AAEE 2012 CONFERENCE
Melbourne, Australia
www.aaee.com.au/conferences/2012/

Prototype of an Intervention Strategy with a focus on mathematics support for first year Civil Engineering students "at risk"

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BACKGROUND
Retention strategies are vital for universities to compete successfully in a deregulated market, as new cohorts of first year Engineering students not only struggle with the new environments, but also may be less prepared in prerequisite areas such as mathematics. In this environment, it is now each university's responsibility towards enrolled students to provide support structures to engage them and to give them a chance to successfully complete their degree.

The Faculty of Engineering & Industrial Sciences at Swinburne University of Technology has experienced the second highest growth rate across all first year Engineering enrolments in Australia this year. To retain these students, an Engagement and Retention strategy is being developed with academic focus on mathematics support. This preliminary study includes an intake of Civil Engineering students enrolled in the first year first semester linear Algebra and Calculus Engineering mathematics subject.

PURPOSE
We report on preliminary outcomes of our investigation into how effective the current retention strategy is, to inform a new Intervention Strategy. We ask the questions: *How do we identify students at risk?* and *Are students who should be, using the services we are offering?*

DESIGN/METHOD
Data available is the number of student visits of the dedicated Mathematics Help centre (MASH), use of online MathsCasts videos created specifically for this cohort of students, and records of individual appointments to assist students to manage their study plan. This data is analysed and matched with the students' scores on major assessment items throughout the semester to find out how students have interacted with available academic support services and what impact this interaction has had on student performance and retention.

RESULTS
As we expected, while the support services are used by many students successfully, others do not seek help when they should. Students who are failing are not engaging sufficiently with the available support. These students appear to be entering the university in the lower range of entry scores, they come from alternative pathways, or are repeating the subject. We suggest criteria to identify students at risk, and the prototype of the new Intervention Strategy.

CONCLUSIONS
To be successful an Intervention Strategy needs to be implemented in the students first semester at critical points in the curriculum to ensure maximum benefit to the student. The proposed strategy is at conceptual stage and will be trialled and enhanced in a future semester.

KEYWORDS
Mathematics, first year, engagement, retention, support.

Introduction

The deregulated Australian higher education market, established following the Bradley Review (Bradley, 2008) is posing challenges and opportunities for universities. While the Government expected an additional 50,000 students to commence university study between 2009 and 2013, universities will in turn potentially produce 217,000 additional graduates by 2025 (DEEWR, 2009). A significant proportion of these additional students will come from low socio-economic status backgrounds and many students will be less prepared for tertiary learning environments. In addition, recent news articles report that universities have reduced their entry requirements, admitting students who, in the past, may not have qualified for university education and these students will require additional support to succeed (Penn-Edwards and Donnison, 2011).

Universities have long recognized the need to support students in their mathematics learning. To address this need, many Australian universities have enabling and bridging programs as well as local mathematics and statistics support centres where students may gain assistance (MacGillivray, 2008). While Nelson, Smith and Clarke (2010) acknowledge the importance of heightened support for students transitioning into university, additional retention strategies have been employed, for example appointments of academic advisors to help navigate the transition to university (Stephenson 2012). As part of these retention strategies, students need to be encouraged to become actively involved in their learning, which means attendance and contribution in classes, but also on-time completion of assessment items (Stephenson, 2012). It has been argued that students who actively participate in their learning attain better results and will achieve deeper levels of learning (Prince, 2004). We refer to the large body of literature discussing transition to university and the first year experience (e.g., Pitkethyl and Prosser, 2001; Krause, Hartley, James and McInnis, 2005).

At Swinburne University of Technology, student numbers in the Engineering Bachelor degrees have grown significantly over the last few years (at an annual growth rate of around 25%, internal report). To cater for these increased student numbers, the Faculty of Engineering and Industrial Sciences is investing in initiatives to improve engagement and retention:

- Academic support in Engineering mathematics in the form of enhanced services offered by the Mathematics and Statistics Help (MASH) Centre; and
- Social and study management support to ease the transition to university in the form of activities implemented by an engagement and retention coordinator.
- In addition, students who are identified as “at risk” are contacted by a company specialising in student retention and are referred to appropriate support services.

While it appears from aggregate attendance records that students are making extensive use of the services of the MASH Centre and are taking advantage of peer study groups and one-to-one sessions with the engagement and retention coordinator, more in-depth research is needed to understand if these services are indeed used effectively, particularly by low performing students who should be seeking support. It is also unclear if students identified as “at risk” and who were contacted indeed include all students that should be contacted. The ultimate aim of this study is to develop a new Intervention Strategy that will actively engage with students at risk as early as possible and suggest support options. In this paper, we ask the questions: *How do we identify students at risk?* and *Are students who should be, using the services we are offering?* We will address these questions and then present the first prototype of the new Intervention Strategy.

This preliminary study focuses on an intake of Civil Engineering students and follows their journey through their first year first semester Linear Algebra and Calculus mathematics

subject in semester 1, 2012. While this preliminary study is looking at a small group of students over just one semester, it is the first step in a much larger investigation into how to increase retention for all first and second year mathematics units, which may in the future also be extended to units such as physics (covering energy and motion), and engineering units, to allow for a complete picture of an Engineering student's transition into university.

This paper is of interest to readers who are considering retention strategies that include mathematics academic support, as well as social and study management support for first year Engineering students.

Support Services

Academic support in mathematics is provided in the MASH Centre, a collaborative "drop-in" learning space staffed with tutors who assist when needed, on a one-on-one basis or in a group. Furthermore, sessions outside the normal opening hours focus on particular subjects. Recently, the MASH Centre has moved into a larger space and more tutors have been employed. In addition, MathsCasts (Loch, Croft and Gill, 2012; Loch, Fitzmaurice and Croft, in 2012), narrated screen video recordings of a tutor's explanation of a mathematical concept, are made available via the University's learning management system on most topics covered in first year mathematics subjects. The MathsCasts produced at Swinburne are recorded by tutors working in the MASH Centre, on topics students have specifically asked for help on.

Social and study management support includes one-on-one appointments with the engagement and retention coordinator to set up a study plan, to link into resources such as a mentor program or counselling if social issues were affecting a student, or to provide guidance on how to access academic support services in mathematics including peer-facilitated study groups.

Students are made aware of the available support services during presentations in orientation week, and then again regularly in the following weeks by lecturers and tutors in class but also via email notifications and posters.

The current engagement and Retention Strategy for Engineering Mathematics 1

Engineering Mathematics 1 is the first mathematics unit most engineering students take at Swinburne. It covers a traditional single-variable Calculus (functions and graphs, differentiation, integration) and Linear Algebra (vectors) curriculum. Assessment consists of weekly assignments, two tests (weeks 6 and 10) and a final exam.

Students considered to be 'at risk' are identified and managed with the following strategies:

1) Students who apply for withdrawal from their course or for leave of absence are encouraged to attend an interview with the retention coordinator. If it appears that they are feeling overwhelmed or unsure about their decision, support options are discussed, including reduction of study load until the student has found a balance in their studies.
2) Students identified as 'at risk' by the unit coordinator based on a Test 1 performance of less than 50% are contacted via email in week 7 (out of 12 teaching weeks), listing support services and offering an individual appointment with the engagement and retention coordinator to set up a new study plan.
3) An external company specialising in student retention has been engaged to identify students 'at risk' early in the semester based on selective demographic criteria. Students are contacted by phone by this company and specific support services are suggested as needed.

Evaluation method

For the cohort of Civil Engineering students who commenced university study in semester 1, 2012, we considered the following data:

- Student visits to the MASH Centre tracked as part of the normal operation of the centre;
- Access to MathsCasts tracked through the learning management system. For the purposes of this study, we look at the number of clicks on six folders containing videos for each study module, not clicks on individual videos. Note that each folder can contain a dozen or more videos;
- The record of one-on-one student visits to seek advice and support;
- The record of referrals by the retention company;
- Individual student performance in tests and the final exam, total mark and resulting grade;
- If available: University entry score (ATAR) and high school mathematics score (Maths Methods). Note that students with Maths Methods score all have an ATAR score, but some students with an ATAR score may not have a Maths Methods score; and
- Previous marks in Engineering Mathematics 1 if a student has attempted before.

We look at patterns emerging and correlation between previous performance and grade, in combination with access of support services to try to identify which students may be at risk, and who has used what types of support.

Results

Are all students who should be, using the services we are offering?

With the range of services available, students can select what suits their purposes best: watching the video explanations from a tutor, asking a tutor in person, attending subject-specific sessions or seeking individual appointments with the engagement and retention coordinator. In this section, we focus on students who failed and we investigate in how far they have accessed the services. Tables 1 and 2 show a summary of the data for S1 2012 by grade achieved. Grades range from N (fail, <50%), to P (Pass, 50-65%), C (Credit, 65-75%), D (Distinction, 75-85%) and HD (High Distinction, >=85%). ATAR and Maths Methods scores are not available for students who entered via alternative pathways. The number of students on which each mean is based is listed in brackets.

Out of the 77 Civil Engineering students enrolled in Mathematics 1, 16 failed (grade of N). Only four out of these visited the MASH Centre – two just once in the semester, and the other two around once a week. Out of these same 16 students, six did not watch any MathsCasts. Five of these six also did not seek help from the MASH Centre, and effectively did not access any academic support services. Out of these five students, three missed at least one major assessment item (i.e. a test or the final exam). On the other hand, we were surprised to find clear outliers with two students accessing MathsCasts excessively (146 and 305 clicks). One of these students also visited the MASH Centre 13 times while the other did not at all. This indicates that these two students studied hard to understand the material and engaged with at least one form of support, however despite most likely taking a considerable time to watch, the videos were not sufficient to achieve a passing grade. These two students should have been identified early in the semester and directed at other forms of support, for example an individual consultation with the engagement and retention officer to produce a study plan.

Table 1: Student previous performance by grade

	# students	Mean ATAR (# students with ATAR)	Maths Methods (# students)	Range of Maths Methods scores
HD >=85	11	87.9 (7)	41 (4)	38-44
D 75-85	13	80.9 (8)	38 (6)	33-42
C 65-75	16	80.1 (12)	36.1 (8)	34-41
P 50-65	21	78.7 (17)	34.5 (16)	30-37
N <50	16	77.1 (8)	33.6 (8)	31-38
ALL	77	80.3 (51)	35.8 (42)	30-44

Table 2: Student access of support services by grade

	# students	# students visiting MASH for maths	Mean MASH visits	# students who accessed MathsCasts	Mean # of times accessed folders (outliers)	Contacted by retention company	Individual appointments with retention coordinator
HD >=85	11	3	1.3	8	36	3	1
D 75-85	13	4	10.3	10	31	3	3
C 65-75	16	5	2.6	11 (10)	31 (19 w/o 148)	2	4
P 50-65	21	7	3.1	18 (17)	34 (28 w/o 135)	1	5
N <50	16	4	6	10 (8)	60 (18 w/o 146, 305)	4	4
ALL	77	22	8.6	57 (53)	37 (27 w/o)	13	17

The data also revealed that students who achieved a HD grade accessed support anonymously via MathsCasts rather than attending the MASH Centre. Further investigation should ensue to assist us to understand why high achieving students appear to prefer MathsCasts.

Looking at all students, it appears that students who received a HD, D or P on average watched more videos than the C or N students (after outliers are removed, see figures in brackets in the third last column of Table 2). This indicates that the high performing students are doing well because they have the skills to select appropriate services to support their learning. On the other hand, it may indicate that low performing students who used the MathsCasts well passed (P) because of this.

Given that S1 2012 was the first semester that a complete set of MathsCasts had been made available for Engineering Mathematics 1, we were positively surprised to see how many times MathsCasts had been accessed: on average 27 times by 73% of students (excluding all outliers).

Out of the 17 students who had been contacted and sought individual appointments with the engagement and retention coordinator, only four did not pass. During these appointments, it was found that most students were not aware of the MathsCasts and a small percentage did not know where the MASH Centre was located. This confirmed that contacting students at critical points during the semester is vital to ensure that they are able to access the support services available in a timely way to avoid disengagement.

In summary, it appears that many of the students who failed did not engage with the support services that were made available, for reasons that remain to be investigated.

Identification of students at risk

The current retention and engagement strategy identified 13 students on the basis of demographic factors such as combination of international students, first in the family to attend university, and living far away from campus. These were consequently contacted by the retention company to create awareness of available support. When examining the performance of these students, we found that their grades covered the whole range: from failing grade to high distinction. However, looking instead at the 16 students who failed, only four of these had been identified as at risk and contacted at the start of semester. A further eight had been emailed following poor Test 1 results. Four students had been missed. A cut off percentage for Test 1 of 63% to contact students would have contained all students who failed.

Given the importance of identifying students at risk early so intervention procedures can be implemented, we looked at information on students' previous performance available before the start of semester: Entry scores (ATAR), and high school mathematics scores (Maths Methods). Linear regression analysis showed that ATAR score (R^2=0.33 and $p<0.01$) and Maths Methods performance (R^2= 0.39 and $p<0.01$) are each correlated to the final mark. However, ATAR and Maths Methods scores are not correlated and neither is access of the support services to the final mark.

Indeed, each student who failed had a Maths Methods score of 38 or under. Interestingly for students who achieved a Credit result, all but 2 students had a study score of 37 or below with only 2 students scoring above 38 and very few students accessing the MathsCasts or seeking assistance in the MASH Centre.

Another interesting result is that the mean final mark for students who have a Maths Methods score is 60.8%, while the overall mean is 65% and students with no ATAR scored 67% on average. From this we conclude that students who have recently completed Mathematics Methods at high school in Victoria are less engaged in their learning than international and mature age students.

Finally, looking at prior attempts, three of the 77 students had failed the subject in a previous semester. All three failed again. Previous poor performance in this subject is clearly an indicator for future failure. Of the two students who had transitioned into first year via tertiary preparation studies, one failed and the other achieved a P grade.

Prototype of the new Intervention Strategy

We now introduce the first prototype of the new Intervention Strategy, which will be adjusted following analysis of existing data on other semesters and other subjects, and then trialled in semester 1, 2013. It consists of two parts – the identification of at risk students, and the intervention implemented to suppport these students.

Identification of "at risk" students

Based on our findings, we are proposing the following criteria to identify a student at risk during three phases of their first semester of study:

Phase 1 (before semester starts):

a) students who have failed Engineering Mathematics 1 before
b) students who have no university entry score (mature age or international background)
c) students who have come via alternative pathways
d) students with a Maths Methods score of 37 or below
e) Students with an ATAR score of under 80

Phase 2 (in week 3, when the deadlines for the first two assignments have passed)

a) students who have accessed MathsCasts excessively

b) students who are identified in the MASH Centre by tutors as lagging behind

c) students who have achieved less than 50% in the first two assignments

Phase 3 (in week 7, after Test 1 results are available)

a) students who perform below 63% in Test 1.

The aim is to identify most of the students who failed by the end of S1 2012, whilst not including too many students who scored top grades. The cut off figures to identify students at risk will need to be looked at very carefully and combinations such as “60% in Test 1 and a Maths Methods score of less than 38” will need to be identified.

Intervention for at risk students

Students identified in Phase 1 will be contacted by the retention company and invited to a session in the MASH Centre with the retention coordinator and tutors during orientation week or in week 1 to discuss their attitudes towards mathematics, and how to build confidence. Regular sessions will be organised with these students to follow up on their progress.

Students identified in Phase 2 will be invited to a session held by a tutor in the MASH Centre. In this session, academic difficulties with mathematical content will be discussed and the tutor will work out a revision and study plan with every student. Follow up meetings will be scheduled as needed.

Students identified in Phase 3 will be invited to weekly small group catch up sessions in the MASH Centre, offered specifically for this unit, and held by a tutor in an interactive way.

Conclusions and future work

There is anecdotal evidence that students who achieve lower marks think that the top performing students do not need to seek help (Karabenick & Newman, 2006). However, we have observed that students who perform highly probably did so because they accessed available support services. Explaining this to all students early in the semester may be a good addition to the intervention strategy. While students pick the combination of services that suits them best, with everyone following an individual strategy, it appears that some of the weaker performers may benefit from guidance in the form of a study plan and help with selecting the support services they benefit most from.

The larger study we plan across all students undertaking an engineering mathematics subject will also look at the timing when students watch MathsCasts and visit the MASH Centre. We assume that there may be a correlation between lower exam marks and a lack of engagement with support services during test and exam preparation times. We will also look at the direct impact the one-on-one sessions with the retention and engagement coordinator have, and monitor student access of resources after they have received notification to warn of potential failure.

It is hoped that with this Intervention Strategy we will be able to identify early in the semester more of the students who would otherwise fail, and work actively with these students to increase their chances of passing. Since engaging with students at risk in a critical period is essential to retain these students (Penn-Edwards & Donnison, 2011), we have identified three such phases. There is discussion already about offering a refresher mathematics course before the start of the first semester to allow students to catch up before regular teaching commences.

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