Building a learning resource to enhance mathematical reasoning

A Presentation to the Biennial Conference of the Australian Association of Mathematics Teachers held in Adelaide, July 2015

by Professor Dianne Siemon (RMIT University), Natalie Banks (Rosebery Middle School) and Will Morony (AAMT)

Overview:

- The STEM imperative
- The *Australian Mathematics & Science Partnership Programme* (AMSPP)
- Round 1 – Multiplicative Thinking (RMF)
- Round 2 – Mathematical Reasoning (RMFII)
  - Approach
  - Indicative tasks
  - Anticipated outcomes
- Where to from here?
  - How you can help
  - AAMT role

Rosebery Middle School

The STEM imperative

44% or 5.1 million jobs at risk from digital disruption [1]

The average performance of Year 8 students in mathematics has not changed since TIMSS 1995 [2]

Shifting 1% of workforce into STEM roles would add $57.4 billion to GDP over 20 years [1]

More than 20% of Year 8 students were being taught by mathematics by teachers who reported feeling only "somewhat" confident in teaching the subject [2]

37% of Australian Year 8 students did not achieve the Intermediate international benchmark (the minimum proficient standard expected) **[2]**

75% of the fastest growing occupations require STEM [1]

Number of Year 12 students studying STEM subjects is declining [1]

1. Price-Waterhouse Report (April, 2015). A Smart Move: Future proofing Australia's workforce by growing skills in science, mathematics, engineering and maths (STEM)
2. Thompson, S., Hillman, K. & Wernet, N. (2012). Monitoring Australian Year 8 student achievement internationally: TIMSS 2011. Melbourne: ACER

The STEM imperative

The number of students taking intermediate and advanced maths at secondary school has fallen by 34% over the last 18 years [3]

Interpreting, applying and evaluating mathematical outcomes is an area of relative strength for Australian 15-year olds but **formulating situations mathematically** and **employing mathematical concepts, facts, procedures and reasoning are areas of weakness** [4]

Australia's mean mathematical literacy performance declined significantly between PISA 2003 and PISA 2012 and males significantly outperformed females [4]

20% of mathematics and physics teachers are teaching out-of-field [5]

3. The Australian Industry Group (March, 2015). Progressing STEM skills in Australia. Melbourne: AiGroup
4. Thompson, S.De Bortoli, L. & Buckley, S. (2013). PISA 2012: How Australia measures up. Melbourne: ACER
5. Weldon, R. (March, 2015). Policy Insights. The teacher workforce in Australia: Supply and Demand Issues

AMSPP Objectives:

The objectives of the *Australian Mathematics and Science Partnership Program* (AMSPP) are to:

(i) build the theoretical and pedagogical skills of school teachers to deliver maths and science subjects;

(ii) increase the number of school students undertaking maths and science subjects to Year 12;

(iii) improve outcomes for these students; and

(iv) encourage more students to study science, technology, engineering and maths (STEM) courses at university through innovative partnerships between universities, schools, and other relevant organisations.

https://education.gov.au/australian-maths-and-science-partnerships-program

Australian Government
Department of Education

Two AMSPP Project Rounds:

1. Priority Project Round (2013)

Submissions for one-year, ‘road-ready’ projects: total funding pool $5M, announced January 2013, awarded August 2013

Reframing Mathematical Futures Priority Project - focus on multiplicative thinking in Years 7 to 10 using the *Scaffolding Numeracy in the Middle Years* (SNMY) resources

2. Competitive Grant Round (2014-2017)

Submissions for extended research projects: total funding pool $19M, announced May 2013, awarded July 2014

Reframing Mathematical Futures II Competitive Grant Project – aimed at building a learning and teaching framework for algebraic, spatial and statistical reasoning in Years 5 to 9

Reframing Mathematical Futures (RMF) (AMSPP Priority Project, 2013):

Aim: To improve student outcomes in relation to **multiplicative thinking and proportional reasoning** in Years 7 to 10**.**

Focus: Students whose future would otherwise be constrained by lack of access to these critical aspects of school mathematics.

Approach: Support school-based specialists in a sample of Australian Secondary schools to work with the *Scaffolding Numeracy in the Middle Years* (SNMY) materials to:

- identify student learning needs,
- deepen teacher knowledge in this domain, and
- improve teacher responsiveness to student learning needs.

Why multiplicative thinking?

Middle Years Numeracy Research Project (MYNRP) commissioned by the public, independent and Catholic school systems in Victoria (1999-2000) – explored number sense, measurement & data sense and spatial sense using rich tasks and Item Response Modelling (IRM) - identified **multiplicative thinking** as the **area most responsible for the seven-year range in student mathematics achievement in Years 5 to 9** (Siemon, Corneille & Virgona, 2001)*

Scaffolding Numeracy in the Middle Years (SNMY) Linkage Project with the Departments of Education in Victoria and Tasmania (2003-2006) - explored the development of **multiplicative thinking in Years 4 to 8** using rich assessment tasks and IRM– **confirmed MYNRP result, produced research-based Learning and Assessment Framework for Multiplicative Thinking (LAF), two formative test options and teaching resources** (Siemon, Breed, Dole, Izard & Virgona, 2006)*

* The Final Reports of both projects can be found on the DEECD website

Notion of targeted teaching that requires:

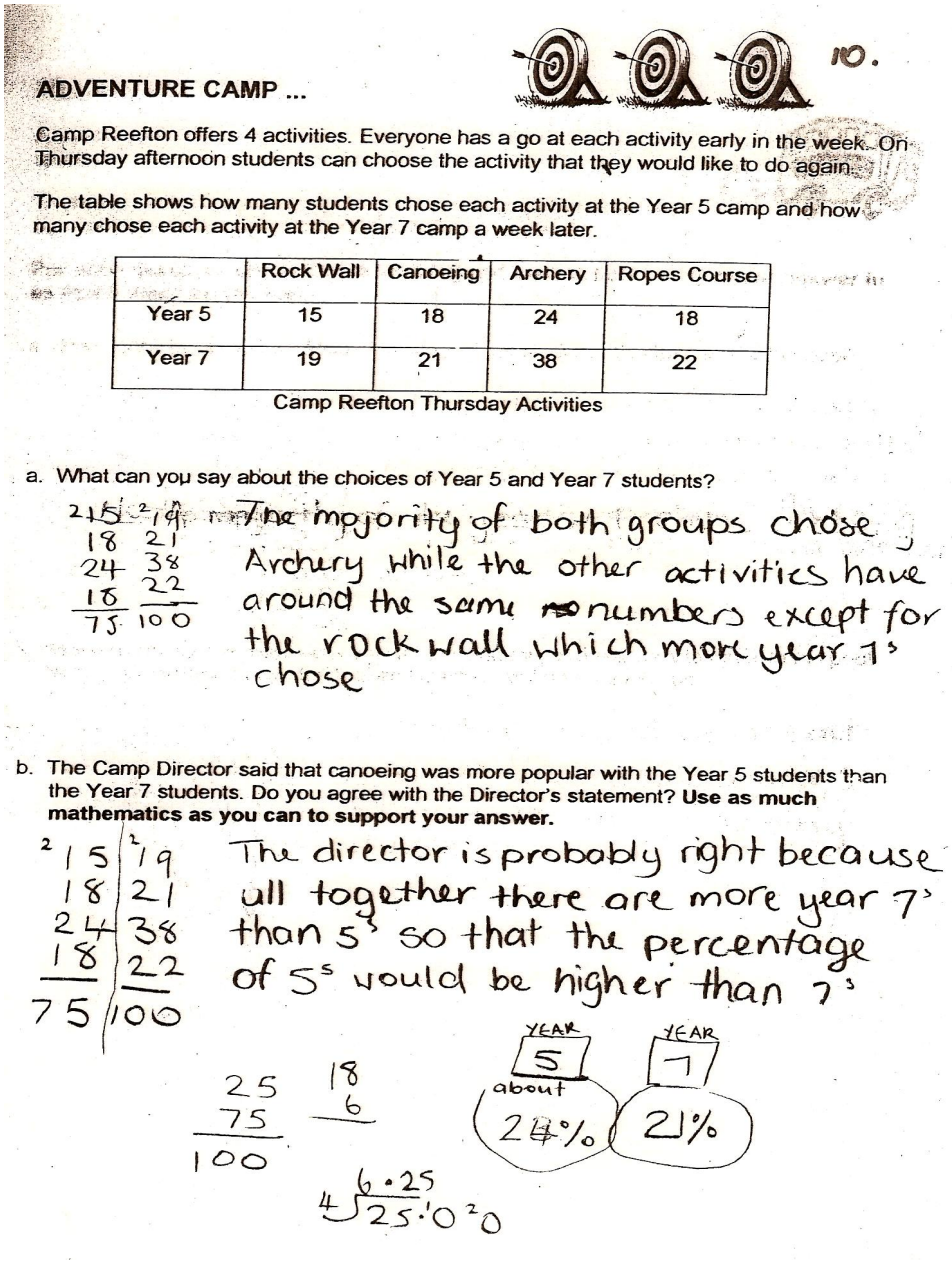
- **access to accurate information** about what each student knows;
- **a grounded knowledge of learning trajectories** (key steps in the development of big ideas and how to scaffold these);
- an **expanded repertoire of teaching approaches** which accommodate and nurture discourse, help uncover and explore student's ideas in constructive ways, and ensure all students can participate in and contribute to the enterprise;

- **sufficient time with students to develop trust and supportive relationships**; and
- **flexibility to spend time with the students who need it most**.

(MYNRP, Final Report, 2001)

Scaffolding Numeracy in the Middle Years (SNMY Project, 2004-2006)

- **Multiplicative thinking** operationalised in terms of
  - (i) core content knowledge (multiplication, division, fractions, decimals, proportion etc),
  - (ii) ability to apply that knowledge in unfamiliar situations, and
  - (iii) capacity to communicate and justify solution strategies
- Hypothetical Learning Trajectory (Simon, 1995) for multiplicative thinking derived from related literature
- HLT used to locate, design, and trial rich assessment tasks
- Cluster-based purposeful sample of 3200 Year 4 to 8 students in Victoria and Tasmania, pre/post test design, support for targeted teaching
- Rasch analysis (e.g., Bond & Fox,2001) used to identify shift over time and test HLT



10.

ADVENTURE CAMP ...

Camp Reefton offers 4 activities. Everyone has a go at each activity early in the week. On Thursday afternoon students can choose the activity that they would like to do again.

The table shows how many students chose each activity at the Year 5 camp and how many chose each activity at the Year 7 camp a week later.

	Rock Wall	Canoeing	Archery	Ropes Course
Year 5	15	18	24	18
Year 7	19	21	38	22

Camp Reefton Thursday Activities

a. What can you say about the choices of Year 5 and Year 7 students?

15 19
18 21
24 38
18 22
75 100

The majority of both groups chose Archery while the other activities have around the same ~~no~~ numbers except for the rock wall which more year 7's chose

b. The Camp Director said that canoeing was more popular with the Year 5 students than the Year 7 students. Do you agree with the Director's statement? **Use as much mathematics as you can to support your answer.**

15 19
18 21
24 38
18 22
75 100

The director is probably right because all together there are more year 7's than 5's so that the percentage of 5's would be higher than 7's

25 18
75 6
100

6.25
4) 25.0 2 0

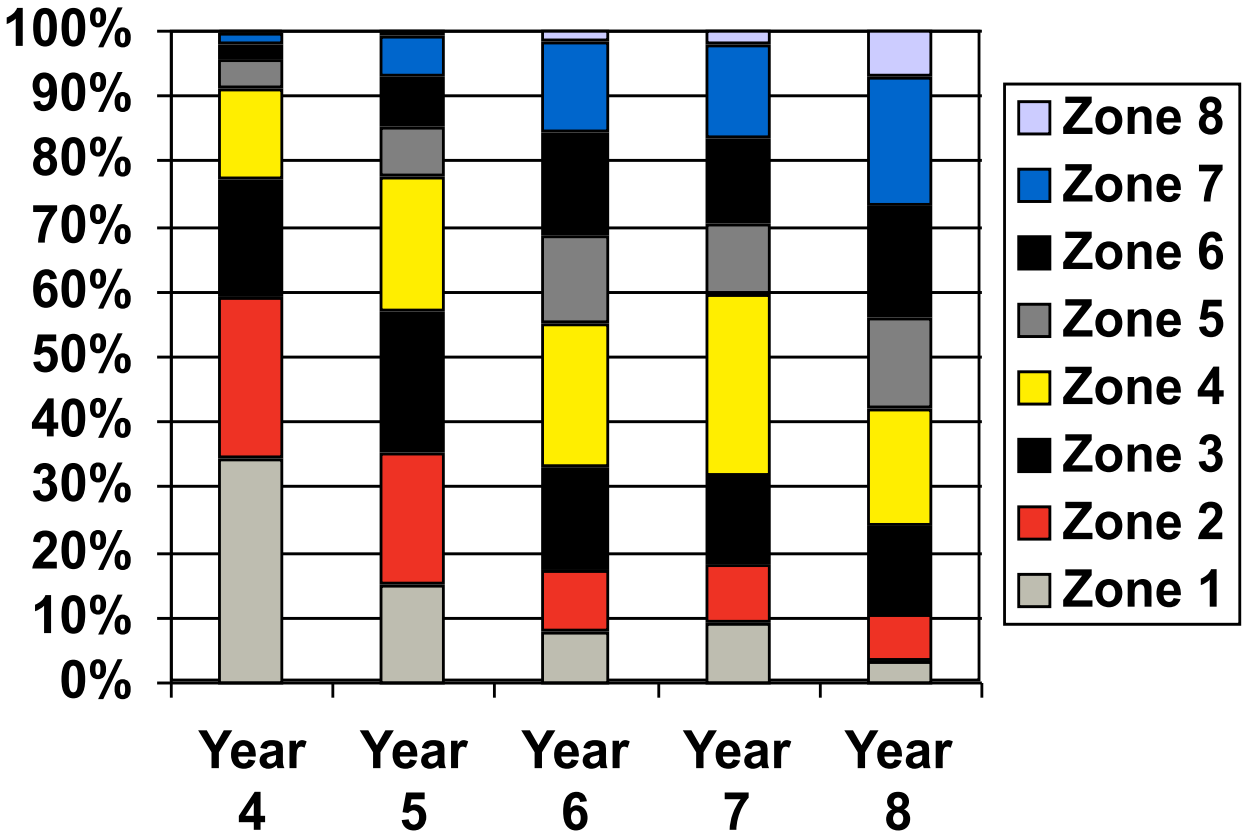
YEAR 5 about 24%

YEAR 7 21%

ADVENTURE CAMP ...		
TASK:	**RESPONSE:**	**SCORE**
a.	No response or incorrect or irrelevant statement	0
	One or two relatively simple observations based on numbers alone, eg, "Archery was the most popular activity for both Year 5 and Year 7 students", "More Year 7 students liked the rock wall than Year 5 students"	1
	At least one observation which recognises the difference in total numbers, eg, "Although more Year 7s actually chose the ropes course than Year 5, there were less Year 5 students, so it is hard to say"	2
b.	No response	0
	Incorrect (No), argument based on numbers alone, eg, "There were 21 Year 7s and only 18 Year 5s"	1
	Correct (Yes), but little/no working or explanation to support conclusion	2
	Correct (Yes), working and/or explanation indicates that numbers need to be considered in relation to respective totals, eg, "18 out of 75 is more than 21 out of 100", but no formal use of fractions or percent or further argument to justify conclusion	3
	Correct (Yes), working and/or explanation uses comparable fractions or percents to justify conclusion, eg, "For Year 7 it is 21%. For Year 5s, it is 24% because 18/75 = 6/25 = 24/100 = 24%"	4

A Year 6 Student Response to *Adventure Camp* Short Task (SNMY, May 2004)

Results … Zone 4 can be viewed as a transitional zone from additive to multiplicative thinking, suggesting that about **40% of Year 7 and 30% of Year 8 students might be deemed to be 'left behind'** in terms of curriculum expectations …



Proportion of Students at each Level of the LAF by Year Level, Initial Phase of SNMY, May 2004 (N=3169)

A 7-8 year range in any one class …

LAF Zone	1	2	3	4	5	6	7	8
Expected by	End of Year 1	End of Year 2	End of Year 3	End of Year 4	End of Year 5	End of Year 6	End of Year 7	End of Year 8
Year 4	**9**	**7**	**5**	**4**	**1**	**1**	**1**	**0**
Year 5	**4**	**5**	**6**	**5**	**2**	**2**	**2**	**0**
Year 6	**2**	**3**	**4**	**6**	**4**	**4**	**4**	**0**
Year 7	**2**	**2**	**4**	**7**	**3**	**3**	**4**	**1**
Year 8	**1**	**2**	**4**	**5**	**4**	**4**	**5**	**2**

Implied class distribution by Year Level based on Initial 2004 SNMY data (N = 3169)

Targeted teaching works

For example, students in an identified sub-sample of 'at-risk' students within the SNMY Project demonstrated major shifts in achievement against the *Learning and Assessment Framework for Multiplicative Thinking* (LAF) as a result of an 18 week, 2 sessions per week teaching program* (Breed, 2011)

Participants:	9 Year 6 students identified at Level 1 of the Framework in May 2004
Results:	All 9 students achieved at Level 4 or 5 of the Framework in November 2005

* A copy of the *Intervention Teaching Program for At Risk Students* is included in the *SNMY Project Findings, Materials and Resources* available on the DEECD and TasEd websites.

Products of SNMY Research:

- A set of **valid and reliable tasks** that can be used with confidence to assess multiplicative thinking across Year levels;
- An evidence-based **Learning Assessment Framework for Multiplicative Thinking** that can be used to inform targeted teaching approaches;
- 8 **Learning Plans** per cluster (24 in all), one for each zone/level of the framework; and
- A number of school-based **authentic tasks**.

http://www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/assessment/Pages/scaffoldnum.aspx

Reframing Mathematical Futures (RMF) (AMSPP Priority Project, 2013):

Aim: To improve multiplicative thinking and proportional reasoning in Years 7 to 10 using the SNMY materials and a supported targeted teaching approach …

Something more needed …

- At-risk student responses to MYNRP interviews (Siemon, Virgona & Corneille, 2001)
- Variable success of targeted teaching in secondary schools (SNMY Final Report, 2006)
- Role of affect and relationships in effective targeted teaching (Breed, 2011)

Views of ‘at risk’ students

“Change the way it’s explained, they need to think about how you understand, not how they explain” (Vincent, Year 9, MYNRP, 2001)

Disengagement has as much to do with student perceptions of how they are treated by their teachers as the teaching practices used …

A sense of cultural connectedness and mutual respect appears more likely to encourage constructive, risk-taking, explorative behaviour than feelings of alienation or uncertainty.

Engagement comes with self-esteem, identity and agency. **It is a consequence of success not a pre-requisite for success.**

It requires sufficient time with students to develop trust and supportive relationships and the flexibility to spend time with those who need it the most.

Final Report of the *Middle Years Numeracy Research Project* (1999-2000)

Adolescent Learners

Learn best when they:

- have high levels of confidence and self-esteem,
- are strongly motivated to learn, and
- are able to learn in an environment characterised by ‘high challenge coupled with low threat’.

OECD (2002). Understanding the brain: towards a new learning science. Paris: OECD Publications Service

Sagor and Cox (2004) identified five essential feelings they believe are crucial to a young person’s well-being and success at school:

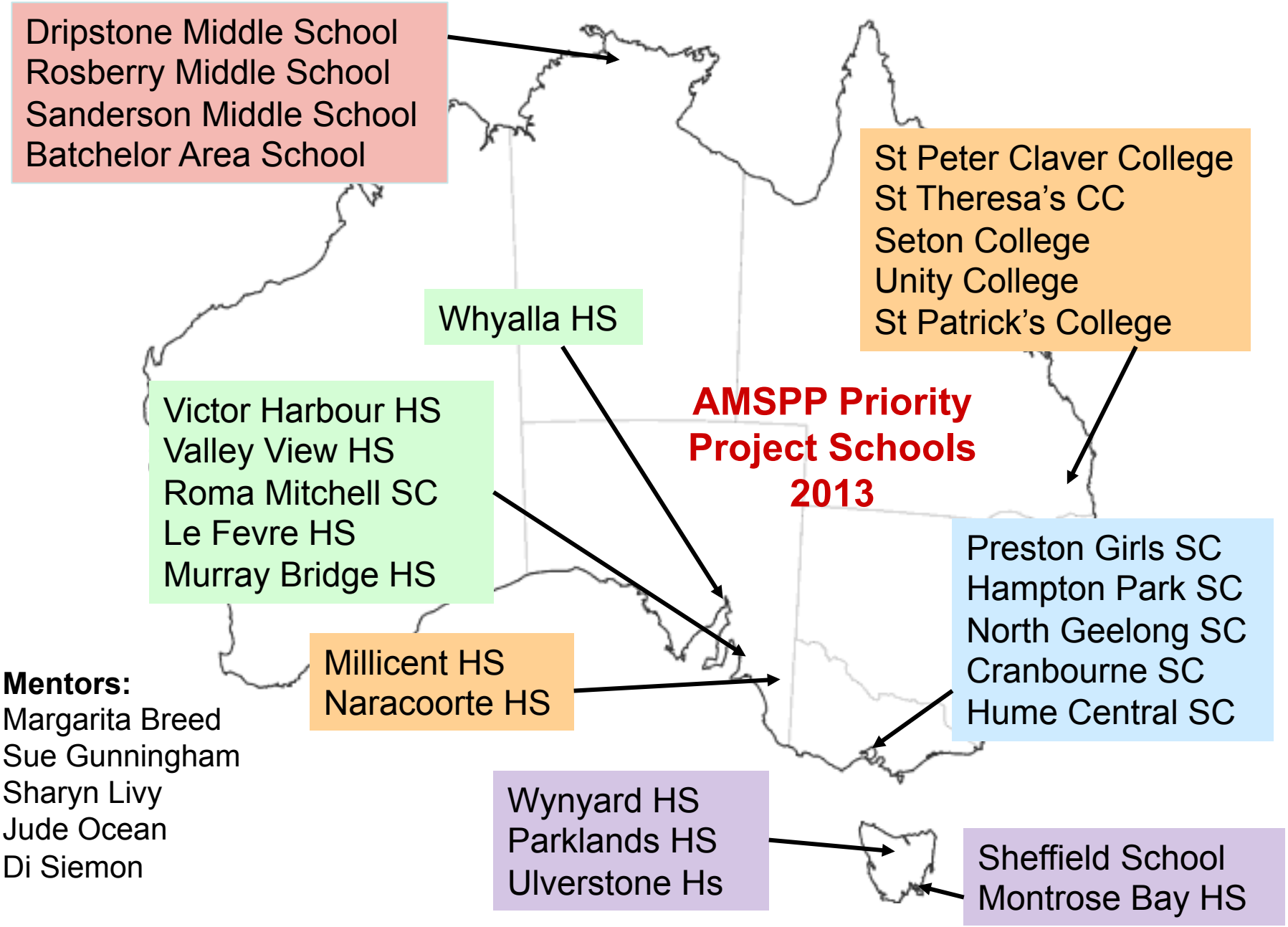
- *the need to feel **competent**,*
- *the need to feel they **belong**,*
- *the need to feel **useful**,*
- *the need to feel **potent**, and*
- *the need to feel **optimistic**.*

Sagor, R. & Cox, J. (2004). *At-risk students: Reaching them and teaching them*. Larchmont, NY: Eye on Education

Expectations of RMF Specialists:

- Identify participating teachers (two per school)
- Administer SNMY Assessment Options (at least four classes per school)
- Use project grants* to meet with team:
  - to mark and moderate SNMY responses
  - plan targeted teaching approach (when, where, how… CBUPO)
  - identify and source relevant resources and activities
  - review progress, share activities, build up resources
- Liaise with the project mentor to identify professional learning needs, seek advice
- Contribute to Collaborate sessions to share observations, resources, ideas and activities

* Two grants of $4500/school to fund time release, resources etc



Mentors:
Margarita Breed
Sue Gunningham
Sharyn Livy
Jude Ocean
Di Siemon

Data Collection:

Data collected July/August and November 2013

- Complete SNMY data sets from just over 1700 students across Years 7 to 10
- Student surveys (attitudes, perceptions of competence, belonging, usefulness, potency and optimism)
- Specialist and Teacher surveys (experience, pedagogical content knowledge, reflections)
- Field notes from school visits
- Artifacts (resources, photos, posters, planning documents)
- Student journals (where available)
- Principal report on funding, in-kind support, perceived value of project and future intentions

One school's experience:

Specialist: Natalie Banks

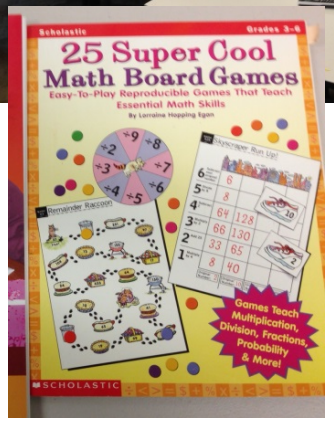
Rosebery MIDDLE SCHOOL

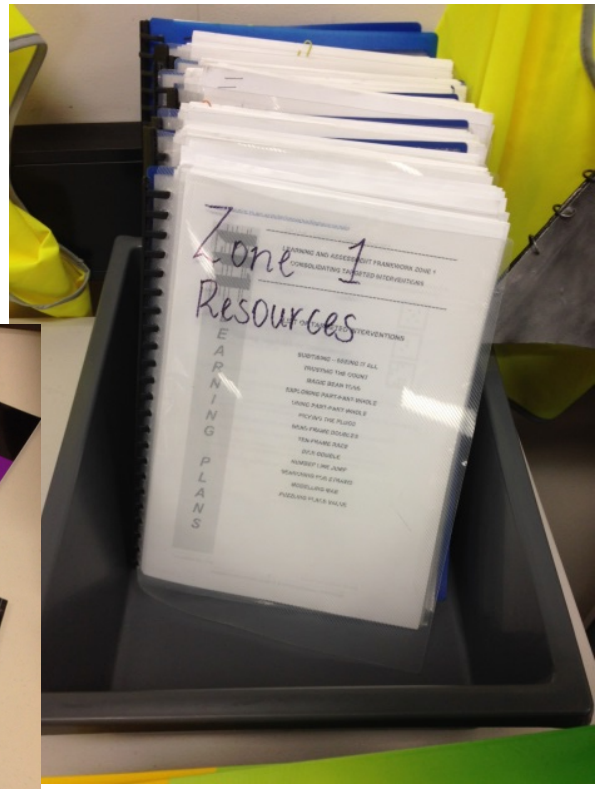
A typical timetable

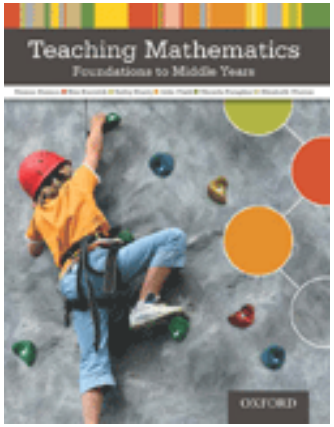
	Monday	Tuesday	Wednesday	Thursday	Friday
L1 8.00 – 9.05	English	Maths	HPE	Specialist 2	RMF
L2 9.05 – 10.05	English	science	English	Specialist 2	
Recess 10.05 – 10.40					
L3 10.40 – 11.45	Maths	Specialist 1	SOSE	Science	English
L4 11.45 – 12.50	Well Being	Specialist 1	SOSE	Science	Science
Lunch 12.50 – 1.20					
L5 1.20 – 2.20	SOSE	English	Maths	SOSE	Well Being

- 4 Year 8 classes. Do Daillies
- 2 x 50 min RMF lessons/week
- 2 classes combined for RMF lessons
- students grouped into SNMY Zones for RMF lessons
- 2 teachers and specialist (1 teacher to 2-3 Zones)

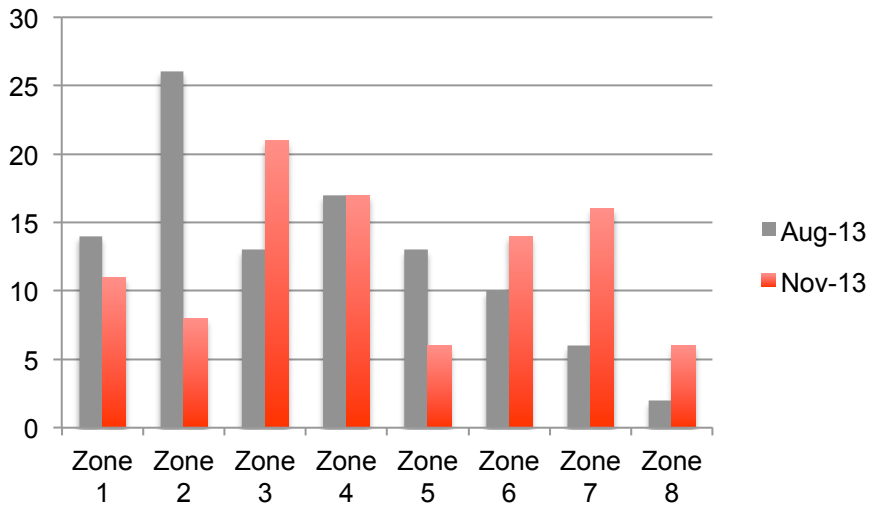
- Resources organised
- Project books provided







Results for students who completed the SNMY Tests in August and November 2013

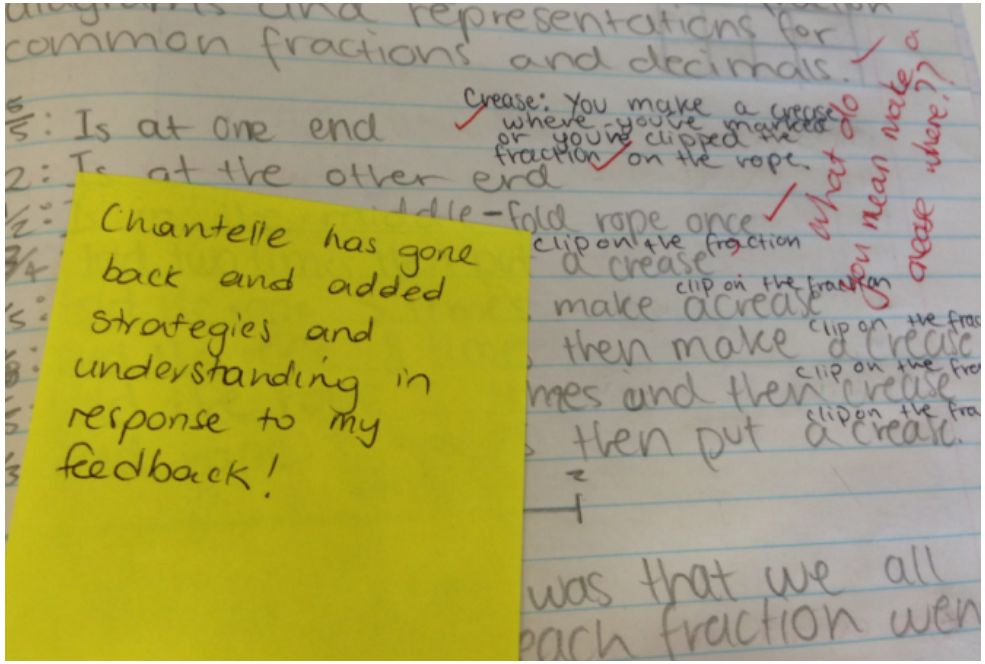


		August 2013		November 2013					
School	No. Students	Mean	SD	Mean	SD	Correl	Av. Diff	Effect Size / Year	Adj Effect Size
Rosebery Middle School	70	3.49	1.87	4.31	2.12	0.713	0.83	1.66	**1.18**

No. Zones Moved	-2	-1	0	1	2	3	4	5
No. of Students	1	13	0	18	15	4	2	1

Positives of the targeted teaching approach

- Increased engagement - reduction in challenging behaviour – improved outcomes
- Improved reflective practice of students and teachers
- Students felt empowered and there was greater ownership of their own learning
- Increased resilience … student leadership



[The] students were highly engaged and loved project time. Peer tutoring just happened. Their post surveys indicated they were enjoying maths … Students wanted to know what they needed to know to move to the next zone – this inspired them to engage even more. The student's reflections became very clearly focussed on what they learnt and what they needed to learn (Natalie Banks, 2014)

Challenges of the targeted teaching approach

- Demanding on teachers, particularly at the outset
- Providing feedback on journal entries time consuming but worth the effort
- Need to be organised, understand activities and build up resources
- Activities need to be clear and students need to access to material/resources
- ESL students need additional support
- Some students need to be encouraged to work in groups
- Need dedicated marking, moderating and planning time
- Set timetable, shared spaces and designated tutor needed for greatest benefit

Seen to be worth it!
The 'RMF targeted teaching' approach was extended to the whole school in 2014

Results for students who completed the SNMY Tests in February and November 2014

Rosebery MIDDLE SCHOOL

Year 7 (N = 136) Effect Size = **0.97**

No. Zones Moved	-3	-2	-1	0	1	2	3	4	5	6
No. of Students	1	5	10	31	31	**26**	**23**	7	1	1

Year 8 (N = 139) Effect Size = **0.4**

No. Zones Moved	-4	-3	-2	-1	0	1	2	3	4	5	6
No. of Students	2	3	10	**25**	**41**	**33**	18	5	2	0	0

Year 9 (N = 110) Effect Size = **0.37**

No. Zones Moved	-4	-3	-2	-1	0	1	2	3	4	5	6
No. of Students	3	6	5	**20**	**22**	**19**	**25**	3	6	0	1

Some issues with implementation and testing in 2014 (particularly for Year 9) but persisting with approach in 2015 and participating in RMFII

AMSPP Priority Project: SNMY Data

Complete (i.e., matched) data sets were obtained from 1732 students, with the majority of students in Year 8

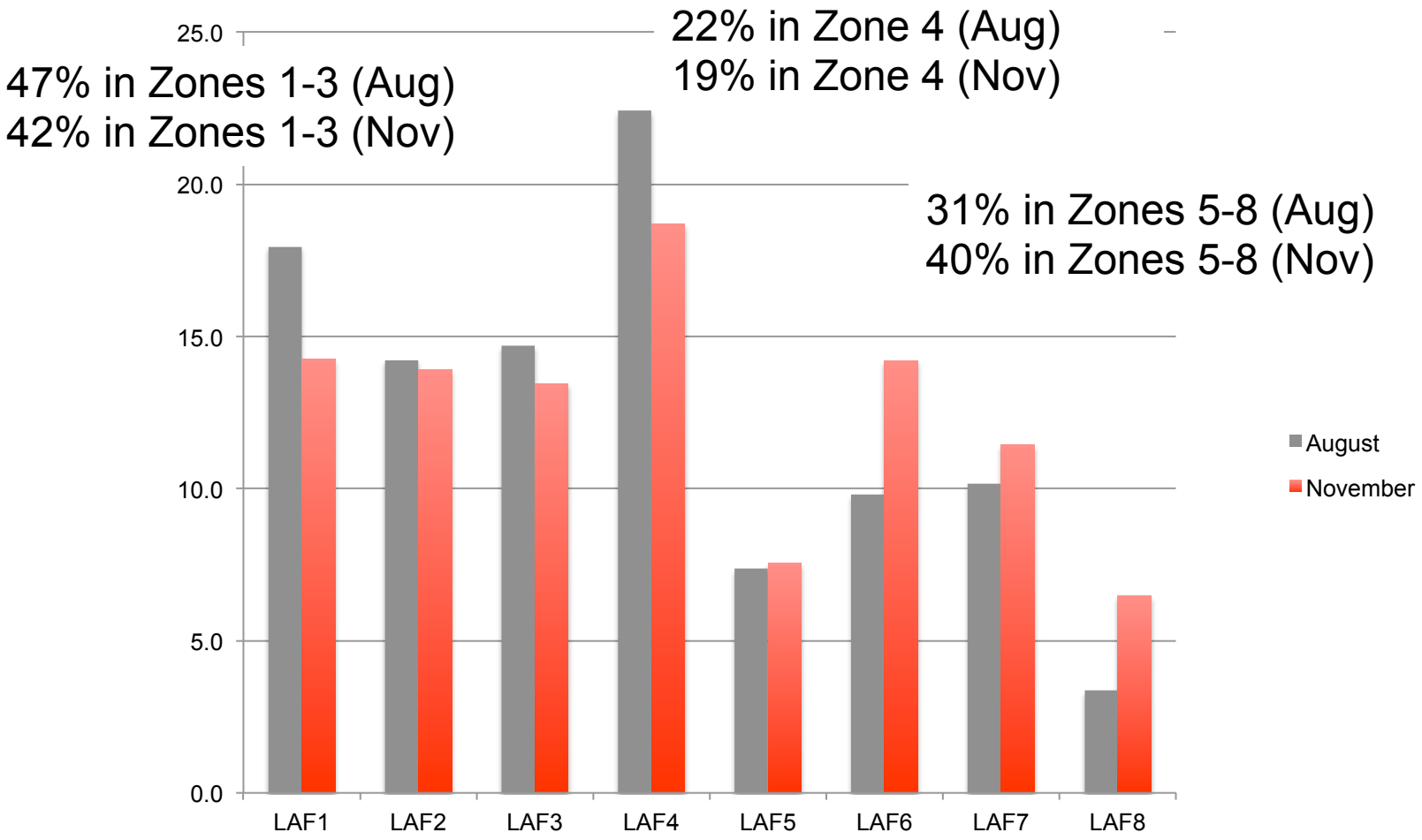
Year 7	Year 8	Year 9	Year 10
19%	59%	20%	2%

Approximate proportion of students by Year Level

Student raw scores were translated to LAF zones/levels using the SNMY Raw Score Translator.
Matched pairs were used to calculate effect size using the means and standard deviations of the pre and post test LAF zone/level data for each school.
Effect sizes were extrapolated to one year and adjusted for regression to benchmark the results.

Result: an overall adjusted effect size of 0.65, which is well above Hattie's (2012) benchmark effect size of 0.4, but considerable variation across schools

Overall improvement in student LAF Levels



Percentage of students at each LAF level, all students, August and November 2013 (N =1732)

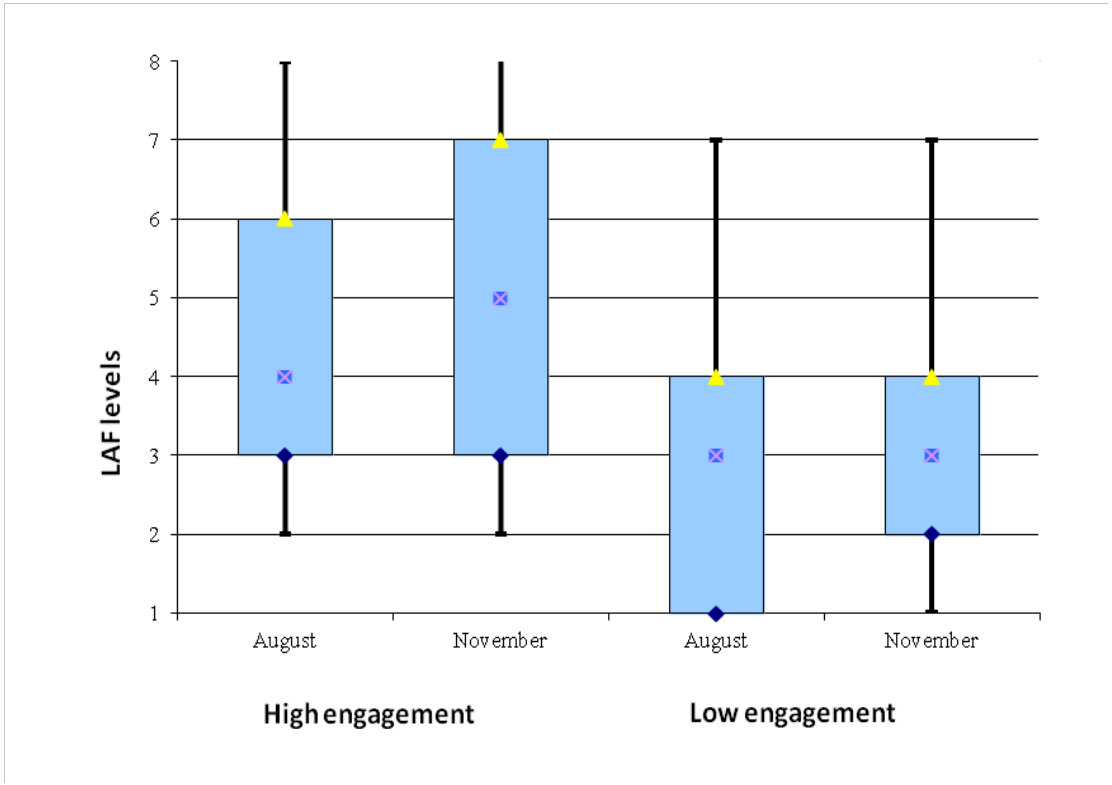
Understanding why…

Reasons for the differential results across schools, were explored at Project Workshop 2 in February 2014.

While there are a range of factors that impact student achievement, many of which are beyond the control of teachers and students, the following factors were offered as reasons for the significant improvement in student SNMY results.

- Teacher engagement with the process, use of LAF to adopt a more targeted teaching approach and share teaching ideas and resources
- Good use made of funds to support collaborative planning and resource development
- Availability of dedicated teaching spaces where differentiated resources could be stored and accessed easily
- Capacity to combine two or more classes to facilitate grouping by LAF Zones
- Team teaching and access to Specialist support staff
- Use of group work, concrete materials, student-directed activities, reflective journals and peer tutoring.

One of the recognised factors impacting student achievement is the **level of student engagement in the testing process**. As a result, in the November testing, schools were asked to rate each student by level of engagement using a scale of 1 (low) to 3 (high). While not all schools provided this data – the results are interesting for those that did.



Comparison of achievement by high and low engagement (N=928)

Student Surveys

There was no discernable difference between the Likert items (statements rated in the basis of 1 (strongly disagree) to 5 (strongly agree) in the August and November 2013 data (effect sizes very small).

However, there was some evidence of a shift in student perceptions in relation to the more direct questions concerning the **five essential feelings** included in the November Student survey (n=931 matched pairs) rated on a scale of 1 (strongly disagree) to 10 (strongly agree) (effect sizes small).

Thinking about maths …	Aug	Nov
I feel **competent**	6.6	6.5
I feel I **belong** in maths classes	5.7	6.8
I feel **useful**	5.6	6.5
I feel I have **choices** in maths	5.8	6.7
I feel **optimistic** about maths	5.5	6.4

Comparison of mean ratings on CBUPO questions, November 2013 (n=931)

Student's perceptions of school mathematics

Analysis of student responses to the two open-ended questions on the August & November Student Surveys, that is,

- What aspect of maths do you enjoy the most?
- What things about maths do you find most difficult or frustrating?

are consistent with the student interview data from the *Middle Years Numeracy Research Project* (Siemon, Virgona, & Corneille, 2001).

That is, students desire and value:

- understanding and success,
- caring, respectful teachers,
- quality explanations, and varied teaching methods.

They find algebra, fractions and decimals difficult and they resent being singled out, not receiving assistance when they need it, and off-task, classroom behaviour.

Drawing Task (McDonough, 2002)

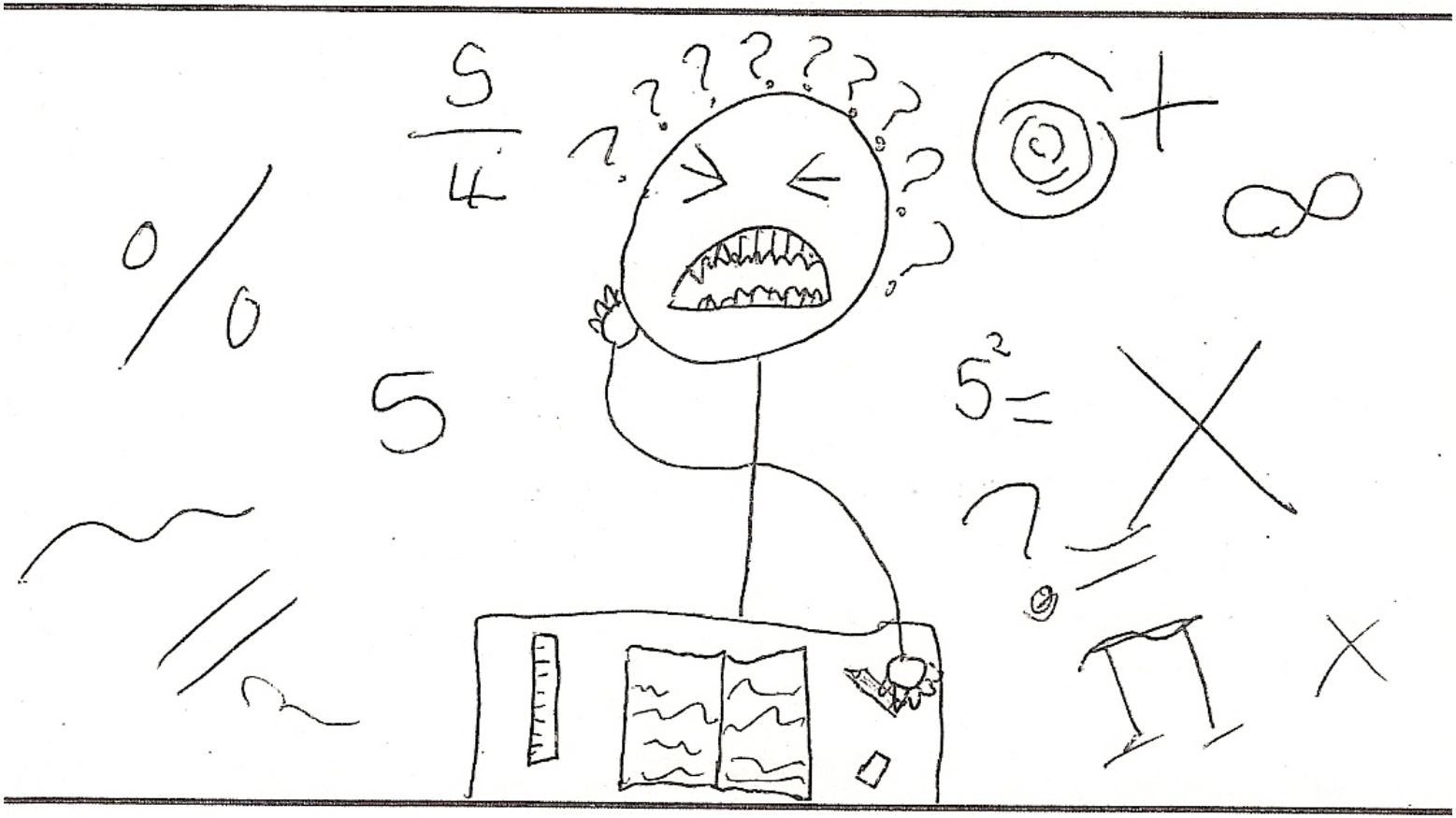
Think of a situation when you are learning maths well. Draw it. Then, describe your drawing

Responses to this task were requested in both the August and November Surveys. Some interesting trends emerged

Initial Category	% Aug	% Nov
Algorithms or text, no reference to self or others	12	7
No response, unclear/irrelevant, sad/frustrated	23	3
Sitting alone in classroom (neutral/happy expression)	15	17
Teacher and self	12	11
Working with other students	15	24
Teacher primary focus in classroom	13	14
Games, manipulatives, real-world	5	13

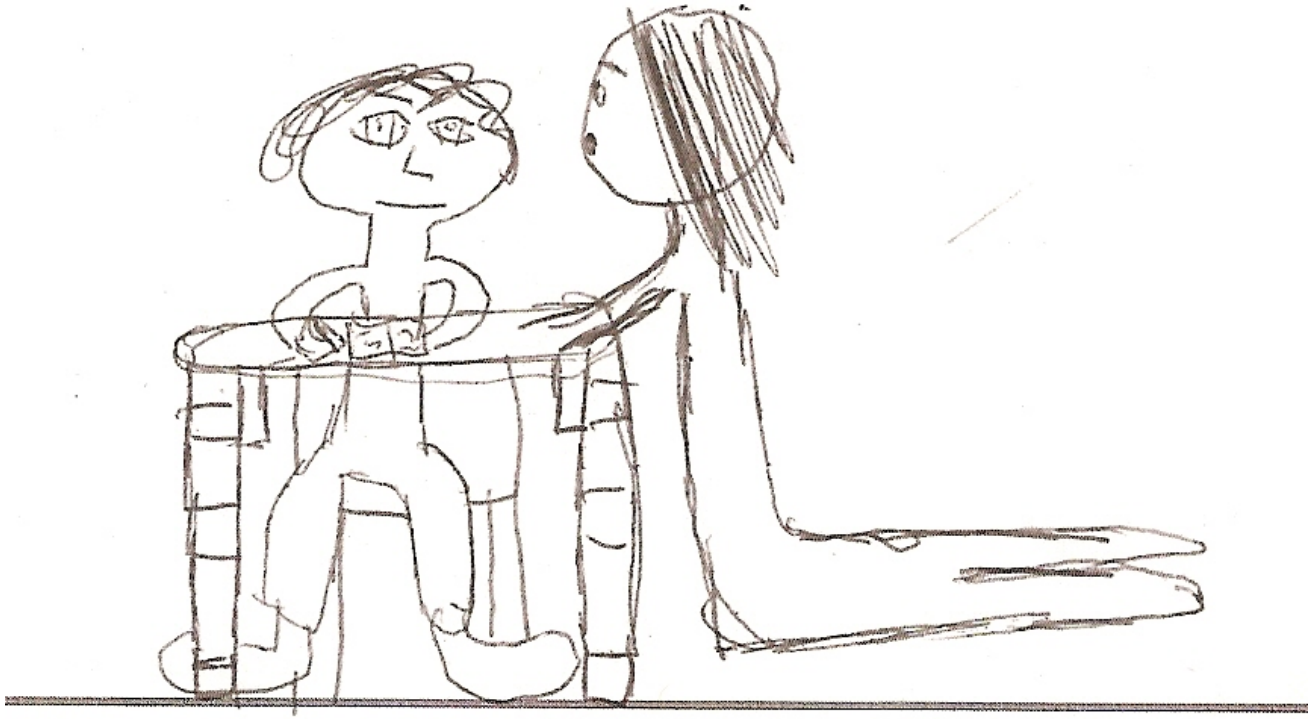
Major features of student drawings, August and November 2013 (indicative sample)

No response, unclear/irrelevant, sad/frustrated



Just confused and angry with the noise and the maths

Teacher and self



A young student is getting frustrated on a maths question, but the teacher can see ~~he~~/she needs help, so the teacher comes over and helps the stuck child.

Reframing Mathematical Futures II (AMSPP Competitive Grant Project, 2014-2017):

Aim: To build a sustainable, evidence-based, integrated learning and teaching resource to support the development of **mathematical reasoning in Years 7 to 10**

Focus: Identifying the 'Big Ideas' in algebraic, spatial and statistical thinking, implementing and evaluating a targeted teaching approach that *"covers the curriculum" …*

Partners:

- Brisbane Catholic Education Office
- Department of Education (TAS)
- Department of Education (WA)
- Department of Education and Child Development (SA)
- Department of Education and Communities (NSW)
- Department of Education and Training (VIC)
- Department of Education (NT)

RMFII Research Team:

RMIT:

- Di Siemon (Project Leader)
- Tasos Barkatsas
- Rebecca Seah
- Sandra van der Pal (Project Manager)
- Claudia Johnstone and Claudia Orrellana (Project Support)

Expert Advisory Panel:

- Rosemary Callingham and Jane Watson (University of Tasmania)
- Lorraine Day (University of Notre Dame, WA)
- Marj Horne (Australian Catholic University, Vic)
- Will Morony (AAMT)
- Max Stephens (Adjunct Professor, RMIT)
- Bruce White (University of South Australia)

- Mike Askew (Monash University)

Research Questions

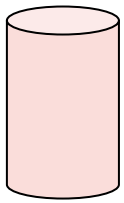
- To what extent can we develop rich tasks to accurately identify key points in the development of mathematical reasoning in the junior secondary years?
- To what extent can we gather evidence about each student's achievements with respect to these key points to inform the development of a coherent learning and assessment framework?
- To what extent does working with the tasks and the knowledge they provide about student understanding assist teachers to improve student's mathematical performance at this level?
- What strategies and/or teaching approaches are effective in scaffolding mathematical reasoning in the middle years?
- What are the key features of classroom organisation, culture and discourse needed to support/scaffold students' mathematical reasoning at this level?

Mathematical Reasoning?

… *capacity for logical thought and actions, such as analysing, evaluating, proving, explaining, inferring, justifying and generalising* (Australian Curriculum: Mathematics, ACARA, 2015, p. 5)

Mathematical reasoning is not something that students walk into your classroom knowing how to do, and what you expect of them. Rather it is a process that must be learned while you are teaching the content.
http://christenvannewkirk.weebly.com/uploads/7/6/4/9/7649111/what_is_mathematical_reasoning.pdf

Mathematical reasoning involves much more than asking 'Why …?" but it is a good start, for example,



- Why is the surface area of a solid cylinder: *height x circumference + 2 x area of the base*?
- When solving linear equations, why do you have to do the same thing to both sides of the equation?

For the purposes of the RMFII project:

Mathematical reasoning encompasses:

i. core knowledge needed to recognise, interpret, represent and analyse algebraic, spatial, statistical and probabilistic situations and the relationships/connections between them;
ii. ability to apply that knowledge in unfamiliar situations to solve problems, generate and test conjectures, make and defend generalisations; and
iii. a capacity to communicate reasoning and solution strategies in multiple ways (i.e. diagramatically, symbolically and orally).

Students are reasoning mathematically when they:

- explain their thinking,
- deduce and justify strategies used and conclusions reached,
- adapt the known to the unknown,
- transfer learning from one context to another,
- prove that something is true or false; and
- compare and contrast related ideas and explain their choices

(http://www.australiancurriculum.edu.au/mathematics/rationale)

Algebraic Reasoning:

A Year 8 student's response to Medicine Doses problem*

$$\text{Child dose} = \text{Adult dose} \times \frac{\text{Age}}{\text{Age} + 12}$$

(a) If the adult dose for a particular medication is 15 mL, what would be the appropriate dose for a 6 year-old child?

15ml x 6 = 90mL. 6+12 = 18÷90 = 5mls

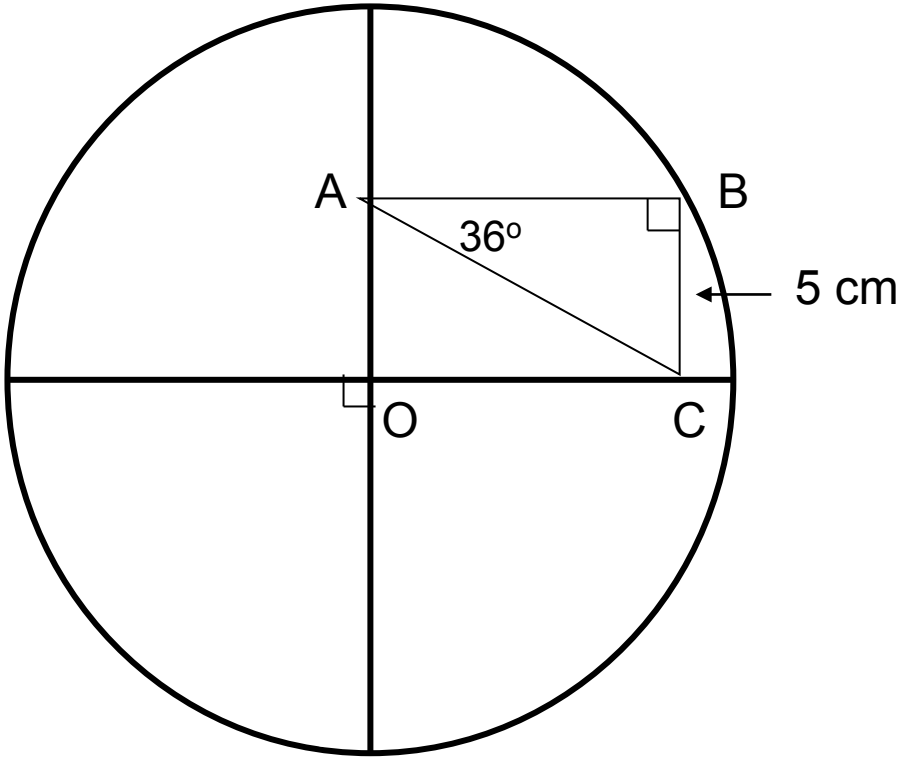
(b) A nurse used the formula to work out the dose for an 8 year-old boy. She correctly calculates it as 6 mL. What was the adult dose in this case?

15mL x 8 = 120ml 8+12 = 20÷120 = 6 mL

* Task from Beesey et al (1998), data from MYNRP (Siemon et al, 2001)

Spatial Reasoning:

What is involved in solving the following?

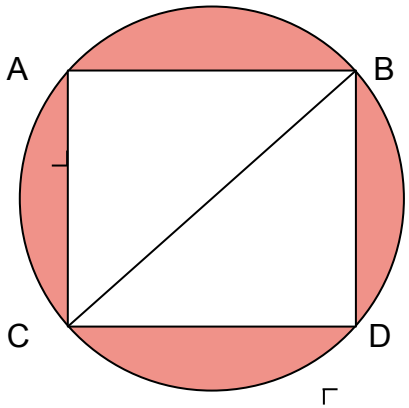


O is the centre of a circle of diameter 17 cm.

ABC is a right triangle with the dimensions shown.

What is the length of the line AC?

Find the area of the shaded part if the diameter of the circle is 22 cm and ABCD is a square



What is involved in solving the following?

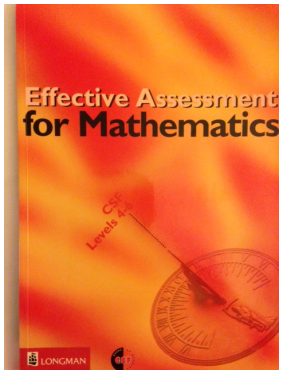
A hiker walked 3 km North, 5 km South West then 2 km East. Where was he in relation to his starting point ?

Statistical Reasoning:

Ariana had a goal-shooting average of 12 goals before the finals? In the semi-final she scored 18 goals and in the final she scored 15 goals. What was her end-of-season average?

…. connections between related concepts, confidence to use the familiar to develop new ideas (ACARA) …

Proportional Reasoning:



Seeing the forest for the trees*

The following table shows information for four countries on total land area, forest and woodland area and population.

	Total land area (sq. km)	Forest & woodland area (sq. km)	Population
Japan	376 520	251 000	124 960 000
USA	9 573 110	2 862 000	260 631 000
Australia	7 644 440	1 450 000	18 238 000
France	550 100	149 310	57 747 000

This data from public sources at the time - it would need to be updated to reflect current situation

Use the information to rank the four countries (1, 2, 3, 4) in terms of people's access to forest and woodland in these countries.

Explain clearly how you arrived at your ranking, showing all relevant calculations.

* Task from Beesey et al (1998)

Our approach:

Our approach is premised on the view that learning cannot be achieved without **accurate information about what each student knows already** and what might be within their grasp with some support from teacher and/or peers. This requires a clear understanding of:

- key mathematical ideas, representations and strategies
- how they are connected, and
- how they might be acquired over time.

Evidence-based developmental progressions/frameworks (e.g. SNMY)

But it also requires:

- **assessment techniques** that expose student thinking,
- **interpretations of what the thinking might mean** in relation to the key ideas and strategies, and
- **access to professional learning and resources** to address the particular learning needs identified.

Professional learning modules, targeted teaching resources – public access (AAMT)

Plan:

Research evidence-based learning trajectories
(developmental frameworks or HLTs)

Algebra
Lorraine Day
Marj Horne
Max Stephens

Geometry & Measurement
Tasos Barkatsas
Rebecca Seah

Statistics & Probability
Rosemary Callingham
Jane Watson

Develop and trial rich tasks to assess the key ideas, strategies and thinking identified by the learning trajectories in 2015. Use to assess student thinking in February/March 2016

Analyse student data using Rasch Modelling. Develop learning and teaching framework(s) for Mathematical Reasoning

Work with teachers to support targeted teaching approaches to Mathematical Reasoning.
Assess student thinking in November 2016

Anticipated Outcomes:

In addition to publications, an **integrated learning and teaching resource** will be developed and disseminated via a web-based portal in collaboration with the **Australian Association of Mathematics Teachers** (AAMT).

This will include:

- validated assessment tools,
- an evidence-based framework for developing mathematical reasoning across the three domains;
- targeted teaching advice for each level of the framework, and
- task-based professional learning modules aimed at deepening teacher's pedagogical content knowledge for teaching Year 7 to 10 mathematics.