When a Mathematics Support Pilot Program Fails Miserably: Looking for Answers

Keith McNaught
University of Notre Dame, Australia
<Keith.McNaught@nd.edu.au>

The implementation of a Post Entrance Numeracy Assessment (PENA) program at the University of Notre Dame Australia (UNDA) Fremantle campus, demonstrated that many Health Science students had inadequate mathematical skills on entry. The development of a support course, offered as a 'strongly encouraged' option, resulted in only 4% of students (not achieving the PENA benchmark) actually engaging. Whilst recognising that Health Science students at this institution have a history of limited engagement with support, this poor level of engagement demanded particular attention. It was clearly linked to mathematics per se, where student negativity to the subject is almost palpable in many undergraduate courses. In attempting to explain this engagement reluctance, the clear need to improve student skills with mathematics demanded a review of how such a support program may be offered.

At the University of Notre Dame Australia (UNDA) Fremantle campus, first-year Health Science students complete a discipline-specific academic literacy unit. This unit, CO115, Academic Research and Writing, includes involvement in two University-wide testing programs. All first-year Health Science students complete a Post Entrance Literacy Assessment (PELA) which is common to five other Schools (faculties), and also Post Entrance Numeracy Assessment (PENA), common to three other Schools. The PELA is a two part assessment focusing on reading comprehension and essay writing. Students deemed 'at risk' in either or both components are required to attend compulsory courses to support their academic progress as they commence their degree.

The PENA testing program arose from the success and benefits seen with the PELA program; namely, students engaging in support, increased academic success and higher retention. The PENA was designed with a relatively low cognitive demand that was pitched at a Year 9/10 secondary school 'general mathematics' level. The test (appendix 1) was developed by experienced secondary mathematics teachers, benchmarked to Year 9 and 10 general curriculum, and trialled in Year 9 and Year 10 classes. Various forms of the test and various iterations were trialled over three semesters, from semester two, 2010, through to semester two, 2011. The test is completed without the use of a calculator, and allowed 20 minutes for test completion. The benchmark score for the test was set at 7/10, based on the success of Year 9 and 10 students completing the test. However, unlike the PELA, the PENA process was not linked to compulsory courses. Students who scored below the benchmark were advised by the CO115 unit coordinator to seek help with mathematics, and were recommended to access the University's free tuition program and engage with support courses already on offer. The courses and tuition were provided by the University's Academic Enabling and Support Centre (AESC).

Creation of a Support Mechanism

As a result of PENA testing conducted in semester one, 2012, a new and specific course titled 'Fundamental Mathematics for Physiotherapy and Health Science' was developed by the AESC, in consultation with the School of Health Sciences. The course was recommended to all tested students who failed to meet the nominated benchmark. The

In V. Steinle, L. Ball & C. Bardini (Eds.), Mathematics education: Yesterday, today and tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia). Melbourne, VIC: MERGA.

purpose of the course was to improve students' mathematical competency to cater for the demands of the Health Science courses. The course was piloted in July 2012.

Based on the mathematical knowledge necessary to complete units in the relevant Health Science degrees, the following course content was presented:

- Order of Operations (BIMDAS)
- Mathematical Notation
- Scientific Notation and positive and negative exponents
- Unit Conversions
- Algebra and Index Laws
- Trigonometry – including Cosine & Sine
- Statistics and Statistical Formulas
- Vectors

That mathematics is innate, inherent and pervasive to a Science based degree, will be accepted as a fundamental and understood premise in this paper. Rather, this paper will explore students' reluctance to engage with a mathematics support program, and the factors which need to be addressed institutionally to support students better with their academic progress.

Engagement in Support Programs

There is clear evidence of the efficacy of support program engagement to improve successful course retention (Fusch, 2011, Seidman, 2005, Nelson, Duncan & Clarke, 2009). There is, however, as much research to show that students who most need to engage with support are unlikely to voluntarily do so (Fusch, 2011, Harris & Ashton, 2011). University 'learning advisors' are long familiar with the non-engagement phenomenon, which can be explained through psychological models. The Dunning-Kruger effect (Dunning & Kruger, 1999) provides a model for explaining students' lack of engagement. The Dunning-Kruger effect notes that students who lack competence tend to significantly overrate their skill set. Self-assessments are unreliable (Mathieson, Barnfield & Beaumont, 2010), yet frequently used or inherently relied upon in connecting students to support mechanisms. Dunning and Kruger (1999) note that students who are unskilled form misconceptions of their own ability, but their incompetence precludes them from recognising their erroneous thinking. Put colloquially, these students 'don't know and don't know they don't know'. Thus, they will not voluntarily engage in support programs, as they will not accurately understand their own skill-set, nor will they have the current capacity to discern this. Kahneman (2011) notes that people (in this case, students) are expected to rely on well-formed judgements, based on evidence. Kahneman distinguishes that "subjective confidence" (2011, p. 87) is erroneous because of a dependence on intuition, not evidence, to make judgements. Therefore, students need help to explore their thinking, so as to make sound judgements. If a university provides students with test results (e.g. PELA test scores), or expects them to intuitively recognise their inabilities, it is also erroneous thinking. If 'at risk' students do not understand their own need, and universities do not acknowledge and meet that need, the same group of students will remain disadvantaged. When a university allows a student identified as 'at risk' to avoid engagement with support, it may well act to extend the disadvantage being experienced. Thus, whilst a university might inherently support voluntary engagement, this might be inappropriate. The University of Notre Dame Australia has provided the sector with an example of compulsorily-required student engagement, backed with evidence of successful retention (McNaught & Hoyne, 2012).

Exploring the Research for a Rationale for Low Engagement

A clear pattern emerged in the University's work on the PENA project with Health Science students. These students were reluctant to engage in a mathematics support program, even though they had been provided with test results which demonstrated the need existed. They were actively encouraged by staff, with whom positive relationships existed, to engage in support programs. There was no speculation that these students were generally apathetic or indifferent; there was ample evidence on the contrary. The potential reasons for a lack of engagement were perceived as specifically related to mathematics. It is possible that prior negative experiences of mathematics may be impacting on the current Health Science students, or that some are suffering from mathematics anxiety.

Reluctance to engage mathematically is a community-wide issue, not specific to Health Science students, potentially arising from long-term negative educational experiences and community attitudes towards mathematics.

> People are generally uncomfortable with mathematics (indeed fearful of it). At a parent teacher meeting at my child's school I observed rather well educated, affluent parents whispering to each other that they could never abide mathematics and would be unable to understand what the teacher was going to demonstrate at the third grade level. Visitors to our household would let a child know albeit in a joking manner, that mathematics homework is akin to a form of torture. (Ginsburg, 1997, p. 23)

> Indeed one might say that US children are educationally at risk at the mercy of: a) a culture that devalues mathematics; b) inhospitable schools; c) teachers who teach badly; and d) textbooks that often make little sense. (Ginsburg, 1997, p. 25)

Mathematics has been badly taught and socially devalued (Di Martino & Zan, 2010). The lack of quality teaching and learning experiences (Bekdemir, 2010) is neither new, nor specific to Australia.

It is popularly perceived as the territory of the academic elite with deficient personalities in direct proportion to their mathematical skill and interest level (Hersh & John-Steiner, 2011). Research suggests that negative attitudes toward mathematics result from poor educative relationships between students and their teachers (Crosnoe, et al, 2010). There is significant research which demonstrates the importance of a positive affective environment within teaching and learning as being a powerful predictor of student motivation towards seeking help, productive risk-taking, and being fully involved in their own learning (Greer & Mukhopadhyay, 2012).

'Mathematics Phobia' denotes a reluctance to engage in mathematical tasks, predominately a reluctance to undertake mathematics units of study as prescribed courses, either at school or post-school (Burns, 1998). The closely related term, 'mathematics anxiety' denotes a debilitating condition, which can be defined as:

> ….feelings of tension and fearfulness that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations. (Curtain-Phillips, 2003, p. 19)

Sherman and Christian (1999) undertook an analysis of the relationship between mathematics attitudes and self-concept. A person suffering from mathematics anxiety will invariably have a negative attitude towards mathematics; however, a person with a negative attitude towards mathematics is not necessarily likely to suffer from mathematics anxiety (Burns, 1998). Research indicates that a distinct relationship exists between low mathematics self-concept and the presence of mathematics anxiety (Kleitman, Stankov, Allwood, Young & Mak, 2012).

Helping a person suffering from mathematics anxiety reduce their negative attitude can be a significant factor in enabling them to manage the condition and thus lessen its impact on their everyday life (Geist, 2010). Mathematics anxiety responds to behavioural and cognitive therapy, and alternative therapies have demonstrated, through their success, that the problems are not mathematical, but psychological (Zettle, 2012). It is reasonably clear that a positive attitude toward mathematics is essential for learning success. Attitude is a major factor in academic success; equally, attitude is a major factor in academic failure. Various research studies note that motivational variables are more significant than aptitude (Stankov, Lee, Luo & Hogan, 2012).

> It is of particular interest to teachers of mathematics that anxiety and confidence predict mathematics performance better than standardized measures of quantitative ability. This knowledge may help instructors and students of mathematics to appreciate the significance of psychological factors in mathematics learning and work towards change. (Ironsmith, Marva, Harju & Eppler, 2001, p. 283)

A lack of enjoyment of mathematics, and/or test anxiety, and/or pre-examination nerves, is not necessarily an indicator of mathematics anxiety. Indeed, test anxiety is a relatively stable personality trait, and can be used to distinguish sufferers of mathematics anxiety (Cheek, Bradley, Reynolds & Coy, 2002). The misuse of the term is a significant issue because it minimizes the tragic impact of the condition and trivializes the 'reality' many individuals feel. Less able students are more likely to experience stress and anxiety than able students (Gelsomin, 2004). Studies have demonstrated that when the stress factors were controlled, students were able to pass test material (Cheek, Bradley, Reynolds & Coy, 2002).

Students of all ages are likely to believe that mistakes and errors are not indicators of learning taking place, but of their lack of ability. This myth, so strongly perpetuated, needs to be overtly challenged in all courses of learning, and frequently articulated to students (Burns, 1998; Ray, Garavalia & Murdock, 2003). It is likely that when a person who is suffering from mathematics anxiety makes errors it reinforces their belief that they are not capable of learning the material.

Just as some teachers who are likely to apportion blame unfairly to students for poor performance (Thompson, Warren & Carter, 2004), the PENA work demonstrated that the staff working with these students may blame them for their lack of engagement. It would be easy to characterise superficially these students as indifferent or disengaged, without earnestly exploring the background experiences which may be specific to a mathematics support program.

Results of the PENA Testing and Data on Engagement With the Support Course

The PENA test has been used for four consecutive semesters in the School of Health Science and the cumulative results over this time are presented in Table 1 below.

Table 1
Summary of PENA testing, 2011 – 2012

	S1 2011	S2 2011	S1 2012	S2 2012
No of students in CO115	164	59	185	73
No. of students completing PENA	135	29	166	68
% of students below benchmark	75%	72%	59%	72%
Average score	50%	52%	59%	44%
Standard deviation	2.2	2.3	2.2	2.1
Range of scores	4-100%	4-100%	4-100%	4-100%

Of the 98 semester one, 2012, students who were below the benchmark and encouraged to complete the 'Fundamental Mathematics for Physiotherapy and Health Science' course, 4 (4%) enrolled in the course.

On the last day of the course, the four students completed the original PENA test, and for three, this was a repeat; all three showed significant improvement. The group is too small to be considered statistically significant for any further analysis of outcomes.

The fourth student, who had not been previously been tested, scored $^{1½}/_{10}$. This student had finished school at the end of Year 10 and entered UNDA on the basis of a Certificate IV. Separately, the student's PELA testing indicated a mark below the benchmark for both reading and writing. This student's mathematical skills were particularly problematic: for example, she was unable to identify odd and even numbers and had limited mental mathematics skills which prohibited engaging in more complex mathematics (e.g. could not mentally calculate 3 x 4 =). The combination of this student's educational background and poor results in both PENA and PELA testing indicates a current skill set that is inadequate for university study. This particular student highlights the issue of the correlation of poor results in both PELA and PENA tests, and that poor literacy is potentially as much contributing factor to low results as is poor numeracy

Discussion

Health Science students at UNDA are the least likely of all cohorts to engage with academic support services (McNaught & McIntyre, 2011). Thus, providing optional courses over the period 2009 – 2011 has proved highly ineffective despite the best intentions and efforts of staff within the School. Data on a ccess to student support demonstrated that Health Science students identified 'at risk', predominantly through PELA, were the least likely to engage with support programs; the University's decision to require engagement changed this dramatically after its implementation in 2012. This shows a need for a course such as ‘Fundamental Mathematics for Physiotherapy and Health Science’ to be linked directly to courses or units in some way. It is possible that students will be so reluctant to engage with mathematics support programs (as they were with literacy based support) that compulsory engagement will be the only credible option. It may well be that compulsory courses are necessary to achieve the necessary foundations for success, where institutions intentionally act to serve their students best. Intervention is essential for support to be effective and it must be recognised that students who require support, often do not seek it (Fusch, 2011). Thus, optional courses and support programs are frequently not taken by those students who could most benefit through engagement (Harris & Ashton, 2011). Compulsory engagement in support programs is the norm within schooling, and increasingly common in a range of health and welfare initiatives. Universities may have tended to avoid compulsory attendance on the principle of adult learning (Knowles, 1980) but such orthodoxy may need to be challenged. On the other hand, ‘making’ students attend must be acknowledged as potentially creating stress and anxiety for at least some students, particularly with a mathematics course. A support course must acknowledge participants’ potential feelings, and create a learning environment which is different from the commonly experienced teaching and learning ‘endured’ by these students whilst in their secondary years. Moreover, the content provided must be well-contextualised to their study needs, to ensure engagement is worthwhile.

The PENA results of the entering Health Science students are seriously concerning. The number unable to complete rudimentary and low level mathematical tasks, prior to commencing a course where mathematics understandings are pivotal for success, is a major issue. It is likely to be an issue for many intuitions, and not limited to the UNDA cohort. UNDA needs to review the lack of specified prerequisites, or alternatively, articulate an internal pathway of preparation for enrolled students to provide adequate preparation for undergraduate success. The trend for universities to have ‘recommended’ rather than ‘required’ prerequisites for courses is a significant issue. The three other Western Australian universities, with comparable undergraduate pathways, have ‘recommended’ subjects only, as UNDA does. Therefore a student can enter a Health Science degree at these institutions without any science or mathematics subject being completed in the upper secondary years, and this phenomenon is not uncommon. Therefore, based on the knowledge of poor performance and the possibility of not having a suitable study background, support and supplementary courses are essential for students to be successful in undergraduate studies. However, given that many will have intentionally avoided mathematics as a subject in Years 11 and 12, their reluctance to engage needs to be acknowledged and appreciated. The students intentionally avoiding mathematics may most need the support and be the least likely to willingly engage, perhaps damaged by prior mathematics learning experiences.

Students entering a Health Science degree may seriously underestimate that mathematics knowledge, skills and understandings underpin much of the content. Moreover, that units have great deal of mathematics embedded within them might be an implicit and covert understanding. For example, a unit such as Biomechanics, a core first-year subject, does not explicitly indicate that mathematics is inherent, and this only becomes apparent as the unit progresses. Dialogue with students who are having difficulties in a unit like Biomechanics often indicates that the individual has not discerned that their struggles are linked to a lack of mathematical understandings, and are often incorrectly understood (e.g. “I’m not good at remembering all the definitions” as a student explanation). Less successful students often focus on tasks (e.g. doing the assignments) whereas more successful students focus on ensuring they understand the content and knowledge being addressed (albeit they still work conscientiously on assignment tasks).

Conclusion

A support program must carry realistic expectations. There were three issues with this support program offered in July 2012. Firstly, more time was needed to deliver the course. Twelve hours was not enough time to cover the required concepts thoroughly. Secondly, realistic expectations need to be held as to the usefulness of such a course for students with a very low skill set. Thirdly, the content of the course was premised on a particular standard of mathematics, mapped to more rigorous upper school mathematics subjects. Too often support and bridging mathematics courses provide content based on irrelevant secondary mathematics topics rather than subject-targeted content. For example, the vectors topic is matched only by the highest level Western Australian mathematics programs, and would be new material to students without such a background. Contextualised mathematics content, specific to the students' study area, is pivotally important. The differences between general numeracy courses, and subject-targeted mathematics courses, warrants discussion at institutions attempting to address the apparent deficit in this area.

Finally, student engagement with a mathematics support program is likely to require engagement, through connection to a specific unit, or Course Regulations. It is naive for a university to expect engagement with any support program will be common in any area, but far more so when the content relates to mathematics. Many students exit their secondary education with a negative view of mathematics and a sincere reluctance to engage with anything related to the subject area. Overtly acknowledging this may be the first step towards engagement and hopefully new and positive learning experiences within mathematics.

References

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. Educational Studies in Mathematics, 75(3), 311-328.

Burns, M. (1998). Math: Facing an American Phobia. Sausalito, CA: Math Solutions Publications.

Cheek, J., Bradley, L, Reynolds, J., & Coy, D. (2002). An intervention for helping elementary students reduce test anxiety. Professional School Counselling, 6/2, 162 - 164.

Crosnoe, R., Morrison, F., Burchinal, M., Pianta, R., Keating, D., Friedman, S. L., & Clarke-Stewart, K. A. (2010). Instruction, teacher–student relations, and math achievement trajectories in elementary school. Journal of educational psychology, 102(2), 407.

Curtain-Phillips, M. (2003). Befriending the Mathematics monster. Today's Catholic Teacher, 37(2), 18 - 21.

Di Martino, P., & Zan, R. (2010). 'Me and maths': towards a definition of attitude grounded on students' narratives. Journal of mathematics teacher education, 13(1), 27-48.

Dunning, D, & Kruger, J. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. Journal of personality and social psychology, 77(6), 1121-1134.

Fusch, D. (2011). Tackling the retention challenge: Defining and delivering a unique student experience: Academic Impressions.

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom. Journal of Instructional Psychology, 37(1), 24.

Gelsomin, M. (2004). Establishing a comfortable atmosphere in the developmental classroom. Research and Teaching in Developmental Education, Vol. 20, Issue 2. Retrieved from ProQuest Education Journals database. (Document ID: 320073801).

Ginsburg, H. (1997). Mathematics learning disabilities: A view from developmental psychology. Journal of Learning Disabilities, 30(1), 20 – 33.
Greer, B., & Mukhopadhyay, S. (2012). The hegemony of mathematics. In O. Skovsmose & B. Greer (Eds.), Opening the cage: Critique and politics of mathematics education (pp. 229–248). Rotterdam, The Netherlands: Sense Publishers.
Harris, A. & Ashton, J. (2011). Integrating academic and language skills within management units. In Developing student skills for the next decade. Proceedings of the 20th Annual Teaching Learning Forum, 1-2 February 2011. Perth: Edith Cowan University.
Hersh, R., & John-Steiner, V. (2011). Loving and hating mathematics. Princeton, NJ: Princeton University Press.
Ironsmith, M., Marva, J., Harju, B., & Eppler, M. (2003). Motivation and Performance in College Students Enrolled in Self-Paced Versus Lecture-Format in Remedial Mathematics Courses, J ournal of Instructional Psychology, 30(4), 276 – 284.
Kahneman, D. (2011) Thinking, fast and slow. New York : Farrar, Straus and Giroux
Kleitman, S., Stankov, L., Allwood, C. M., Young, S., Mak, K. (2012). Metacognitive Self-Confidence in School-Aged Children. In M. M. C. Mok (Ed.), *Self-directed learning oriented assessment in the Asia-Pacific* (pp. 147 - 163). New York: Springer.
Knowles, Malcolm (1980). The modern practice of adult education: From pedagogy to andragogy. Wilton, Connecticut: Association Press.
Mathieson, F., Barnfield, T. & Beaumont, G. (2010). Are we as good as we think we are? Self-assessment versus other forms of assessment of competence in psychotherapy. The Cognitive Behaviour Therapist, 2, pp 43-50. doi:10.1017/S1754470X08000081.
McNaught, K. & Hoyne, G. (2012) Predicting a student's success in Health Sciences based on their academic writing skills. Proceedings of the 15th Pacific Rim First Year in Higher Education Conference, Brisbane June 26th – June 29th, 2012.
McNaught, K. & McIntyre, F. (2011). When a pass is not a pass. Journal of Academic Language and Learning, 5(1), A100-A109.
Nelson, K., Duncan, M. E., & Clarke, J. A. (2009). Student success: The identification and support of first year university students at risk of attrition. Studies in Learning, Evaluation, Innovation and Development., 6(1), 1-15.
Ray, M, Garavalia, L, & Murdock, T. (2003). Aptitude, motivation, and self-regulation as predictors of achievement among developmental college students. Research and Teaching in Developmental Education, 20(1), 5 – 21.
Seidman, A. (Ed.). (2005). College student retention: Formula for student success. Westport: Praeger Publishers.
Sherman, H., & Christian, M. (1999). Mathematics attitudes and global self-concept: An investigation of the relationship. College Student Journal, 33(1), p.95.
Stankov, L., Lee, J., Luo, W., & Hogan, D. J. (2012). Confidence: A Better Predictor of Academic Achievement than Self-Efficacy, Self-Concept and Anxiety? L earning and Individual Differences, 22(6), 747-758.
Thompson, G., Warren, S., & Carter, L. (2004). It's not my fault predicting high school teachers who blame parents and students for students' low achievement. High School Journal, 87, 5-14.
Zettle, R. D. (2012). Acceptance and commitment therapy (ACT) vs. systematic desensitization in treatment of mathematics anxiety. The Psychological Record, 53(2), 3.