ARE SCIENCE STUDENTS READY FOR UNIVERSITY MATHEMATICS?

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ABSTRACT

At UTS students in science courses often struggle with the first year first semester mathematics subject. This year we requested all commencing science students take a Readiness Survey so that we could advise them of suitable pathways for the mathematics subjects in their degree. One such pathway includes taking a one-semester subject of introductory calculus before the regular mathematics subject. This paper reports on the practicalities of running such a test before semester starts, and the pathways taken up with varying levels of success by Science students. Insights are offered from a parallel survey and pathway used for some years now with Engineering students in the same institution.

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INTRODUCTION

In the post -Bradley era (Bradley, Noonen, Nugent, & Scales, 2008), where universities are required to respond by continuing to widen access to tertiary education to non-traditional students, there is a heightened responsibility to provide educational experiences that recognise and cater to diverse student intakes. This responsibility is further heightened by the current attention by tertiary institutions (Universities Australia, 2012) and the Australian Government (Office of the Chief Scientist, 2012) given to problems of improving the uptake and success of students in the study of Science, Technology, Engineering and Mathematics (STEM).. One of the problems central to the teaching of undergraduate mathematics to first year students is the level of preparation undertaken at high school and elsewhere (Carmody, Godfrey, & Wood, 2006). A lack of adequate mathematical knowledge and computational proficiency is a problem world-wide (Heck & van Gastel, 2006). This study examines the impact of students undertaking two unit General Mathematics as preparation for undergraduate Science degrees at the University of Technology, Sydney (UTS). In this context, it also examines the impact of non-compulsory diagnostic testing on this group of students.

BACKGROUND

Mathematical Modelling for Science (MMS) is a first year, first semester, service subject for Physics, Chemistry and Forensic Science students at the University of Technology, Sydney. The majority of students undertaking the subject have studied two units of Mathematics (including General Mathematics) at high school with ATARs in excess of 72. (The distribution of ATARs for the Autumn 2013 cohort can be seen in Figure 1.) A small number of students transfer from other degrees into Science, or have taken an alternative pathway to university. MMS has exhibited many of the traits of first year service subjects including high failure rates and high attrition as well as providing poor preparedness for later subjects. These aspects motivated an initiative to address one of the potential root causes of high failure rates, the degree of preparedness of recent school leavers for studying first year mathematics. The initiative was to formalise (to a degree) diagnostic testing of first-year Science undergraduates. The diagnostic test is used to identify students who are at risk of failure and to recommend remediation and support programs.

Diagnostic testing of mathematical knowledge and skills of Engineering students has a long history at UTS (and in the literature, Armstrong and Croft (1999), for example), but the same cannot be said about the diagnostic testing of Science students in UTS first-year mathematics subjects. Prior to 2013, a diagnostic test had been offered in Blackboard™ but the test was optional, and the take up rate was poor. For the first time in 2013, Science students were recommended to undertake an online diagnostic test to assess their readiness for mathematical study immediately following enrolment in the subject. Students failing the test were recommended to enroll in Foundation

Mathematics and attempt MMS at a later date. Foundation Mathematics is an enabling subject, which may also be taken for credit in most courses. The subject aims to increase a student's chance of success at university by developing essential mathematical knowledge and skills in the areas of algebra, functions, calculus and probability.

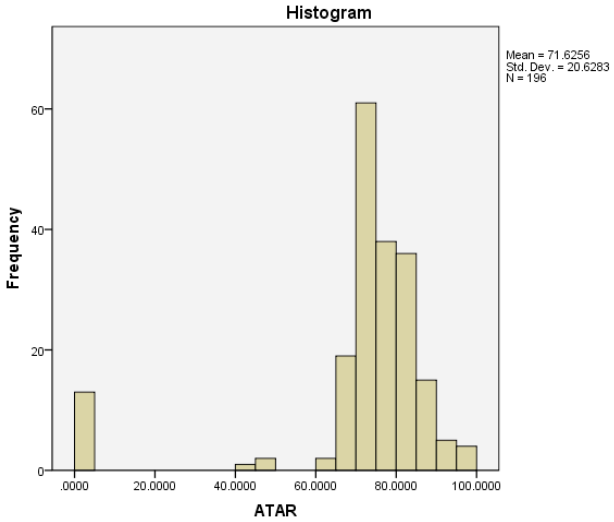

Figure 1: Distribution of ATARs for Autumn 2013 cohort of MMS.

IMPLEMENTING DIAGNOSTIC TESTING

The Diagnostic Test (Readiness Survey) used at UTS has been developed over many years to reflect a range of essential concepts and skills typically taught in secondary school mathematics courses that include calculus. There are twenty multiple choice questions, and besides the usual distractors students are offered the response "I have not seen this before" to discourage guessing. Over the years we have found that the easiest questions involve choosing the correct binomial factors of a quadratic expression, and finding the vertical intercept for a line whose equation is given in general form. The most difficult questions are choosing the correct value for an angle given its sine and cosine ratios, and changing the subject of an equation involving algebraic fractions:

4. If a and b are real positive numbers, then the value of x in the equation

$$\frac{1}{x} - \frac{1}{a} = \frac{1}{b}$$

is given by:

(a) $x = \dfrac{ab}{b+a}$ (c) $x = a - b$

(b) $x = \dfrac{a+b}{ab}$ (d) $x = a + b$

Figure 2: An example of the questions on the diagnostic test

The delivery of the test has evolved from pen and paper to online. Recently we have been using the capacity of the new Mathematics Study Centre website, http://www.mssc.uts.edu.au/, being built with funding from our Equity and Diversity unit. This platform incorporates a booking system so that students, once enrolled at UTS, can be sent an email inviting them to complete two practice tests online, and then book a time to come to campus to complete the actual test under supervision. The test is completed within 50 minutes and many students finish well within that time. Calculators are not permitted.

OUR EXPERIENCES WITH DIAGNOSTIC TESTING

As noted earlier, students from MMS are recommended to take the Readiness Survey. This is particularly emphasised to students who have not undertaken calculus at high school, or it has been

some time since they attended high school. Fifty-four students of a possible two-hundred took the diagnostic test, many electing to transfer to Foundation Mathematics after receiving their results. In this section we discuss the mathematical performance of the first year students in the diagnostic test and the tests taken during the course of the semester in MMS. In particular, we are interested in the performance of students who undertook General Mathematics at high school.

THE DIAGNOSTIC TEST RESULTS

The distribution (Figure 3) is not too dissimilar to the distribution of ATARs but the histogram masks the underlying performance of the students who have studied General Mathematics (Figure 4).

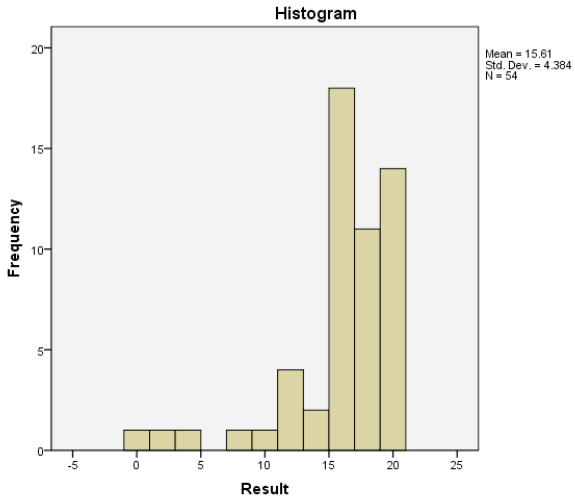

Figure 3: Distribution of Diagnostic Test results for Autumn 2013 cohort

In the box plot below, a "Math" of "1" indicates Extension 2 Mathematics, a "2" indicates Extension 1, a "3" indicates 2 unit Mathematics, a "4" indicates General Mathematics, and categories 10 and 11 indicate the highest level of maths studied was in Year 10.

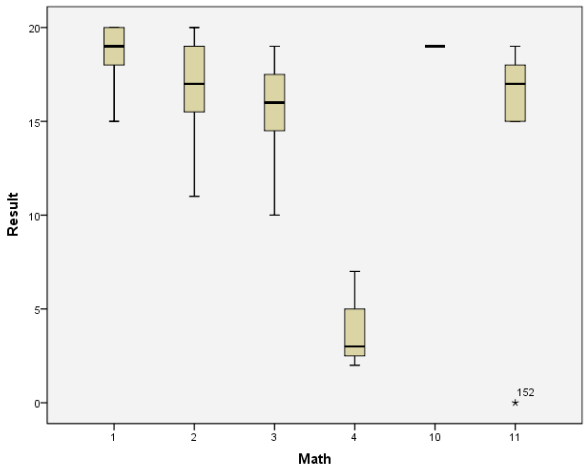

Figure 4: Box plot of the relationship between performance on the diagnostic test and the nature of Mathematics study undertaken at high school

It can be seen that performance on the diagnostic test is strongest by students who have undertaken four units of Mathematics, followed by three units, followed by two units. Performance by students who have undertaken two units of General Mathematics ("4") is noticeably poorer than these other categories and suggests that these students are not adequately prepared for tertiary mathematics study. This suggestion is borne out by performance in the class tests, as can be seen in Figure 5 – where we see a similar pattern in performance.

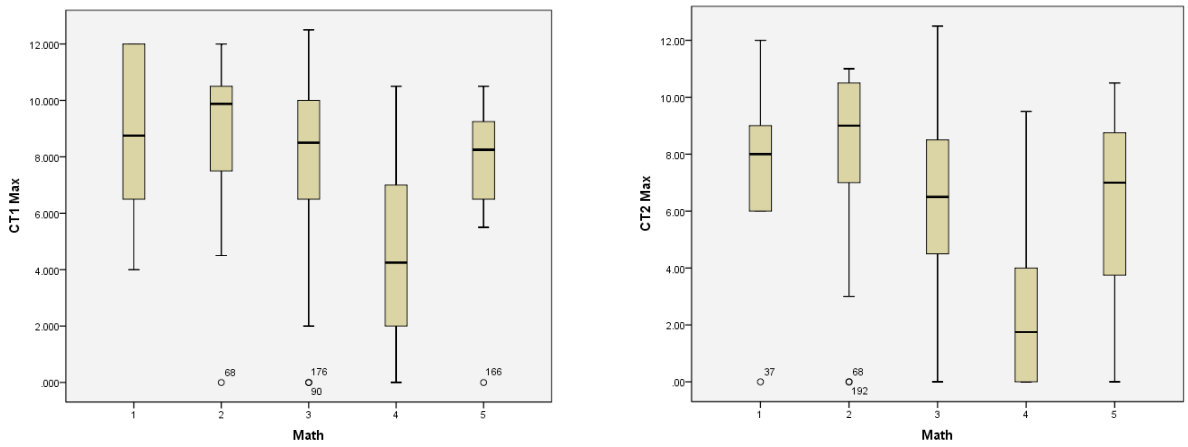

Figure 5: Performance in the class tests based on level of Mathematics studied at high school

It is anticipated that the final results for the subject will show a similar distribution. Hence, while students may have decided to take General Mathematics in an effort to maximise their ATAR, their subject performance suffers through inadequate preparation. (An analysis of the performance of students in MMS who enrolled in Foundation Mathematics is yet to be undertaken.)

FUTURE DEVELOPMENTS

The test has been used with beginning Engineering students for many years, most recently as part of the enrolment process, with advice given to those scoring below 50% in the test that they would be better served by starting with Foundation Mathematics. Since 2008, with the backing of the Faculty of Engineering, students failing the diagnostic test have been *required* to take Foundation Mathematics in their first semester, then go on to the regular initial subject Mathematical Modelling 1. Students on this path can catch up by taking the second semester maths subject over the summer. Given the performance of students who studied General Mathematics, it is anticipated that this approach will also be adopted for Science students undertaking mathematics subjects in their first year.

CONCLUSION

Poor performance by students of General Mathematics (approximately 10% of the cohort) cannot be ignored. In addition to the flow-on effects of higher failure rates, and higher attrition, there are the added personal costs of reduced levels of confidence, non-standard programs and negative impressions of mathematics. The use of diagnostic testing and remedial action are one means by which poor preparedness can be ameliorated.

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