Year 13 or first-year university - a holistic learning design that attempts to combine elements of secondary and tertiary learning and teaching

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Abstract: *For many years, Australian universities have been accepting students into their courses, including Science, with inadequate mathematical backgrounds. In addition to this lack of mathematical preparation, students are ill-prepared for the demands of independent learning as required by university courses. Thus many students are enrolling in university courses without basic numeracy skills and furthermore, they lack the ability to cope with the requirements of self-directed learning. This results in students being totally overwhelmed by their first few weeks experience at university which can result in significant 'drop-out' rates. This report describes a learning design used in the delivery of a first-year mathematics unit that attempts to remediate numeracy skills and develop the independent learning skills required by the 'traditional' university experience.*

Introduction

It is widely accepted that universities have been accepting students into their courses, including Science, with inadequate mathematical backgrounds (Broadbridge & Henderson, 2008; King, 2008; Rubinstein, 2009; Rylands & Coady, 2009). This has reached crisis level as reported in The Australian, June 3, 2009, 'Review into poor mathematics qualifications'

> The Group of Eight universities has launched a review into the declining state of mathematics at schools and universities, concerned they will have to make increasing numbers of students take additional catch-up courses to compensate for the low-level maths with which they are leaving school.

Universities are now under considerable pressure to provide catch-up courses according to Professor Gavin Brown, director of the Royal Institute of Australia, who in the same article, is quoted as saying

> Students are increasingly coming into university not being equipped to do the quantitative things they need to do. They eventually discover they need some of these skills and it is then hard to fit in the remedial teaching.

According to Pell and Croft (2008), students' lack of mathematical preparedness results in (for students) '… disillusionment, failure, withdrawal and loss of self-esteem [and] for staff there is increased pressure and lack of job satisfaction.' In trying to address this concern, our institution has responded by providing various support mechanisms for students who lack basic mathematical skills. These included diagnostic testing, 'catch-up' classes, additional tutorial sessions, 'PASS' (Peer Assisted Study Sessions) and a 'mathematics support centre' provided by the Student Learning Unit. However, these measures have been largely ad hoc, and did not target specifically the 'at risk' students. Pell and Croft (2008) take this further by citing the United Kingdom perspective on mathematics support centres, where anecdotal evidence indicates that

- students who most need the support, fail to access it;
- students who do access the support would have passed their mathematics units anyway;
- students who are borderline would most benefit as they need this extra support to ensure their success.

Poor mathematical skills are only part of the problem. Some students coming directly from secondary school to university, where self-directed learning is an expectation, experience extreme difficulties with this. Secondary school has not prepared them for self-directed learning despite the best efforts of their teachers. Also, anecdotal evidence at our institution indicates that many first-year students believe that turning up to classes is enough to 'pass'. This suggests that students are not engaged with their learning and view their learning of mathematics as 'something that is "done to them"' (Swan, 2005; p.3).

This theme is further explored by Lidbury (2008; p.1) where the intractable problem of 'student engagement and learning at university' is raised. Is a lack of engagement a part of the reason why interventions to address poor mathematics background do not produce the results we desire? Anecdotal evidence suggests that it is. A ten year study conducted by Krause, Hartley, James and McInnis (2005, p.87) found that

> An important indicator of engagement is time devoted to academic endeavours, including class attendance and time spent on campus.' The study also found that 'In addition to spending time in class and on campus, engagement is fostered through time spent with other students, with academics and with student support staff in the learning community.

However, this study revealed that students are spending fewer hours on campus (15.9 hours in 2004, down from 17.6 hours in 1994), while the percentage of students in paid employment has risen (47% in 1994 compared with 55% in 2004). Given these statistics, there are many challenges that tertiary institutions must face in order to provide a learning environment that both stimulates and supports first-year students.

The transition from school to university

Numerous studies have been conducted internationally over many years on the first-year student experience (for example, Raaheim & Wankowski, 1981; Hoyles, Newman & Noss, 2001; Macaro & Wingate, 2004; Krause, Hartley, James & McInnis, 2006). There appears to be general accord that many students experience stress in trying to adjust to the new learning environment. Farnill and Robertson (1991; p.197) as cited in Jones and Frydenberg (1998; p.4) state that "The first few weeks of tertiary study is a time of high vulnerability with many new demands, when old supports have been left behind and new ones not yet generated."

Secondary school often provides a nurturing environment for students where students receive constant encouragement and direction and have formed stable student-student and teacher-student relationships (Jones & Frydenberg, 1998). The university environment however, while providing the stimulus of a new beginning, does not necessarily provide the same supportive environment. In addition to this, students can experience a very different learning environment. According to Clark and Lovric (2008), the transition from school to university mathematics is characterised by changes in teaching and learning styles, the level of conceptual understanding required and exposure to and routine use of abstract concepts. Students must also learn effective time management skills and move to a more self-directed approach to learning.

After years of providing largely informal remedial activities for students who are ill-prepared mathematically, our institution introduced a unit that is trying to address some of these problems by taking a holistic approach to students learning. The main objectives of this unit are:

- to better engage students in the study of mathematics and its applications early in the session;
- to reduce students' frustration so that they will be able to cope with the rigors of tertiary study; and
- to provide opportunities for meaningful reflection on learning.

A description of this unit follows.

The unit - Mathematical Reasoning

The unit Mathematical Reasoning resulted from a project aimed at improving teaching and learning at our institution. It was developed in association with the Student Learning Centre, which offers many of the remedial mathematical courses. The first intake of students was in 2008. The unit is offered over 12 weeks, and attracts the same credit points as the majority of units at our institution. A student's grade is dependent upon the marks received.

Students who were enrolled in this unit were judged 'at risk' mathematically, as they scored less than 70% on a basic mathematics skills test. All students enrolled in 2008 were undertaking a business course that included a statistics unit. The high failure rate in this statistics unit was one of the driving forces in developing this unit. Informal conversations with students about why they found statistics (and mathematics) courses so difficult, highlighted a number of difficulties that included a lack of algebraic skills as well as some emotional complications that appeared to be brought on just by the 'thought' of mathematics. It was these concerns that prompted the development of the unit.

The holistic learning design of this unit was designed to incorporate four key elements:

- revision of basic arithmetical/mathematical skills;
- the relevance of mathematics to their university course;
- developing appropriate study skills for university;
- addressing mathematics anxiety/test phobia.

The mathematical content consists of six topics, four are 'core' – basic arithmetic, basic algebra, linear functions and graphs, and linear equations. The other two topics relate to the discipline the student cohort is studying. In 2008 and 2009, as the cohort was/is business oriented, the two topics were basic statistics and financial mathematics. In 2010, a science student cohort will be added. This cohort will study the four core topics as well as trigonometry and quadratic equations. All examples (where possible) are given in a business context and will include a science context in 2010. In the delivery of the content, current real-world examples are used as much as possible in an attempt to show students the relevance of mathematics to their discipline and their everyday lives.

Many students find that the study skills used at secondary school are not adequate for tertiary study (Haggis & Pouget, 2002). Minimalistic learning strategies based on rote memorisation of formulae and rules with little or no conceptual understanding are soon revealed as inadequate (Mann 2001). Students who use/resort to these approaches cite lack of time due to family, social and work commitments. Hence time management skills and activities are discussed in class in conjunction with strategies to overcome procrastination.

It is often said that "learning mathematics is not a spectator sport". Students need to be engaged with the learning process, if meaningful learning is to occur (Swan, 2005). Effective methods of studying mathematics are discussed after students have had the opportunity to determine their learning styles. Staff report that for some students, the realisation that their dislike of mathematics has resulted from study methods that were at odds with their learning style has helped to improve their attitude towards mathematics. The use of reflective journals has proved successful in altering attitudes towards mathematics (Coady & Rylands 2008). We have observed feelings of success begin to emerge as a student's marks in class tests improve over the session due to their taking responsibility for their learning and subsequent achievements.

Journal entries revealed that one of the more common reasons for disliking mathematics was mathematical anxiety and/or test phobia. This unit explores the reasons why a student can suffer from mathematical anxiety and suggests methods that may lessen its impact on students' performances. Many students confuse mathematical anxiety with test phobia. Test phobia is defined and students are asked to participate in various surveys that seek to determine their test preparation strategies. After various strategies are discussed and linked to particular learning styles, students are encouraged to employ better methods of test preparation and are able to verify what methods lead to success.

The teaching methodology aims for conceptual understanding. Thus, the unit is not content-heavy in comparison to 'traditional' first-year mathematics units. Students are encouraged to participate in a collaborative student-student, and student-teacher environment. In many classes, the lecturer/tutor is more of a facilitator. Problems are presented and discussed, with explanations following. Common mistakes and misconceptions are made explicit which leads to a more meaningful learning experience.

Continual assessment takes place over the 12 weeks of instruction. The number of assessment tasks is excessive by university standards (18 tasks in total). However, the reason for this is to foster self-directed learning behaviours by:

- providing sufficient opportunities for students to experiment with different learning strategies so that success is a real option; and
- encouraging students to take responsibility for their own learning.

Many of these practices are employed in secondary schools, so have we created micro 'year 13', as part of the transition process to university mathematics? Has this improved student performance? This is discussed in the next section.

Effective or not?

It has already been shown (Coady & Rylands 2008) that the first delivery of the unit Mathematical Reasoning (under another name) resulted in improved attitudes towards mathematics by the end of the teaching session. Along with this is an increased belief in their ability to succeed. Pintrich (2003; p.671) writes:

> Students who believe they are able and that they can and will do well are much more likely to be motivated in terms of effort, persistence, and behaviour than students who believe they are less able and do not expect to succeed …. There also is good evidence to suggest that these confident students will also be more cognitively engaged in learning and thinking than students who doubt their capabilities to do well….

In this section we consider two other measures which relate to success. Firstly, two groups of weak students are compared: one group succeeded with Mathematical Reasoning before undertaking the statistics unit, and the other did not. Secondly, we consider the benefits of the large number of assessment tasks.

Students who failed the basic mathematics skills test should not have enrolled in statistics before successfully completing Mathematical Reasoning. However, a few have done so. This provided the opportunity to compare weak students who attempted statistics with and without Mathematical Reasoning. Many students enrolled in Mathematical Reasoning, but dropped out either officially or unofficially. For most of these students we have no way of knowing how much of Mathematical Reasoning they completed, so these students have been excluded from the analysis given in Table 1.

Of almost 900 students who sat the basic mathematics skills test in 2008, 271 failed. Of these 271 students, 33 had completed the first year statistics unit by the end of 2008. Table 1 presents the outcome for all 33 students who failed the basic mathematics skills test some time in 2008 who and then went on to complete the first year statistics unit. Of the 18 students who passed Mathematical Reasoning and who have completed the statistics unit, only 39% obtained a passing grade. These results are an indication that Mathematical Reasoning is improving students' chances of passing statistics.

	Math Reasoning: Not attempted	Math Reasoning: Passing grade	Math Reasoning: Fail grade
First year statistics: passing grade	0	7	0
First year statistics: fail grade	15	11	0

Table 1: Students who failed the basic mathematics skills test and who completed the first year statistics subject.

Increased engagement with the mathematics is enforced in the unit by having 18 assessment tasks. Of these, 12 online quizzes are formative tasks. Thus, a measure of the level of engagement in the unit could be the number of formative tasks attempted. Angus and Watson (2009) noted that regular, online testing worth few marks improves student performance in the final examination. Is regular work benefiting our students? The number of formative assessment tasks completed when compared to the difference between the final examination and basic mathematics skills test marks (as a percentage) for the 110 students in second semester 2008 resulted in a significant positive correlation of 0.26 (significance level 0.01). In addition to the online quizzes, three class tests, an assignment, a 'final reflection' (a journal entry which described a student's mathematical journey over the session) and a final examination (pen and paper) made up the remainder of the assessment tasks. All of these tasks contribute to the final mark and subsequent grade. For each of the class tests and the assignment, feedback was provided both before and after the tasks were completed. Before each of the class tests, students were given a sample paper. Students were encouraged to attempt this paper and seek feedback on their solutions, before attempting the actual class test. A further step was taken with class test 2 in that students were given the opportunity to sit a 'practice class test 2' under examination conditions. Their solutions were marked and feedback given, in the tutorial immediately following this 'practice' test. The assignment was due towards the end of the session. Students were encouraged to hand in their solutions at least two weeks before the due date, in order to receive feedback. This feedback consisted of informing students where they had errors, with suggestions on how and where to find help, for example, in the lecture notes or textbook. Marking of these assessment tasks was conducted by the teaching team.

Conclusion

Mathematical Reasoning has provided some students with a 'lifeline' in the uncertain and sometimes overwhelming university environment. The teaching methodology seeks to promote engagement while fostering the expectation of self-directed learning. However, success has been limited to those students who are willing to put in the extra effort required to change their attitude towards learning.

The Hon Julia Gillard MP, Minister for Education. Minister for Employment and Workplace Relations, Minister for Social Inclusion, Deputy Prime Minister, announced that

> Today just 32 per cent of Australian 25 to 34 year olds have a bachelor's qualification. … our intention is to get that up to 40 per cent.
>
> … This will create an additional 80 000 student places over the four years from 2010 to 2013, allowing about 50 000 additional students to participate in higher education. (Gillard, 2009)

Some of these students will study disciplines where at least some mathematics is needed. In the future there will be more students needing some tertiary mathematics and more students needing assistance with the transition to university and with basic skills. Thus greater alignment is needed between student expectations of university life and the expectations of universities regarding their students, if this target set by the Federal Government is to be met.

Acknowledgements

The authors wish to acknowledge the support and work of the 'Mathematics Reasoning Team' in the implementation of this unit; Ms Lyn Dormer, Ms Lyn Armstrong, Dr Maureen Morris and Mr John Nicholls.

Part of this report was presented at a symposium held at the University of Wollongong, 'Building leadership capacity for the development and sharing of mathematics learning resources across disciplines and universities', 16 – 17 February 2009.

References

Angus, S. & Watson, J. (2009). Does regular online testing enhance student learning in the numerical sciences? Robust evidence from a large data set. *British Journal of Educational Technology, 40*(2), 255–272.

Broadbridge, P. & Henderson, S. (2008). *Mathematics Education for 21st Century Engineering Students*, Australian Learning and Teaching Council (AMSI), Retrieved June 20, 2009 from http://www.altc.edu.au/resources?title=&authors=&ptitle=&institution=&year=All&category=All&discipline=1675&rtype=A&keywords=&pid=

Clark, M. & Lovric, M. (2008). Suggestion for a Theoretical Model for Secondary-Tertiary Transition in Mathematics. *Mathematics Education Research Journal, 20*(2), 25-37.

Coady, C. & Rylands, L. (2008). The use of reflective journals in a first year mathematics unit. *UniServe Science Proceedings*, The University of Sydney, 166-170.

Farnill, D. & Robertson, M. (1990). Sleep disturbance, tertiary transition stress and psychological symptoms among your first year Australian college students. *Australian Psychologist*, 25(2).

Gillard, J. (2009). Post budget speech - Investing in education and innovation to create the jobs of the future. Retrieved June 20, 2009 from http://www.deewr.gov.au/Ministers/Gillard/Media/Speeches/Pages/Article_090521_153929.aspx

Haggis, T. & Pouget, M. (2002). Trying to be Motivated: perspectives on learning from younger students accessing higher education. *Teaching in Higher Education, 7*(3), 323-336.

Hoyles, C., Newman, K. & Noss, R. (2001). Changing Patterns of transition from school to university mathematics. *International Journal of Mathematical Education in Science, 32*(6), 829-845.

Jones, B. & Frydenberg, E. (1998). Who needs help and when: Coping with the transition from school to university, *Paper presented at the Annual Conference of the American Educational Research Association*, Montreal, Canada.

King, R. (2008). *Addressing The supply and quality of engineering graduates for the new century*, Australian Learning and Teaching Council, Retrieved June 20, 2009 from http://www.altc.edu.au/resource-addressing-supply-quality-engineering-graduates-uts-2008.

Krause, K., Hartley, R., James, R. & McInnis, G. (2005). *The First Year Experience in Australian Universities: Findings from a Decade of National Studies.* Retrieved June 20, 2009 from http://www.dest.gov.au/sectors/higher_education/Publications _resources/profiles/first_year_experience.htm

Lidbury, B. (2008). *Independent Learners or Year 13? A discussion paper on the first year university learning experience for students in science degrees* Retrieved June 20, 2009 from .http://science.uniserve.edu.au/workshop/IndependentLearnersYear13BrettL.pdf

Macaro E. & Wingate, U. (2004). From sixth form to university: motivation and transition among high achieving state-school language students. *Oxford Review of Education, 30*(4), 467 – 488.

Mann, S. (2001). Alternative perspectives on the student experience: alienation and engagement. *Studies in Higher Education*, *26*(1), 7-19.

Pell, G. & Croft, T. (2008). Mathematics Support-Support for All? *Teaching Mathematics and Its Applications, 27*(4), 167-173.

Pintrich, P. (2003). A Motivational Science Perspective on the Role of Student Motivation in Learning and Teaching. *Contexts Journal of Educational Psychology*, *95*(4), 667–686.

Raaheim, K. & Wankowski, J. (1981). *Helping students to learn at university*. Sigma Forlag, Skraneflaten 9, 5060 Soreidgrend, Norway.

Rubinstein, H. (2006). *Mathematics and statistics: critical skills for Australia's future.* Australian Academy of Science Retrieved June 20, 2009 from http://www.review.ms.unimelb.edu.au/FullReport2006.pdf.

Rubinstein, H. (2009). A *national strategy for mathematical sciences in Australia*, Retrieved June 20, 2009 from http://www.amsi.org.au/pdfs/National_Maths_Strategy.pdf .

Rylands, L. & Coady, C. (2009). Performance of students with weak mathematics in first-year mathematics and science. *International Journal of Mathematical Education in Science and Technology*, *40*(6), 741–753.

Swan, M. (2005). Improving learning in mathematics: challenges and strategies. Department for education and skills Retrieved June 20, 2009 from http://www.ncetm.org.uk/files/224/improving_learning_in_mathematicsi.pdf