Redressing mathematics education: Access to learning for students in Australian schools

Dr Bronwyn Ewing
Queensland University of Technology
Bf.ewing@qut.edu.au

The provision of new and innovative mathematics teaching ideas in primary and secondary classrooms in Australia is often insufficient for sustainable improvement in Aboriginal and Torres Strait Islander and low SES students' learning of mathematics The ideas struggle to have positive effects: 1) when low attendance and negative behaviour are endemic across a school, 2) when school practices and learning spaces disengage students, 3) when positive partnerships are not formed between teachers and their Indigenous teacher aides, 4) when classrooms do not involve community leaders or acknowledge local knowledge, and 5) when teachers do not believe that the students are capable of the work because of their socioeconomic status, their geographical location or parent education. Where ideas have been successful, they have been integrated into whole-school changes that challenge attendance and behaviour, integrate and legitimise local community knowledge, build in practices to support the culture of the students, and change teacher attitudes towards and relationships with the students. Whilst there are small successes, gaps remain.

Introduction and background

In 2016, more than half (53%) of the Aboriginal and Torres Strait Islander population were under the age of 25 years (1). In 2017 there were 215,453 students enrolled in Australian schools identifying as Aboriginal and Torres Strait Islander comprising 5.6% of all students in 2017 (2). The Apparent Retention Rate for Aboriginal and Torres Strait Islander students from Year 7 to 12 was 62.4% in 2017, up from 59.8% in 2016. This represents a significant increase in Aboriginal and Torres Strait Islander Apparent Retention Rates since the rate increased by over 4 percentage points between 2013 and 2014 (2). This rate has increased significantly over the past 10 years from 47.2% in 2008 to 62.4% in 2017.

While the rate increases are positive, every year in Australia, the National Assessment Program - Literacy and Numeracy (NAPLAN) shows that Indigenous school students are well behind their non-Indigenous peers. The National Assessment Program: Literacy and Numeracy National Report for 2017 (3) indicated slightly greater gains in numeracy were recorded for the 2015 to 2017 cohort from Year 3 to Year 5 Indigenous students (101 score points) than for non-Indigenous students (96 score points). There were larger gains for the 2015 to 2017 cohort Year 5 to Year 7 for non-Indigenous students (62 score points) than Indigenous students (57 score points). For the "2015 to 2017 cohort, the gains for Year 7 to Year 9 numeracy for Indigenous and non-Indigenous students nationally were not significantly different although the gains for

Indigenous students appeared to be higher than for non-Indigenous students (53 compared 49 score points)(3)."

The Report *Widening gaps: what NAPLAN tells us about student progress* (4) demonstrated that the spread of student achievement in schools more than doubles. Whilst the middle 60 per cent of students in Year 3 are working within a two-and-a-half year range, by Year 9, the range widens to five and a half years. The top ten per cent of students in Year 9 "are about eight years ahead of the bottom ten per cent (p. 2)". Low achieving students fall ever further back with low achievers in Year 3 "an extra year behind high achievers by Year 9. They are two years eight months behind in Year 3, and three years eight months behind by Year 9 (p. 2)". Most of this range increases between Year 3 and Year 9.

The 2015 Programme for International Student Assessment (PISA) is an international survey of 15-year-olds (5). An analysis of the survey demonstrated that Indigenous Australian students had a mean score that equated to around 2-2.5 years of schooling below non-Indigenous students in mathematical, scientific and reading literacy, showing no significant change in scores between 2012 and 2015 in any domain (6).

The socioeconomic status and geographical location of students also impacts achievement (5; 6). Students in low socioeconomic areas start behind, and make less progress in school. Many regional and rural students make up to two years less progress than students in inner city areas between Year 3 and 9 (4).

By Year 9 students' numeracy skills and attainment will affect their life outcomes. Low achievement and generally poor educational results have been found to link to higher levels of unemployment, limited life earnings, opportunities and poor health (7; 8). Further links are shown with vision or hearing loss and linguistic, social and learning difficulties and behavioural problems in school (9), problems that can lead to reduced educational performance and life opportunities such as employment and income and contact with the juvenile justice or adult criminal justice system. The cycle continues.

Successful educational outcomes are considered to be an important protective factor against poverty and disadvantage (10). A quality education provides opportunities for all students to improve their socioeconomic situation on the basis of merit, not circumstance, thus maximising their potential. High expectations and an effective instructional model are critical for this success.

Intervention: A Model for Teaching Mathematics in Primary, Secondary schools and TAFE

Underpinning the model of *Reality, Abstraction, Mathematics and Reflection (RAMR)* (11) is a concern for equity and social justice in mathematics education and the recognition of the structured nature of inequality in contemporary societies. More specifically, the consequences of unequal access to valued resources such as power and knowledge, it is concerned with the ways and means by which this situation can be changed. In response, the model sought to construct expanding emancipatory possibilities for teachers, trainers and students (12; 13; 14). Informed largely by social constructivism (15), it combined a range of instructional procedures drawn from Indigenous approaches to learning: reality, abstraction, mathematics and reflection

(RAMR) (11), Payne and Rathmell's (16) theory of mathematics learning, and Bruner's (17) three modes of representation (enactive, iconic and symbolic).

Briefly, social constructivism rests on the premise that what students can do with assistance is more indicative of their cognitive development than what they can do alone (18). Moreover, the focus is on the interplay between language and thought and cognitive development and culture (19). Researchers who claim that priority should be given to social and cultural processes (20) draw mainly from Vygotsky's (15) contention that social interaction and culture are constitutive of an individual's cognitive development. Extending the constructivist view, Vygotsky observed that a student's abilities are strengthened through quality social and cognitive interaction between the students and the teachers or trainers. In the learning context, the teacher supports students at the cutting edge of their competencies and adjusts the amount of scaffold (17) or support, to take account of the new learnings of the student. Vygotsky (15) refers to this as a student's "zone of proximal development" (p. 137), that is, the difference between a child's actual development and potential development at that point in time. The actual extent of this zone is determined through collaborative teaching and learning.

Informed by social construction, the RAMR model refers to a pedagogic cycle of reality, abstraction, mathematics and reflection with the intention of supporting teachers and trainers with the teaching of mathematics, and then, the learning of their students (21). Reality refers to factors such as the material setting, the teachers and students present and what they know and believe, the language that is used, the social relationships and expectations of the people involved and their identities, as well as historical, cultural and institutional factors. It also includes the observations of mathematics taken from a teacher's and or student's perceived reality. In this sense, the focus is on how teachers and students produce their realities of mathematics in everyday life, as well as what the activities of everyday life are. It is a process of co-construction. The teacher and students contribute to the construction of a particular shared reality in the learning context. Thus, for teachers to understand a learner's ideas, they need to orient themselves with respect to those ideas and the context within which they arise. From the perceived reality, the teacher supports the student to create abstract representations of it using the hands-body-mind—multisensory experiences, materials, language and symbols.

The process of abstraction emerges from the student's reality, and in doing so, enables them to represent the identified reality using their hands, body and mind, materials, symbols and language in a range of ways to create meaning. Here abstraction refers to some kind of lasting change, that is, the result of abstracting enables the learner to recognise new experiences as having the similarities of an already formed experience (22). In this learning process, they are creating meaning. That is, abstraction and learning becomes a social matter in which experience and its interpretation inform each other.

Through this process, negotiation of meaning becomes a necessary condition for mathematics learning (23). When students' interpretations differ from the teacher's, negotiating meaning is crucial. As students negotiate, reflect and communicate in that context and articulate their thinking socially, their developing conceptual understandings are increasingly reified, that is, they take a reality of their own because they are made more explicit within the context.

Through this ongoing interplay of participation, reflection and reification, learners give shape to their experiences and meaning for mathematics learning (24). In this dialogic framing reality and abstraction are intrinsically relational. These elements and the knowledge formulated from them serve as a basis for further construction and negotiation of meaning, here, mathematical meaning because they have been abstracted from students' perceived realities. Each phase builds on, and is connected to the previous phase to stimulate and encourage conceptual understanding. Table 1 provides a succinct overview of the model.

Table 1. RAMR model

Reality	Learning through awareness of local cultural and environmental knowledge and experiences about the idea; constructing and participating in kinaesthetic activities that introduce the idea and are relevant in terms of knowledge and experience.
Abstraction	Learning through the process of abstracting the idea from reality and representing it using the body-hands-mind; creating representations of it using the hands-body-mind—multisensory experiences, materials, language, and symbols.
Mathematics	Learning through enabling the appropriation of formal language and symbols for mathematical ideas; practising to become familiar with all aspects of the idea.
Reflection	Learning through connecting the idea back to reality, enabling the validation and justification of one's own knowledge; using reflective strategies flexibility, generalising, reversing, and changing parameters.

Benefits of RAMR

Apart from what was discussed previously, there are several reasons that provide the evidence for the benefits of using the RAMR instructional cycle for teaching students. First, the RAMR instructional cycle provides multimodal forms of learning and opportunities for students to see their realities of mathematics in everyday life, orienting themselves to those ideas and the context from which they arise. These forms of learning include seeing, hearing, touch and muscle movement—visual, auditory, kinaesthetic, and tactile learning aids memory and retrieval skills (25). Second, students with disability and those who struggle because of other factors have multiple characteristics that affect their ability to learn mathematics. They create the need for connecting the importance of content to everyday life to increase motivation (26). Third, body movement and manipulation of materials in the reality and abstraction phases allows students to represent their reality using their hands, body and mind, materials, symbols and language in a range of ways to create meaning (16). These phases allow students to recognise new experiences as having the similarities of an already formed experience (22). Fourth, through this process, the construction of knowledge and meaning making becomes a necessary condition for mathematics learning (23). Fifth, the setting of problems back in reality, enable students to validate, justify and generalise their own knowledge so that they can extend on ideas (17).

The benefits of teachers applying the RAMR instructional cycle is presented in the following discussion from one secondary teacher, Jane, and involves one Year 12 student Emily.

The cycle intent included: placing 5 objects in order of size, sorting 3D objects and selecting objects given two given attributes.

Reality = develop awareness of recycling: What do you know about recycling? What is each recycling item made of – introduce different materials, shapes and sizes. What do we recycle? Where do the recycled materials go?

Abstraction = multisensory experiences: using their bodies students order themselves from shortest to tallest, manipulate objects using their hands to order items from smallest to biggest and group like 3D objects together, using their minds to look at items and describe their attributes.

Mathematics = appropriation formal language: connect recycling ideas to maths and name 3D objects, concepts of smallest to biggest and demonstrate understanding of attributes to group like items together.

Reflection = connecting ideas back to reality - sort recycling items into aluminium, glass and paper, class project crushing aluminium cans, order items from smallest to biggest.

The student who worked through this RAMR instruction cycle with her teacher was able to place five objects in order of size, sort 3D objects and select objects given two attributes achieving the intent of the cycle. This cycle was particularly useful for the student because she could manipulate her body and objects to represent contextually constructed mathematical meaning from the reality pertaining to recycling.

Conclusion

Efforts over the past decade to improve schools' numeracy performance have placed greater emphasis on students to complete more challenging levels of numeracy. Given these expectations and the continued achievement difficulties of Aboriginal and Torres Strait Islander students experience, there is a need for teachers to have a repertoire of instructional strategies that they can use to assist students. Contextualising to culture situates mathematics learning in that which already exists, that is, students' culture, community and home languages (including the sky, the sea, the land and spiritual values) and "Indigenous knowledge systems" (27). Others, such as the Canadian Indigenous People (28) are calling for learning systems that are contextualised and holistic. To achieve learning systems that are contextual and holistic, relevant regulations and curriculum need to be established where cultural values, beliefs, traditions and language are contextualised and interwoven in all learning programs.

Students who use holistic thought processing are more likely to be disadvantaged in mainstream mathematics classrooms, because mathematics is presented largely as hierarchical and is broken into parts with few clear connections made between concepts or with the students' culture, community and home languages.

Through the process of contextualising to community and culture, students are more likely to gain access to education because they identify and recognise their own culture in what they are learning. When learning is decontexualised, that is, where there is dissonance between the curriculum and pedagogical approaches embedded in the official education and Indigenous knowledge systems, student engagement in learning is less likely to occur. For example,

If the instructional method favours the learning styles of students from Western cultures (as seems to be the case in contemporary formal school settings), then these students would perform quite well, while the performance of the disadvantaged students from indigenous cultures would not be as good. However, if indigenous students are given the opportunity to learn through an instructional medium that favours their learning or cognitive styles, then the likelihood is that learning would be facilitated and enhanced.

What is critical is that Aboriginal and Torres Strait Islander students are provided with effective education that recognises in explicit and implicit ways their culture, community and home languages and that they are used as sustained entry points into all areas of student learning. Until such time that educators recognise this important issue, these students will continue to struggle in mathematics, and fail to be provided with opportunities to access and discuss their mathematical knowledges, thinking and ideas in the context of their communities.

Note: To find out more about working with Aboriginal and Torres Islander communities contact Associate Professor Grace Sarra *grace.sarra@qut.edu.au*; To find out more about working with Incarcerated young people and students with intellectual disabilities contact Dr Bronwyn Ewing, *bf.ewing@qut.edu.au*

References

1. Australian Bureau of Statistics. (2018a). Aboriginal and Torres Strait Islander Population, 2016 census article, . Retrieved 12/09/2018, from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2071.0~2016~Main%20Features~Aboriginal%20and%20Torres%20Strait%20islander%20Population%20Article~12
2. Australian Bureau of Statistics. (2018b). Student growth, by State, 2016 to 2017-Schools, Australia, 2017, graph 2. Retrieved 12/08/2018, from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4221.0main+features22017
3. ACARA. (2018). National Assessment Program Literacy and Numeracy Achievement in Reading, Writing, Language Conventions and Numeracy National Report for 2017. Retrieved 12/08/2018, from http://www.nap.edu.au/docs/default-source/default-document-library/naplan-national-report-2017_final_04dec2017.pdf?sfvrsn=0
4. Goss, P., Sonnemann, J., Chisholm, C., Nelson, L.,. (2016). Widening gaps: what NAPLAN tells us about student progress. Retrieved from Grattan Institute, https://grattan.edu.au/wp-content/uploads/2016/03/937-Widening-gaps.pdf
5. Organisation for Economic Co-operation and Development (OECD). (2017). *PISA 2015 Results (Volume IV): Students' financial literacy.*
6. Thomson, S., & De Bortoli, L.,. (2017). PISA 2015: Financial literacy in Australia. Retrieved from https://research.acer.edu.au/ozpisa/27

7. Department of the Prime Minister and Cabinet. (2014). Aboriginal and Torres Strait Islander Health Performance Framework 2014 Report. Retrieved 12/06/2017, from https://www.pmc.gov.au/sites/default/files/publications/indigenous/Health-Performance-Framework-2014/tier-2-determinants-health/204-literacy-and-numeracy.html
8. Department of the Prime Minister and Cabinet. (2017). ABORIGINAL AND TORRES STRAIT ISLANDER HEALTH PERFORMANCE FRAMEWORK 2017 REPORT. Retrieved 12/06/2018, from https://www.pmc.gov.au/sites/default/files/publications/indigenous/hpf-2017/tier2/204.html
9. Hopkins, S. (2014). A visual profile of Queensland indigenous and non-Indigenous school children, and the association between vision and reading'.Unpublished Doctor of Philosophy thesis, Queensland University of Technology: Brisbane. *Australian Indigenous Health Bulletin, 14*(2). Retrieved from
10. Ewing, B., & Sarra, G. (2018). Working with incarcerated indigenous and low socioeconomic status youth and their teachers to improve learning outcomes in mathematics. [journal article]. *Curriculum Perspectives, 38*(2), 117-128. doi: 10.1007/s41297-018-0056-8
11. Matthews, C. (2008). Stories and symbols: Maths as storytelling. Retrieved 24/08/09, from http://www.aeu-vic.labor.net.au/professional/files/PV_Mathews_6_3.pdf
12. Du Plessis, J., & Ewing, B. (2017). Reasonable adjustments in learning programs: Teaching length, mass and capacity to students with intellectual disability. *Universal Journal of Educational Research, 5*(10), 1795 -1805. doi: 10.13189/ujer.2017.051018
13. Ewing, B. (2017). An exploration of assessment approaches in a vocational and education training courses in Australia. *Empirical Research in Vocational Education and Training, 9*, Article no. 14. doi: 10.1186/s40461-017-0058-z
14. Ewing, B. F., Cooper, T. J., Baturo, A. R., Sun, V., & Matthews, C. (2011). *Contextualising the teaching and learning of measurement in Torres Strait Islander schools*. Paper presented at Proceedings of the 1st International Conference of STEM in Education 2010, Queensland University of Technology, Brisbane, Qld. Retrieved from https://eprints.qut.edu.au/49302/
15. Vygotsky, L. (1930). *Mind in society: The development of higher psychological processes* (M. Cole, Trans.). Massachusetts: Harvard University Press.
16. Payne, J., & Rathmell, E.,. (1975). Number and Numeration'. In J. N. Payne (Ed.), *Mathematics learning in early childhood* (pp. 125-160). Reston VA: National Council for Teachers of Mathematics.
17. Bruner, J. (1985). Vygotsky: A Historical and Conceptual Perspective. In J. V. Wertsch (Ed.), *Culture, Communication and Cognition: Vygotskian Perspectives*. Cambridge: Cambridge University Press.
18. Marti, E. (1996). Mechanisms of internalisition and externalisation of knowledge in Piaget's and Vygotsky's theories. In A. Trypon, Voneche, J.

(Ed.), *Piaget - Vygotsky: The social genesis of thought* (pp. 57-82). Uk: Psychology Press.
19. Saxe, G. (1991). *Culture and Cognitive Development: Studies in Mathematical Understanding*. Hillsdale, NJ: Lawrence Erlbaum Associates.
20. Engestrom, Y. (1996). Work as a testbench of activity theory. In S. Chaiklin, & Lave, J. (Ed.), *Understanding practice: Perspectives on activity and context* (pp. 64-103). Cambridge: Cambridge University press.
21. YuMi Deadly Centre. (2012). *Overview: Philosophy, pedagogy, chance and culture* (Vol. 1). Brisbane: YuMi Deadly Centre, Queensland University of Technology.
22. White, P., & Mitchelmore, M. (2002). Teaching and learning mathematics by abstraction. In T. T. M. Thomas (Ed.), *Intelligence, learning and understanding in mathematics: A tribute to Richard Skemp*. Flaxton: PostPressed.
23. Voigt, J. (1994). Negotiation of mathematical meaning and learning mathematics. In P. Cobb, & Yackel, E. (Ed.), *Learning mathematics: Constructivist and interactionist theories of mathematics development* (pp. 171-194). Dordrecht: Kluwer Academic Publishers.
24. Goos, M. (2004). Learning mathematics in a classroom community of inquiry. *Journal of Research in Mathematics Education, 35*(4), 258-291.
25. Witzel, B. S., Riccomini, P. J., & Schneider, E. (2008). Implementing CRA With Secondary Students With Learning Disabilities in Mathematics. *Intervention in School and Clinic, 43*(5), 270-276. doi: 10.1177/1053451208314734
26. Browder, D. M., Spooner, F., Ahlgrim-Delzell, L., Harris, A. A., & Wakeman, S. (2008). A meta-analysis on teaching mathematics to students with significant cognitive disabilities. *Exceptional children, 74*(4), 407-432.
27. Nakata, M. (2007). The Cultural Interface. *The Australian Journal of Indigenous Education, 36*, 7-14.
28. Assembly of First Nations. (2005). First Nations early learning and child care action plan. Retrieved 12/02/09, from http://www.afn.ca/cmslib/general/elcc.pdf