Accelerated Indigenous Mathematics

Summary

The Accelerated Indigenous Mathematics (AIM) program has been researched, developed, trialled and refined by the YuMi Deadly Centre (YDC) at Queensland University of Technology. The AIM program is based on years 3–9 of the Australian Curriculum: mathematics, and can be used in any Australian school.

The program improves the mathematics learning outcomes of underachieving years 7–9 Aboriginal and Torres Strait Islander students so they can access senior mathematics courses with the motivation and confidence to succeed. It is a three-year mathematics program consisting of 24 modules covering all mathematics for years 3–9. Two modules are taught per term.

The 24 modules are based on a vertical sequence of mathematics learning from years 3 to year 9 for each topic. The AIM program provides mathematics, mathematics pedagogy and lesson-management knowledge. The program builds a solid base at ability level and learning is accelerated through to age-level work.

The AIM pedagogy enables teachers to construct lessons for their students. Modules are taught as a structure – a connected set of ideas – in large chunks, not as small pieces spread over years. Teachers learn many new ideas about mathematics and teaching mathematics. Schools run alternative classes using the AIM program and create summative assessment processes and parent reporting processes.

YDC collaborates with school staff and students to provide professional learning and support – online and face-to-face – to use the modules effectively.

This project was funded under the Australian Government's Closing the Gap: Expansion of intensive literacy and numeracy programs for Aboriginal and Torres Strait Islander students.

Target student group

The program was developed to assist Queensland secondary schools and F–10 (P–10) schools with junior secondary Aboriginal and Torres Strait Islander students at around beginning year 3 levels in mathematics. These schools were in regional, rural and remote locations.

Nine schools (community, boarding and regional), nine principals, and 39 teachers and teacher aides were involved in the trial. Approximately 85 per cent of the 500 students involved in AIM were Aboriginal and Torres Strait Islander students.

A non-Aboriginal and Torres Strait Islander modification of the AIM program is being delivered to another 11 secondary schools. (This modification is funded by an Australian Research Council [ARC] Linkage grant for five schools and an equity grant from Queensland University of Technology for the remaining six schools.)

Method

The AIM program was trialled to refine resources designed to accelerate the mathematics understanding of very low-performing junior secondary students so they could access senior mathematics courses, and also to construct theory regarding effective acceleration of mathematics knowledge.

The program relied on teachers knowing their students, their activities, background and culture, and on schools collaborating with parents and community. Schools were encouraged to visit parents and carers, run community activities in mathematics to support pride in heritage, establish high expectations, and present mathematics that promoted confidence and achievement.

The AIM program encouraged the development of school leadership teams to organise, support and work with their teachers. The schools identified students and formed the AIM program classes. Schools were asked to provide feedback to YDC staff by following an action research process.

The program was taught actively, using all senses, with a strong basis in the kinaesthetic activity. A lesson planning cycle, Reality–Abstraction–Mathematics–Reflection (RAMR) cycle (Cooper, Nutchey & Grant 2013) was developed, based on an Aboriginal and Torres Strait Islander philosophy (Matthews 2009). Lessons started and ended with reality. They were flexible and reversible, and they actively built ideas through body, to hand, to mind, to generalisations and connections.

The first year of the AIM program focused on the basics of mathematics; the second year on multiplicative topics; and the third year on generalisation or algebraic topics. A series of pre- and post-tests provided diagnostic and achievement data.

A set of culturally appropriate modules developed understandings of years 3–9 mathematics, and replaced the regular mathematics program for years 7–9. Modules were seamlessly sequenced and like topics were connected. The focus for learning was on big ideas, sequences and connections. The first units in vertically sequenced modules built the foundations, and repeated those ideas through the remaining units to accelerate learning.

The modules provided only an outline of lessons and relied on teachers understanding the structure of mathematics across years F–9 (P–9), and the pedagogy of working with students' own reality.

Schools had access to the modules; professional learning days; in-school support through visits; online support through website, email and help desk; and a small amount of funding to provide mathematics materials.

Teachers and teacher aides attended eight professional learning days each year. Two professional learning days were conducted at the start of the year, covering theory, pedagogy, Aboriginal and Torres Strait Islander cultures, research and data-gathering processes, as well as the two modules for Term 1. Two professional learning days were conducted at the end of Terms 1, 2 and 3 or at the start of Terms 2, 3 and 4, covering the two modules for each term and discussing progress.

The cost for YDC to provide the training and resources was $20,000 per year for three years. Schools may also need to provide around $1,000 for additional mathematics materials.

YDC staff visited each participating school once a term. YDC staff provided face-to-face support for the teachers, modelled AIM teaching, and assisted with planning for teaching the modules. YDC staff also conducted interviews and gathered data during visits.

Results

Participants and key stakeholders were involved in the design of data collection. Focus groups were conducted on professional learning days for discussion about approaches to data gathering and proposed directions. These sessions influenced the questions asked in future interviews.

Questionnaire design was also discussed on the professional learning days and responses influenced modifications. Interviews between YDC staff and teachers (or teacher aides) were general discussions. Topics for discussion were often determined by participants. Data was gathered from teachers through the professional learning days and the visits, and from the teachers sending in pre- and post-tests and comments on the modules.

The pre- and post-tests were determined by YDC staff in relation to the modules. Discussion at professional learning days led to modifications and, sometimes, participant involvement in test development.

Improvement in learning was significant in relation to past school performance. Feedback from observations, interviews and other data gathering with teachers showed that all teachers found the implementation of the AIM program resulted in improved attendance and student engagement, improved classroom discussion and talk about mathematics, and improved student understanding of mathematics. The teachers also reported that they found the lessons more enjoyable. Teachers spent more time preparing activities and looked forward to the lessons. Observations of classes showed a marked decrease in behavioural problems and an increase in the quality of mathematics teaching.

Feedback from pre- and post-tests was similarly significant. Because of irregular attendance in six of the schools, the number of students completing pre- and post-tests was low (less than 50 per cent overall). The students tested showed significant improvements in understanding the mathematics topics in each module. The significance of these improvements was greater as the teachers and students became more familiar with – and competent in – the structure and pedagogy of the modules, and also greater in schools where observations showed a stronger implementation of AIM. The gap between Aboriginal and Torres Strait Islander and other students closed in classes where there were both types of students.

Data gathered from pre- and post-tests showed overall improvement in student learning across various topics such as whole numbers, decimal numbers, operations and measurement. For example, in two boarding schools where there was stability in attendance and data, students in the 2010 cohort were found to be succeeding beyond past expectations in year 11 mathematics in 2013. In one school, many were in higher level senior school courses. More details can be found in the *Summary of 2012 AIM progress report to DEEWR* (p6–12).

To view detailed data and supporting documentation such as the summary of the progress report, contact Queensland University of Technology using the contact details provided at the end of this document.

Lessons learned

The success of the AIM program was because the mathematics structure reflected the learning style of most Aboriginal and Torres Strait Islander students by starting from the whole and working to the parts.

The professional learning days and school visits supported both out-of-field teachers (teachers not trained in teaching secondary mathematics) and in-field teachers (teachers trained in teaching secondary mathematics) to become competent in teaching AIM.

There was an increase in teachers' engagement and enjoyment of teaching mathematics. Teachers used modules, activities, sequencing and pedagogy in other learning areas.

Posters for the stages of the RAMR cycle were developed by a school and used to show students the phases of the lesson. This had a positive effect on learning.

Pre- and post-testing was difficult, with some teachers over supporting pre-testing because of the students' level of learning; and some students disengaging with post-testing, saying they had already demonstrated that learning. Some pre-test results were above ability and post-tests below. This skewed results and created issues of validity and reliability.

Irregular attendance and non-school attendance of students, changes in principals and teachers – even adverse weather conditions – impacted on the program direction, implementation, attendance and collection of longitudinal data.

Testimonials about AIM:

> Tower Valley* is a regional high school with 40 per cent Aboriginal students. It used AIM as a replacement for mathematics subjects in classes with lower achieving students. Frank* was teaching out-of-field. He adopted the AIM pedagogy, admitting that he spent half his lessons outside doing activities. His classes became a great success. Attendance, engagement, discussion and knowledge of mathematics all improved. His principal stated that every student attended his mathematics classes, but they ran away from other classes. (*Names have been changed.)

> Hillsdale* is an elite girls' boarding school. It has one class of students with performance well below the other students. This class gets extra attention through the school's support teachers: an extra 1.5 to 2 hours of mathematics per week. The school uses the AIM program for this class, modifying the units to match the regular mathematics programs. In 2013, the 2010 AIM intake of 16 year 8 students reached year 11. Twelve students are succeeding in Mathematics A, and a further two students succeeding in Mathematics B (the more advanced secondary mathematics subject in Queensland schools). The other two students moved interstate. The AIM program works well as a support program. (*Names have been changed.)

Next steps

The AIM program is based on first-hand research into student mathematics learning, and integrated with the best of the literature. The underlying theory of the YuMi Deadly AIM program is very sustainable, in particular the vertical curriculum, the use of big ideas, the RAMR teaching cycle, cultural inclusivity and collaboration with community.

At present, the AIM program is active in nine secondary schools, and a modified AIM program for schools with few or no Aboriginal students is active in 11 secondary schools. These settings include remote years F–10 Aboriginal community 'Hi-Top' schools and remote years 8–10 Aboriginal community secondary schools; low-income years 8–12 urban, regional and remote secondary schools with a variety of cultural groups and minorities; middle-income years 8–12 urban secondary schools with a significant group of underperforming students; years 8–12 Aboriginal boarding schools; and years 8–12 elite boarding schools with a small Aboriginal cohort operating at mathematics levels well below other students. Schools include government, religious and independent sectors. The AIM program works effectively in any school with secondary students who are underachieving in mathematics.

Modules of the AIM program can be selected to meet the needs of particular students. For example, first-year modules have been used in year 10 as preparation for vocational mathematics subjects, and in year 11 pre-vocational mathematics courses. The AIM program is also being used by learning support teachers to help students who are having difficulty learning secondary mathematics through traditional methods of instruction. The AIM program can be replicated to a large or small extent.

Professional learning of the vertical sequencing and active pedagogy involved in the AIM program would be required. Schools would need to allocate funds for resources, training, in-school support, and release time for staff.

YDC is organising a final draft of all booklets, modules and tests to provide to schools. Professional learning will be available online. AIM resources and training will be packaged into a saleable form for new and existing schools to access. There will be a fee for online support, the materials and the provision of training to cover the cost of YDC staff providing the support and maintaining the support processes.

YDC will be upgrading and supporting AIM modules until at least the end of 2015. Two other projects are running using modified AIM resources for schools with no Aboriginal students, with the last of these to end in 2015.

Longitudinal data will be available from schools that have been associated with the AIM program for four years.

> The teaching life in many of the schools participating in the AIM program is very difficult. There are many changes in principals, teachers and students. Behaviour and attendance is poor and teachers find their classrooms very challenging to the point of desperation. AIM gave teachers a program that had purpose and hope in terms of student progress. Most teachers who attended the PL [professional learning] days worked hard at implementing the program.

Overall, all nine schools presently using the AIM program wish for the project to be sustainable and to continue in 2014. Discussion and preparation for continuation of the program is part of the AIM strategy for 2013.

Research base

The AIM program is based on a theory for accelerating the building of big mathematical ideas (Warren & Cooper 2009) through structured sequences that span year levels, models and representations.

The sequence uses effective models and representations that strongly relate to desired internal mental models, have few distracters, and have many options for extension. It uses models and representations in a sequence that reflects increased flexibility, decreased overt structure, increased coverage and continuous connectedness to reality. The consecutive steps explore ideas that are nested wherever possible, and later thinking is a subset of earlier thinking.

The complexity of the sequence can be facilitated by integrating models and the development of superstructures. The sequence facilitates abstraction by comparison of models and representations (Cooper & Warren 2011).

The AIM program breaks the curriculum instruction into 24 modules, which vertically organise the learning of mathematics topics from years 3 to 9 (Cooper, Nutchey & Grant 2013). This allows teachers to teach to ability and still spend time on age-appropriate activities. It changes the way the mathematics is accelerated. Instead of building all topics across the three years (years 7–9) as in the horizontal curriculum, one-third of the topics are completed in each year, with the years 8 and 9 mathematics program filling in the gaps left from year 7.

The assessment is diagnostic and relates to the structured sequences in the vertical curriculum, enabling it to measure achievement as well as provide indications for teaching. This means that the overall testing regime would have rapid changes in some mathematics ideas (as units covering these ideas are completed), requiring a method of determining growth based on disjoint learning movements and weighted aggregation of diagnostic test results.

The AIM program bases its theory of accelerated mathematical learning on the ontological relationship between reality and mathematics, and the inclusion of contexts that are relevant to the local community (Matthews 2009). This program adopts an approach to Aboriginal students' learning that gives preference to experiencing mathematics within an authentic rather than school-like context (Cooper, Baturo, Ewing, Duus & Moore 2007).

If a mathematics idea is embedded in something of value to the learner’s community, this provides motivation, a community connection and – most importantly – a framework in which to understand the idea, particularly in vocational contexts (Ewing, Cooper, Baturo, Sun & Matthews 2010). This is in line with growing global recognition of context-based initiatives (Cooper et al 2007). Underpinning the success of contextualisation is the notion that mathematics is a symbolic, culturally biased system, creatively abstracted from and reflected back to reality (Matthews 2009). The promotion of this relationship ensures that the learners perceive themselves as central to mathematics, since doing mathematics involves abstracting from and reflecting back to the world of the learner. This view of mathematics and the learning of mathematics is embodied in the special RAMR teaching cycle (Cooper et al 2013) used in the AIM program.

Further reading and links

The following supporting materials for this report can be requested from Queensland University of Technology:

- *Summary of 2012 AIM progress report to DEEWR*
- *AIM scope and sequence for 2013*
- 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
- Sandhu S, Kidman G & Cooper T 2013, ‘Overcoming challenges of being an in-field mathematics teacher in Indigenous secondary school classrooms’, 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)*, MERGA, Melbourne, Victoria
- Kidman G, Cooper T & Sandhu S, ‘The pedagogical contribution of the teacher aide in Indigenous classrooms’ in *Proceedings of the 37th conference of the International Group for the Psychology of Mathematics Education*, 1, Kiel, Germany: PME.

Other support materials

Cooper TJ, Baturo AR, Ewing B, Duus E & Moore K 2007, 'Mathematics education and Torres Strait Islander blocklaying students: The power of vocational context and structural understanding', in JH Woo, HC Lew, KS Park & DY Seo (eds), *Proceedings of the 31st Conference of the International Group for the Psychology of Mathematics Education,* PME31, Seoul, Korea, July 8–13, 2 (pp177–184), The Republic of Korea: The Korea Society of Educational Studies in Mathematics

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

Ewing BF, Cooper TJ, Baturo AR, Sun V & Matthews CJ 2010,'Contextualising the teaching and learning of measurement in Torres Strait Islander schools', *Proceedings of the 1st international STEM in education conference,* Queensland University of Technology, Brisbane, Australia, November 26–27, 2010, www.stem.ed.qut.edu.au/index.php/conference-proceedings.html#c

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

Warren E & Cooper T 2009, 'Developing mathematics understandings and abstraction: the case of equivalence in the elementary years', *Mathematics education research journal,* 21 (2), pp76–95

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