YuMi deadly mathematics professional learning

Summary

The YuMi Deadly Maths Professional Learning (YDM PL) project was developed by Queensland University of Technology's (QUT) YuMi Deadly Centre (YDC) to provide professional learning to teachers on the years F–9 mathematics program YuMi Deadly Maths (YDM). YDM was originally designed to improve teachers' capacity to effectively teach mathematics to students in Aboriginal and Torres Strait Islander and low-SES schools.

YDM aims to enhance students' mathematics learning outcomes and improve employment and life chances. It focuses on the *how* of teaching, and is aligned with the Australian Curriculum: mathematics. It can also be aligned with other programs, such as First Steps and Explicit Teaching. It has been used successfully in schools across Queensland and in Victoria. There are five YDM Centre for Excellence schools. These schools can be contacted for further information via QUT (see contact details at the end of this document).

Target student group

The target group is years F–9 primary, secondary and special school students in metropolitan, regional, rural and remote locations, their principals, parents or carers, and key community members. Although the program is effective for all students, the particular focus is on schools with significant populations of Aboriginal and Torres Strait Islander students, and schools with low-SES, ESL, migrant and refugee students.

The YDM PL project has directly delivered YDM to 137 schools across Queensland and Victoria, using a train-the-trainer model. For example 35 schools, 35 principals and 140 teachers. Indirectly, it has delivered YDM to 420 teachers through train-the-trainer processes, and to approximately 40,000 students and an unknown number of parents and carers. Of these students, approximately 8 per cent (or 3,520 students) were Aboriginal students.

YDM PL's predecessor, called Teaching Indigenous Mathematics Education (TIME), delivered YDM to 102 schools, their students, teachers, principals and communities.

Method

YDM PL training is for two years and usually covers the YDM approach, number, operations and algebra in the first year, and geometry, measurement, statistics and probability in the second year. The introduction to YDM covers philosophy, pedagogy, school leadership, cultural implications, community involvement and implementation in school. The YDM PL project asserts that Aboriginal and Torres Strait Islander, low-SES and ESL students learn mathematics effectively when there is whole-school change that involves community, and takes account of cultural and contextual differences.

Participating schools receive seven booklets on how to teach mathematics, 12 days of PL (either face-to-face or online) and online or website support. Teachers are encouraged to use action research in their implementation of YDM, and to provide feedback on the approach and materials. Schools are encouraged to involve parents, carers and members of the community in the program.

YDM advocates an active pedagogy based on big ideas, sequencing and connections, and a Reality–Abstraction–Mathematics–Reflection (RAMR) cycle (Cooper, Nutchey & Grant 2013; Mathews 2009; Sarra, Matthews, Ewing & Cooper 2011), which starts with the students' knowledge. It builds mathematics knowledge through body, hand and mind activities, practises the idea, connects it to other mathematics topics, and validates and applies the knowledge back into the students' world. Knowledge is extended through flexibility, reversing and generalising activities.

More specifically, the RAMR cycle moves through four stages (Cooper et al 2013; Sarra et al 2011):

1. Reality: working from reality and local culture, ensuring prerequisites are known and finding something in students' everyday lives and interests to act out (kinaesthetic activity) as a starting point for instruction.
2. Abstraction: abstracting mathematics ideas from these everyday instances to mathematical forms through active pedagogy that involves kinaesthetic, physical, virtual and pictorial activities; builds language; and connects to symbolic representations (moves body to hand to mind).
3. Mathematics: ensuring formal language and symbols are understood; consolidating the new ideas through practice; and using instruction to ensure new ideas are connected to existing knowledge.
4. Reflection: validating students' new knowledge with their reality, reflecting ideas back to reality through applications and problem-solving, and looking to extend the ideas learnt to where they are flexible, reversed and generalised.

YDM can fit into schools' existing mathematics programs because of its focus on the *how* of mathematics teaching. Schools can use their existing courses and add in the RAMR cycle as a framework for lesson planning and teaching.

YDM aligns with the Australian Curriculum: mathematics. It consists of:

- seven booklets on how to teach YDM
- a professional learning structure for teaching YDM
- an online 'Blackboard' course, which includes access to extra resources, discussion groups and some diagnostic tests
- a website, with help desk and free resources
- an action research process for implementation.

The YDM PL project is train-the-trainer. YDC delivers YDM training to one principal or administrator and four teacher trainers per school. The teacher trainers then train and support the teachers in their school to implement YDM with their students. Training includes one day of principal training, plus six days of teacher training per year for two years. Across the two years, training covers the nature of YDM itself, number, operations, algebra, geometry, measurement, statistics and probability and sustainable implementation. At the end of two years, schools have a complete program for teaching mathematics. Continued access to the online support is available at the school's request.

The training total cost is $15,000 per year for two years. An agreement detailing deliverables and the payment plan is drawn up between QUT and the school, and is signed by both partners. Schools may need to provide around $1,000 for additional mathematics materials.

Schools control the implementation of the program in their classrooms and are encouraged to involve the community. The teachers are encouraged to use action research and pre- and post-testing when trialling YDM.

YDC maintains contact with the school via phone, email, the help desk and the Blackboard site. Questions are answered and teacher trainers can use the discussion forum to communicate with other schools. Teacher trainers are encouraged to complete a reflective portfolio, describing the school's activities, successes and challenges. A template is provided for consistency of data gathering. Teachers are encouraged to send these portfolios to YDC twice a year.

At the end of each year, YDC also conducts an annual Sharing Summit, where schools can report on their implementation and share their successes with colleagues.

Results

Feedback from teachers and schools indicates improvement in teaching and learning.

In feedback forms at the end of the PL days, principals and teachers state that the sessions were excellent. In their portfolios, teachers report that using YDM has markedly improved students' attendance, engagement, behaviour and achievement in mathematics, and also their ability to talk about mathematics. It has made teaching much more enjoyable and, as a consequence, there is an increased use of activities, discussions and problem-solving in the classroom. It has increased teachers' ability to plan and teach effective mathematics lessons.

Principals report that YDM has improved the quality of mathematics teaching and learning, and positively affected both teacher practices and student performance and achievement, enabling mathematics teaching to be renewed. These findings have been supported in presentations by teachers at the Sharing Summits. They have also been supported by pre- and post-test results provided in portfolios.

Evidence from secondary school year 8 pre- and post-tests result for decimals, measurement and geometry showed continuous improvement in learning. Year 10 pre- and post-test data for measurement also showed improvement in learning in most instances.

Evidence from primary school year 2 pre- and post-test results for numeration showed improvement of approximately 20–40 per cent. Year 4 pre- and post-test results for common fractions, place value and geometry demonstrated variable strong improvement.

Although these findings are strong, they are predominantly from voluntary reports of YDM PL, and its predecessor project TIME. As such, they may reflect schools in which YDM has been successful, rather than schools in which YDM has not been successful. Currently, the 102 TIME schools are being followed up in an attempt to get more complete results.

There are two other results with greater validity. In the first, all 48 teacher trainers from a separate cohort of 12 schools returned portfolios. All documented improved engagement and class discussion and 40 documented improved achievement. In the second, the NAPLAN data was reviewed for 20 schools.

NAPLAN results for years 3 and 5 were compared with results for years 5 and 7 respectively. Year 3 NAPLAN results from 2009 were compared with year 5 results in 2011, and year 5 NAPLAN results from 2010 were compared with year 7 results in 2012. The analysis showed 5 per cent improvement in relation to the national average from year 3 to 5, and 4 per cent improvement for years 5 to 7. Eighteen of the 20 schools' NAPLAN results improved from years 3 to 5. Seventeen of the 20 improved from years 5 to 7. Details are in *Evidence of effectiveness of YUMI Deadly Maths* (2013).

Lessons learned

YDM PL enables teachers to develop their own lessons. YDM reflects best practice through its focus on big ideas and connections, operating from the whole to the parts.

YDM encourages schools to extend mathematics to the parents, carers and community in a manner that is two-way strong, operating to and from the community. Students' cultures are valued, respected and taken into account in learning, building pride and dignity.

YDM empowers teachers to provide students with mathematics experiences that are relevant and enjoyable. Teachers learn innovative teaching approaches and the mathematics that underlies what they are teaching.

YDM builds mathematics knowledge through social constructivism, activity and discussion. It reveals the underlying structure, allowing learning to be built around big connected ideas instead of many small rules. Through its RAMR cycle, mathematics is learned in a multi-sensory manner, focusing on generalisations that enable depth of understanding. It focuses on using body, hand and mind activities to build visual imagery and mental models.

Teachers' first classroom trials to implement YMD are crucial, because of the difference between YDM and traditional mathematics teaching. YDM is strengthened if YDM staff can assist in classrooms during first trials.

Testimonials follow from people involved with YDM:

> The mathematics head of department of a rural state high school attended the year 4–7 training because his school was underperforming. When he returned to his school, he extended the year 4–7 ideas to Algebra and wrote a RAMR unit for year 9 Algebra, which was extremely successful in terms of pre- and post-test results.

> Many schools and teachers are still using the program after four years. Transferring staff bring YDM to their new school or want the YDM program implemented into the new school.
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> [The] school did not participate in the early YDM training. However, as a National Literacy and Numeracy Partnership regional school, they employed a mathematics coach trained in YDM. This coach taught the teachers YDM. The school received an award for the quality and extent of improvement in students' learning.

Beenleigh, Kingston, Marsden and Vincent state schools in Queensland and Sunshine Harvester Primary School in Victoria have been made Centres for Excellence in YDM. Their success is evidence that YDM is a compelling force for positive change in mathematics teaching, creating change that is sustainable by schools.

Next steps

Government funding for YDM ended in 2012; schools are now funding the YDMPL project from their school budgets. At the time of writing this report, 35 self-funded schools have contracted to use YDM. To continue this work, the YDM program is being marketed across Australia, starting from Queensland.

Taking up YDM at a deep level requires six PL days a year; this may have altered by the start of 2014, because the training program will be online. Teachers are encouraged to change their practice, and to plan and teach lessons from knowledge of mathematics that is structural and from knowledge of teaching that is constructivist. YDM identifies that mathematics understanding is developed across year levels, requiring schools to develop centralised plans for teaching and learning mathematics. YDM encourages moving mathematics outside the classroom and involving the community.

Research base

YDM emphasises mathematics as a sequenced and connected structure of big ideas, a language that models and describes reality, and a tool for problem-solving. The YDM PL is built around four key ideas, as outlined below.

First, mathematics is a living, growing, creative act at which students can excel. YDM is based on the relationship between perceived reality and invented mathematics (Matthews, 2009).

It has three tenets:

- Mathematics is a cultural and contextual abstraction of reality based on symbols.
- Mathematics reflects back on reality and empowers people to solve problems in their lives.
- Abstraction and reflection are creative but also culturally biased acts.

Second, mathematics learning is undertaken through active participation, relating kinaesthetic activity to mental models through a sequence of body to hand to mind (Cooper et al 2013). The big ideas of mathematics can only be learnt when constructed anew and individually from work across representations, ie materials, language, pictures and symbols (Cooper & Warren 2011), and in discussion with teachers and peers (English & Halford 1995). Through self-construction, mathematics knowledge is integrated with each student's existing knowledge and constructed into a rich schema. The schema contains a complete definition of the idea (often multi-faceted), all applications of the idea, all connections to related ideas, and the experiences of the learner related to the idea (Piaget 1952; Skemp 1976). The schema develops from connecting different representations. The learner has deep understanding of mathematics ideas and is able to apply the ideas to their world.

Third, mathematics teaching is seen as more powerful if it reveals the underlying structure and relates to the mathematics knowledge within local culture and community. YDC believes that effective teaching requires students to interact with activities and respond to questions and discussion to build, consolidate and extend mathematical ideas (English & Halford 1995). The YDM pedagogy views teaching as a cycle through four phases, reality–abstraction–mathematics–reflection (Matthews 2009; Sarra et al 2011). (The RAMR cycle is described in the Method section of this document.)

Fourth, mathematics improvement is enhanced when accompanied by community involvement and whole-of-school change to improve attendance and learning. The YDM program is strongly influenced by the philosophy of the Stronger Smarter Institute (Sarra 2003). It encourages schools to involve parents, carers and community in mathematics learning. The program works best in schools with strong community–school partnerships: schools that embrace local leadership within school and community, that develop positive identity and pride in heritage, and that have high expectations regarding attendance, engagement and performance.

Further reading and links

Evidence of effectiveness of YuMi Deadly Maths, YuMi Deadly Centre, Queensland University of Technology

Cooper T, Nutchey D & Grant E 2013, 'Accelerating the mathematics learning of low socio-economic status junior secondary students: An early report', 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)*, pp 202–209, MERGA, Melbourne, Victoria

Cooper TJ & Warren E 2011, 'Years 2 to 6 students' ability to generalise: Models, representations and theory for teaching and learning', in J Cai & E Knuth (eds) *Advances in Mathematics Education: Early algebraization: A global dialogue from multiple perspectives,* pp187–214, Springer-Verlag, Berlin Heidelberg

English L & Halford G 1995, *Mathematics education: models and processes*, Lawrence Erlbaum Associates, Mahwah, New Jersey

Matthews C 2009, 'Stories and symbols: Maths and storytelling', *Professional voice* 6 (3), pp45–50

Piaget J 1952, *The child's conception of number*, Humanities Press, New York

Sarra C 2003, 'Young and black and deadly: strategies for improving outcomes for Indigenous students', in *ACE quality teaching series: practitioner perspectives*, 5, Australian College of Education, Deakin, Victoria

Sarra G, Matthews C, Ewing B & Cooper T 2011, 'Indigenous mathematics: creating an equitable learning environment', in N Purdie, G Milgate & HR Bell (eds), *Two way teaching and learning: toward culturally reflective and relevant education*, pp 173–185, ACER Press, Camberwell, Victoria

Skemp R 1976, 'Relational understanding and instrumental understanding', *Mathematics teaching, 77*, pp 20–26

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