Country Reports

Australia

Australia has been found to have a particularly successful approach to maths in the post-16 vocational sector and may be of particular use and/or relevance to the UK context. The Reality, Abstraction, Mathematics and Reflection model has been widely used in Australia; lessons from this model could be usefully incorporated in the UK context. Students' current knowledge, linked to their social and cultural backgrounds, underpins their learning of maths. Problem solving and creativity are also both key to this model. Other successful approaches in numeracy have also included embedding numeracy into vocational contexts; team teaching, where two or more teachers work together to plan lessons; ensuring that the numeracy skills developed through VET match the needs of the workplace; flexible delivery; culturally appropriate provision; and identification of learners' actual skills levels at the commencement of the course.

1.1 Relevant Policy

According to the OECD, Australia *'has fair and inclusive practices that strive for equity, quality and high completion rates for upper secondary and tertiary education'*.[1] VET policy in Australia is well developed, with strong employer links, a well established qualifications system, and a high degree of flexibility and local autonomy.[2]

ACARA, the curriculum authority, consulted international good practice when developing the senior secondary mathematics curriculum, including curricula from Finland, Singapore, Hong Kong and the UK.[3] Maths requirements are contained in industry-aligned training packages, which are defined nationally and delivered by individual institutions.[4]

Training of trainers may require greater policy focus. A recent study on numeracy skills in the teaching of process manufacturing industries, for example, found that VET practitioners lacked an understanding of numeracy requirements, and the appropriate skills, experience and qualifications with which to deliver appropriate training.[5]

1.2 Institutions and Courses

General System

In Australia school education lasts for 13 years; the division between primary and secondary levels differs by state and territory. Generally speaking, primary education lasts for seven or eight years (until Years 6 or 7), and secondary education runs for five or six years (from Years 7 or 8 until Year 12).[6] Within secondary education there is a further division into secondary (three or four years, until Year 10 - leading to a School Certificate) and upper secondary (from Years 10 - 12, leading to a Higher Secondary Certificate).[7]

In New South Wales, learners must stay in secondary school until the completion of Year 10 or its equivalent; they are then required to remain either in approved education and training, or undertake training plus work until they reach the age of 17.[8]

Vocational Courses

There is also the option for young people who have completed Year 9 to undertake a full time apprenticeship or traineeship, completion of which will be taken to equate to completion of Year 10.[9] Non-school based education after Year 10 generally takes place in colleges of Technical and Further Education, or TAFE.

Mathematics bridging courses are available at TAFE colleges to allow learners who have not recently studied mathematics or have only studied mathematics at a basic level to progress to courses where maths skills are a prerequisite.[10] TAFE NSW (New South Wales) delivers a course in conjunction with the University of New South Wales, which covers the content of the Higher School Certificate level 2 mathematics course. This is designed to provide bridging knowledge or assistance with content for students at tertiary level.[11]

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1 http://www.oecd.org/edu/EDUCATION%20POLICY%20OUTLOOK%20AUSTRALIA_EN.pdf

2 http://www.oecd.org/edu/skills-beyond-school/45163853.pdf

3 http://www.acara.edu.au/verve/_resources/Senior_Secondary_Mathematics.pdf

4 http://www.emis.de/proceedings/PME31/2/177.pdf

5 http://www.ncver.edu.au/wps/wcm/connect/4e2a520b-f449-485f-a343-e7bc6a32953d/2627.pdf?MOD=AJPERES&CACHEID=4e2a520b-f449-485f-a343-e7bc6a32953d

6 http://www.studyinaustralia.gov.au/global/australian-education/education-system

7 http://www.studyinaustralia.gov.au/global/australian-education/education-system

8 http://www.schools.nsw.edu.au/leavingschool/

9 http://www.schools.nsw.edu.au/leavingschool/schoolleaveage/faqs/ft-apprent-studentyr9.php

10 https://www.tafensw.edu.au/howex/servlet/Course?Command=GetCourse&CourseNo=22235&tpInd=Y

11 https://www.tafensw.edu.au/howex/servlet/Course?Command=GetCourse&CourseNo=29330&tpInd=Y

1.3 Practice and Pedagogy

TAFE institutes are required, according to the curriculum authority, *'to respond to the needs of people disengaged from education and training, such as early school leavers and those who are unemployed and unskilled'*.[12] Young people in Australia who have previously disengaged from school require an *'interplay of participation and reification giving shape to their mathematical understandings'*, supported by teacher recognition of students' different learning styles.[13]

One of the challenges for maths education is that contextualisation is difficult to align with the competency-based training frameworks, used in TAFEs, through which topics can be compartmentalised or atomised[14]. Academics have also argued that *'random insertion of contexts into assessment questions and classroom examples in an attempt to reflect real-life demand and to make mathematics more motivating and interesting…. ignores the complexity, range and degree of students['] experiences as well as the intricate relationships between an individual's previous experience, mathematical goals and beliefs'*.[15] Other challenges for the delivery of maths education in TAFE include:[16]

- A focus on a narrow range of competencies in accredited curricula.
- Slowness to adopt new technologies.
- Use of discredited pedagogical techniques; students are often expected to learn skills without the provision of real-life context, and then to apply these skills to real-life work situations.
- A reduction in the amount of mathematical content in training packages (which are Australian industry-specific curricula).
- A lack of evaluation of VET-based maths programmes.

An early (2001) study by NCVER on literacy and numeracy provision on VET found that successful approaches in numeracy delivery included embedding numeracy into vocational contexts; team teaching, where two or more teachers work together to plan lessons; ensuring that the numeracy skills developed through VET match the needs of the workplace; flexible delivery; culturally appropriate provision; and identification of learners' actual skills levels at the commencement of the course.[17] This last point is challenging as pre-course testing can be too off-putting to learners (and inaccurate), so teachers and trainers require high levels of diagnostic skills.[18] The report also makes the point that self-paced training materials may not be appropriate for learners with low levels of literacy and numeracy.[19] This is partly due to such materials requiring a relatively high level of literacy, and partly due to a need to be assertive when requiring assistance from the teacher or tutor, when learners may have low levels of self-confidence.[20]

A 2006 study of maths and horticulture in a community school setting found that the separation of maths and horticulture did not work, as learners tended not to attend the maths-specific classes. Delivery was most effective when it integrated real-life tasks with virtual simulations. In a fence construction exercise, *'horticulture students found difficulty in determining the number and placement of fence posts even with a calculator because they did not understand the situation as division. A computer simulation (using PowerPoint) in which fences could be built with virtual posts and discussed in terms of fence distance, post separation and number of posts was found effective in following up real life fencing situations.'*[21]

The Reality, Abstraction, Mathematics and Reflection model, as outlined below under Skilling Indigenous Queensland, has been used more widely in mathematics education, with its original inception in primary schools. It has been a key part of the YuMi Deadly Maths Program (YDM), which has been running in over 100 Queensland schools.[22] Students' current knowledge, linked to their social and cultural backgrounds, underpins their learning of maths. Students then generate their own symbols *'to represent their understanding of the mathematical process. These symbol systems are then compared to, and assist in understanding, the meanings of standard symbols, symbolic language and their connection to reality.'*[23] This process enables students to explore the underlying structure of maths. Problem solving and creativity are both key to this model.[24]

Torres Strait Islanders (TSIs): Blocklaying Students[25]

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[12] http://eprints.qut.edu.au/57774/5/Ewing_&_Sarra_&_Cooper_&_Matthews_&_Fairfoot_.pdf
[13] http://eprints.qut.edu.au/14357/1/14357a.pdf
[14] http://eprints.qut.edu.au/14357/1/14357a.pdf
[15] http://eprints.qut.edu.au/14357/1/14357a.pdf
[16] http://www.avetra.org.au/abstracts_and_papers/16_FITZSIMONS.pdf
[17] http://www.ncver.edu.au/wps/wcm/connect/bee1e5a7-37d5-4b04-a470-7e3415570d85/nr9004.pdf?MOD=AJPERES&CACHEID=bee1e5a7-37d5-4b04-a470-7e3415570d85
[18] http://www.ncver.edu.au/wps/wcm/connect/bee1e5a7-37d5-4b04-a470-7e3415570d85/nr9004.pdf?MOD=AJPERES&CACHEID=bee1e5a7-37d5-4b04-a470-7e3415570d85
[19] http://www.ncver.edu.au/wps/wcm/connect/bee1e5a7-37d5-4b04-a470-7e3415570d85/nr9004.pdf?MOD=AJPERES&CACHEID=bee1e5a7-37d5-4b04-a470-7e3415570d85
[20] http://www.ncver.edu.au/wps/wcm/connect/bee1e5a7-37d5-4b04-a470-7e3415570d85/nr9004.pdf?MOD=AJPERES&CACHEID=bee1e5a7-37d5-4b04-a470-7e3415570d85
[21] http://www.emis.de/proceedings/PME31/2/177.pdf
[22] http://eprints.qut.edu.au/57679/2/57679.pdf
[23] http://eprints.qut.edu.au/56072/2/
[24] http://eprints.qut.edu.au/56072/2/
[25] http://www.emis.de/proceedings/PME31/2/177.pdf

Target Group:

The target group for this intervention was Torres Straight Islanders (TSIs), who experience significant social disadvantages associated with poor maths performance and limited opportunities in education and employment. The intervention focused particularly on TSIs who had not previously achieved well in maths. Most of the case study interviewees had ability in maths equivalent to around mid elementary school.

The Context:

According to the study, maths *'is taught from a Eurocentric position which means that indigenous and other minority cultures experience alienation from and conflict with it'*. The vocational teacher, a master builder, had no formal training in maths education, and had a procedural approach to maths education. Prior to the intervention, he was already using vocational contexts through which to teach maths.

Nature of Intervention:

An action research project was undertaken, pairing a research team with a vocational teacher, in order to support students to meet the requirements of a blocklaying course. The research took a case study approach.

Two levels of intervention were undertaken. In the first, researchers undertook professional learning and planning sessions with the tutor. In the second, model lessons were undertaken with the students. The focus was on *'teaching structural understanding of the students' mathematics-learning difficulties identified by the teacher'*.

Activities covered (a) whole and decimal numbers, and conversion from millimetres to metres; (b) proportion and measurement to interpret house plans drawn with a scale; and (c) area and volume of footings. Activities were focused on modelling and were linked, where possible, to the broader blocklaying course. With the area and volume activity, for example, students worked with pictures of tiles to help them relate length and width to area. PowerPoint presentations were used in two of the activities; in one, the PowerPoint was used to show the relationship between millimetres and metres, and to support students to convert the scale onto a physical plan and with building blocks.

Results/Impact:

- Students, teachers and administrators believed that the intervention had been successful.
- Both attendance and achievement were higher than would have been expected, and students were able to build with blocks at the end of the course.
- Funding was maintained, at a time where funding for many courses was cut, because of successful programme outcomes.

Lessons Learned:

- Students found it easier to understand mathematical concepts when they were applied in real-life vocational contexts.
- A key factor for the success of the programme was the strong relationship that the tutor had with his students.
- Kinaesthetic learning increased levels of engagement among students.
- Use of modelling increased students' discussion of topics related to maths.
- A context-specific lesson of this intervention was that TSI students were more motivated by gaining skills that could be of direct use to their community; maths was presented in this light.

Skilling Indigenous Queensland[26]

Target Group:

The project focused on VET courses with high levels of enrolment from indigenous communities.

The Context:

Indigenous students in Australia have *'experienced multiple and cumulative disadvantages'*.

Nature of Intervention:

The four-year project involved 39 teachers/trainers and assistants, and 231 students. Case studies were developed using a combination of *'mixed methods design participatory collaborative action research'* and community research. The aim of the project was to investigate the teaching and learning of maths in VET courses. The overall project was a four year course, and the research cited here looked specifically at teaching practice and expectations, focusing on 21 participants.

The intervention included the following courses: Metallurgy, Civil Construction, Indigenous Housing Repair and Maintenance, Children's Services Certificate, Retail, Horticulture and the Remote Area Teacher Education Programme. It trialled a model known as *Reality, Abstraction, Mathematics and Reflection (RAMR)*, which had initially been developed for primary school students and had seen successful outcomes. This model, based on social constructivism, had high expectations of indigenous students.

The 'reality' aspect of the model *'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*

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[26] http://eprints.qut.edu.au/57774/5/Ewing_&_Sarra_&_Cooper_&_Matthews_&_Fairfoot_.pdf

identities, as well as historical, cultural and institutional factors'. Teachers' and students' perceived views of maths are also taken into account. Teachers then support students to create abstract representations of this perceived reality using *'multisensory experiences, materials, language and symbols'*. Students create meaning through this process, and negotiate this meaning through group discussion; *'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'*.

Results/Impact:

- Teachers were found to have high expectations of students; students also had high expectations of themselves and their tutors.
- Impact was not explored in depth as part of this analysis.

Lessons Learned:

- The theoretical nature of the presentation of this project makes practical learning for other maths programmes difficult. The RAMR model is therefore explored in more detail above.

Catering for Motivational Differences in Vocational Access Course in Numeracy[27]

Target Group:

The target group was young, unemployed people who left school prior to Year 11. Several students were required to attend the training by the court system; others had previously been expelled or had dropped out of school for other reasons. Students attending the course were generally 15-16 years old.

The Context:

The target group are required to attend access courses in numeracy and literacy in Queensland; the aim of this policy is to reduce unemployment and to increase skills levels.

Nature of Intervention:

A study was delivered in one TAFE institute which looked at students' and teachers' perceptions of teaching and learning. The aim was to investigate effective materials for teaching maths in TAFE access courses, using everyday and vocational contexts to teach maths, with a case study approach.

There was no active intervention from the research team; instead they combined lesson observations with semi-structured interviews which asked participants about their previous experiences of maths education, and their experience of the access course.

As part of the study, students were grouped into two categories. The first group tended to be disengaged, with negative attitudes towards learning and maths. The second group tended to participate, but were indifferent towards learning and maths.

Results/Impact:

- Students with different levels of engagement benefit from different ways of teaching maths.
- Disengaged students were more responsive to one-to-one tutoring and self-paced workbooks. They also benefited particularly from supportive, respectful and equal relationships with peers and tutors. These students need to be supported to develop an identity which enables them to view themselves as controlling external situations, such as money, employment and the police; numeracy focusing on these topics could be a first step.
- Engaged/indifferent students also benefited from one-to-one tutoring and supportive relationships. Workbooks tend not to work well; students need to be stretched towards concepts and strategies. For this target group, resilience is believed by the study authors to be a possibility for the move towards a more conceptual approach to maths: *'questions such as, what gives these students the strength to rebuild their lives, where is the numeracy that underpinned this resilience, what numeracy do they need for their vocation, and how can this be linked to formal pre-vocational mathematics?'*
- TAFE tends not to support the needs of either group of learners; this situation is *'exacerbated by the lack of resources, the uninspiring learning spaces, familiarity and success in traditional numeracy teaching interactions, and the competing need to make progress through outcomes'*.

Lessons Learned:

- It is important that tutors are trained to deliver maths at the appropriate level; in the case of this course, the level of the students was mid-primary and the tutors had little training delivering at this level.
- Small teaching groups are ideal so that teachers can give greater individual support to students.
- Students with different levels of motivation should, ideally, be separated into different classes so that their distinct needs can be met.

[27] http://eprints.qut.edu.au/14357/1/14357a.pdf

1.4 Key Points of Learning

Contextualisation is difficult to align with competency-based training frameworks, through which topics can be compartmentalised or atomised.

Successful approaches in numeracy delivery may include embedding numeracy into vocational contexts; team teaching, where two or more teachers work together to plan lessons; ensuring that the numeracy skills developed through VET match the needs of the workplace; flexible delivery; culturally appropriate provision; and identification of learners' actual skills levels at the commencement of the course.

Pre-course testing can be too off-putting to learners (and also can be inaccurate), so teachers and trainers require high levels of diagnostic skills.

Self-paced training materials may not be appropriate for learners with low levels of literacy and numeracy. This is partly due to such materials requiring a relatively high level of literacy, and partly due to a need to be assertive when requiring assistance from the teacher or tutor, when learners may have low levels of self-confidence.

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[28] http://eprints.qut.edu.au/56072/2/