) | | | | | | |
|---|---|---|---|---|---|---|
| Grade | MAB180 2002 | | | MAB131 2002 | | |
| | enrolled | % Comp | % Discont | enrolled | % Comp | % Discont |
| W,K | 68 | 4.41% | 92.65% | 43 | 20.93% | 55.81% |
| 1 | 14 | 0.00% | 100.00% | 11 | 0.00% | 81.82% |
| 2 | 21 | 0.00% | 76.19% | 30 | 3.33% | 93.33% |
| 3 | 13 | 7.69% | 84.62% | 25 | 32.00% | 48.00% |
| 4 | 53 | 15.09% | 58.49% | 43 | 27.91% | 53.49% |
| 5 | 39 | 41.03% | 38.46% | 53 | 41.51% | 37.74% |
| 6 | 39 | 46.15% | 33.33% | 25 | 76.00% | 20.00% |
| 7 | 29 | 58.62% | 31.03% | 31 | 74.19% | 16.13% |
| all | 276 | 22.83% | 56.52% | 261 | 36.02% | 42.15%% |

Of the students who received a grade of 7, the percentage of MAB180 who discontinued is nearly twice that of MAB131. If a student does not pass MAB180 it is unlikely that they will complete the course within 5

years, and most of them will discontinue the course. It is only slightly better for those students who fail MAB131.

### *3.2 Data from the QUTMAC*

This section investigates the progression of those students who used the QUTMAC programs as compared to the total cohort described above. Use of the QUTMAC here is considered only for participation in support sessions and/or exam workshops; use of the dropin component of the QUTMAC program is not taken into account.

**MAB180**
Seventy engineering students in MAB180 used at least one component of the QUTMAC programs in semester 1 2002. Of these 70, 32 used the maths support sessions and 63 used the exam workshops, and 25 used both. That is, 7 students who used the support session never used the Exam workshops and 38 students who came to the exam workshops never used the support sessions. At the end of 2006, 30 of these 70 students had completed their engineering course, 6 were still enrolled, 18 have left QUT, 6 transferred to other QUT courses, and 3 transferred to other Engineering courses.

**MAB131**
One hundred and one engineering students used at least one component of the MAC program. Of these 101 students 88 used the maths support sessions, 95 used the exam workshops and 82 used both. That is, 6 students who used the support session never used the Exam workshops and 13 students who came to the exam workshops never used the support sessions. Nine of the 101 students are still enrolled at the end of 2006, and 55 had completed their engineering course. 14 have left QUT, 5 transferred to other QUT courses, 11 transferred to other Engineering courses.
Table 4 summarises the above information which can be compared with the data in Table 2.

**Table 4**
**Summary of Engineering students that used the MAC programs. As before, omit the numbers columns apart from the total & fill in all the %'s so that the rows add to 100%**

| Table 4: Summary of Engineering students that used the MAC programs. | | | | | |
|---|---|---|---|---|---|
| **Unit** | **No of MAC users** | **Completed before the end of 2006** | **% completed** | **Discontinued by end of 2006** | **% discontinued** |
| MAB180 | 70 | 30 | 42.86% | 24 | 34.29% |
| MAB131 | 101 | 55 | 54.46% | 19 | 18.81% |
| All Engineering | 171 | 85 | 49.71% | 43 | 25.15% |

### *2.2 Discussion*

In comparing Tables 2 and 4 we see that students that use the QUTMAC either in the support sessions or the exam workshops are nearly twice as likely to complete the course as the whole cohort and half as likely to discontinue engineering. Because the QUTMAC programs are voluntary, the students self-select. That is they knew that they had gaps in their mathematical knowledge and skills and made an effort to use the QUTMAC to fill those gaps. Such students are more likely to complete the course than those who had gaps and could not see them and/or did not bother to use the resources that were available to them.

## 3. Conclusion

Students who commence engineering come with a range of prior learning experiences that impact on the type of mathematics program that they can most appropriately engage in at tertiary level. Those who come with only the core mathematics (Maths B) or equivalent from high school are directed to MAB180. These students have lower completion rates and higher discontinuation rates than those students who come with the advanced mathematics (Math B&C) and enter into MAB131. Students who choose to do the optional programs offered by the QUTMAC have improved completion rates and less discontinuation than the cohort as a whole regardless of mathematics unit studied.

## References

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