

# Tracking Structural Development Through Data Modelling in Highly Able Grade 1 Students

Joanne Mulligan  
*Macquarie University*  
<joanne.mulligan@mq.edu.au>

Mike Mitchelmore  
*Macquarie University*  
<mike.mitchelmore@mq.edu.au>

Kerry Hodge  
*Macquarie University*  
<kerry.hodge@mq.edu.au>

Lyn English  
*Queensland University of Technology*  
<l.english@qut.edu.au>

A 3-year longitudinal study *Transforming Children's Mathematical and Scientific Development* integrates, through data modelling, a pedagogical approach focused on mathematical patterns and structural relationships with learning in science. As part of this study, a purposive sample of 21 highly able Grade 1 students was engaged in an innovative data modelling program. In the majority of students, representational development was observed. Their complex graphs depicting categorical and continuous data revealed a high level of structure and enabled identification of structural features critical to this development.

Our studies of early mathematical development have focused on the role of pattern and structure in promoting early algebraic thinking and generalisation (Papic, Mulligan & Mitchelmore, 2011; Mulligan, English, Mitchelmore, & Crevensten, in press). Several of these studies have shown that the provision of explicit and connected structured tasks over a school year can significantly advance the development of such mathematical processes as patterning and unitising, spatial structuring, multiplicative reasoning, and generalisation.

Aligned with these studies is the investigation of young children's data modelling and representational skills (English, 2012). With a growing emphasis on statistical reasoning in the curriculum, an integrated approach to the study of data modelling can bring much insight into young children's mathematical and scientific reasoning. This paper reports an exploratory study of how an emphasis on structuring graphical representation might enhance the development of metarepresentational competence (English, 2012). A central aim of the study was to identify explicitly the structural features that play an essential role in this development.

## Background to the study

Over the past decade, the Pattern and Structure Project at Macquarie University has aimed to find reliable methods for measuring and describing the structural growth in mathematics of 4 to 8 year olds. In a series of studies, the project has promoted a strong foundation for mathematical development by focusing on critical, underlying features of mathematics learning. The construct Awareness of Mathematical Pattern and Structure (AMPS) was developed, which our studies have shown generalises across early mathematical concepts, can be reliably measured using the Pattern and Structure Assessment (PASA) interview, and is correlated with mathematical understanding (Mulligan & Mitchelmore, 2009). AMPS has two components: not only an understanding of common mathematical structures but also a tendency to look for patterns in new situations. Our belief is that a focus on the development of AMPS can bring increased coherence to the study of learning and teaching of early mathematics. The Pattern and

Structure Mathematical Awareness Program (PASMMap) was developed concurrently with the studies of AMPS to implement a corresponding pedagogy.

A large-scale two-year longitudinal evaluation study *Reconceptualising Early Mathematics Learning* found that Kindergarten students who engaged in the PASMMap program achieved significantly higher AMPS in the middle of Grade 1 than a comparison group (Mulligan et al., in press). A subsequent longitudinal project *Transforming Children's Mathematical and Scientific Development<sup>1</sup> 2011-2013* extends the initial study with some students tracked through from 2010. This project explores the role of pattern and structure in mathematics and science learning in Grades 1 to 3 and tracks a new cohort of highly able students from Kindergarten through to Grade 2. This research integrates English's research on data modelling (English, 2012) with the study of structure.

### *Research on Data Modelling*

Data modelling is a developmental process that begins with young children's inquiries and investigations of meaningful phenomena (e.g., exploring the growth of flowering bulbs under different conditions), progressing to deciding on the factors that may have influenced the observations; and then structuring, organising, analysing, visualising and representing data; organising and displaying data in simple tables, graphs and diagrams; and analysing the data to identify any relationships or trends (Lehrer & Schauble, 2005).

A longitudinal study of data modelling in Grade 1 (English, 2010) indicated that children as young as 6 years old can successfully collect, represent, interpret, communicate, and argue about the structure of data provided that they address familiar themes. The study has revealed young children's competence in structuring and representing data they collect, together with skills in creating multiple and varied representations, in spite of minimal instruction. An understanding that their different representations show the same data has also been evident in children's responses. Children's use of various inscriptions including labelling vertical and horizontal axes of their bar graphs and the sectors in their circle graphs, and their application of appropriate scaling and colouring, illustrate their awareness of the importance of constructing data representations that are readily interpretable. Overcoming obstacles and limitations in their representational material, such as using two columns to display extended data and adjusting their scaling to accommodate a wide range of values, indicates critical and flexible thinking in their dealing with data. Innovative representations, such as applying an awareness of the structure of a heart rate monitor graph, show young children's creative links with their world and their ability to reason analogically (English, 2012).

### Theoretical Approach

Research into students' understanding of graphing has described four increasingly sophisticated stages of development (Prestructural, Unistructural, Multistructural, and Relational) ranging from simple showing attributes, methods of displaying data, to understanding relationships and variation (Watson & Fitzallen, 2010; Watson & Kelly, 2005). Prestructural representations lacked mathematical features such as countable items. At Unistructural level items were organised so that they could be counted, but at the Multistructural level arrangements were more structured, using grid-like features, for example. At the Relational level data revealed horizontal and vertical features that were

---

<sup>1</sup> Australian Research Council Discovery Project DP110103586 (2011-2013)

coordinated and ordered. To some extent, the development of our stages of structural development based on AMPS reflects the work of Watson and colleagues.

Our approach is to apply the AMPS construct to the analysis of students' development of data-structuring skills. AMPS is measured by assessing students' responses to a wide variety of mathematical tasks in terms of the critical features of the underlying structures. Responses are classified into the following five levels (Mulligan & Mitchelmore, 2009):

1. *Prestructural*. Children pick on particular features that appeal to them but are often irrelevant to the underlying mathematical concept.
2. *Emergent*. Children recognise some relevant features but are unable to organise them appropriately.
3. *Partial structural*. Children recognise most relevant features of the structure, but their representations are inaccurate or incomplete.
4. *Structural*. Children correctly represent the given structure.
5. *Advanced*. Children recognise the generality of the structure.

Applying these structural levels to the analysis of students' graphical representations requires explicit description of the structural features that students must learn. Previous research has shown that the development of data representation usually begins with pictorial or concrete icons lacking a structured organization. Students may focus on one (possibly mathematically irrelevant) aspect of the data and not use relational or metarepresentational aspects (Watson & Fitzallen, 2010). This behaviour corresponds to our prestructural and emergent levels. At the structural level, students may draw icons in rows with the correct numbers of icons vertically aligned, so that frequencies can be compared using the lengths of the rows; prestructural students would probably not align the icons. The basic structural feature here is the principle of elementary graphical representation that equal numbers can be represented by equal lengths. In the subsequent development of formal categorical and continuous graphical representation, spatial structuring is necessary in visualising and organising representations along with relational understanding of the concepts of equal spacing, unitising, coordination of axes, and scale.

The present study investigated empirically the role of all these possible structural features in the development of graphical representation. By choosing highly able students as the subjects of the investigation, it was hoped to be able to observe in a relatively short time period what otherwise might be a lengthy development.

## Method

### *Participants*

Participants were 21 students in an academically selective Grade 1 class, all male, of an independent school in an Australian city. The students ranged in age from 6 years and 1 month to 7 years and 10 months (mean 6 years and 6 months) at the beginning of Grade 1, following their participation in PASMAT during Kindergarten. Students came from high socio-economic backgrounds and a range of cultural/ethnic groups.

### *Assessment*

As measures of students' high ability, the researchers administered the Peabody Picture Vocabulary Test, 4<sup>th</sup> edition (PPVT4) (Dunn & Dunn, 2007) and the Raven Coloured Progressive Matrices (RCPM) (Raven, 2004) in October of their Kindergarten year. The median score on each test was at the 95th percentile. Students were also administered two

forms of the PASA interview at the beginning of Kindergarten and at the end of Grade 1 (Mulligan & Mitchelmore, in press). Broadly, the majority of students were classified as operating at the structural or advanced structural level at the Grade 1 interview.

### *Data Collection and Analysis*

On the basis of assessment data and in consultation with the Grade 1 classroom teacher, students were divided into two learning groups: advanced (10 students) and less advanced (11). Each group was withdrawn from the regular class mathematics lesson for one hour per fortnight for four consecutive school terms (16 sessions) for the data modelling program. A suitable room was provided for this purpose. The classroom teacher was consulted about the planning and implementation of the program and was debriefed following each session. The lead researcher and an assistant led the sessions.

All student work samples, including their own written accounts of their activities, were collected and analysed along with observation and evaluation notes taken by the researchers during and after the learning sessions. Student data were collated in a student profile. Collection of video data was not permitted. Work samples were analysed for features of AMPS and subsequently coded for level of structural development based on the features revealed. Analysis of work samples employed an iterative process for comparing prior learning with new structural features (Lesh & Lehrer, 2000). Where appropriate, comparisons were made with data drawn from the students' PASA transcript.

### *Data Modelling Learning Sessions*

An overall aim of the learning sessions was to develop a pedagogical approach to structuring data for young students prior to the use of technological tools. The program followed a series of tasks focused on several topics of interest that were relevant to the students' school learning program and incorporated a variety of opportunities for representing categorical and continuous data (*Pets in our class, Birthdays, Holiday destinations, Daily temperature, Melting ice, Growth of chickens, and Growth of onions*).

The sessions began with opportunities to discuss the topic and suggest ways of collecting and representing data. So that students could develop intuitive skills in visualising and sketching data, they were given minimal instructions on how to represent data and usually drew freehand on blank paper. Students' iterative refinement of their representations was important. After questioning of students individually about their representations from prior and present sessions, minimal scaffolds enabled them to improve the clarity and mathematical detail of their graphs. Students in the advanced group usually made two or three refinements per session; the other group made one. Students frequently compared representations and discussed similarities and differences and strategies for drawing improved graphs. Students justified their approaches to representing the data and explained the mathematical and scientific ideas inherent in the data.

## Results

We provide examples of the development of AMPS within the graphical representations created for two topics, *Our pets* and *Daily temperature*. In the first example, students were given a template of a two-way table (with columns for type of pet, tally and number) to assist in recording data they collected from the class. They were then

given a partially completed pictogram to complete. Figure 1 shows Mark's<sup>2</sup> initial attempt to represent the data without any scaffolding from the teacher. He self-corrected his one to one matching and added vertical and horizontal grid lines to structure the data. He explained that "there can only be one animal in each box if you want to count them".

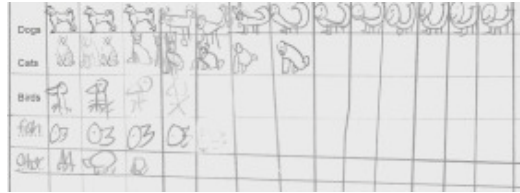


Figure 1. Mark's initial attempts to represent the data on *Our pets*.

Two weeks later we asked students to use 2 cm grid paper to record the data as a vertical pictogram, a task that most students found easy. We then asked them to reproduce their graph from memory. Figure 2a shows Mark's first attempt. Instead of different pictures, he used a single icon, a box. We may surmise that he was reproducing the boxes that contained the icons in his previous representation (Figure 1). He drew all his boxes roughly the same size and added numbers to represent the number of boxes to save the reader the effort of counting them. When asked to re-represent the data in a more accurate way, he re-drew the graph using crosses instead of boxes ("because they are easier to draw") and horizontal lines to align the crosses (Figure 2b).

Figure 2c depicts Mark's final attempt to represent the data as accurately as possible. He chose to use an even more efficient method, vertical lines, and coordinated the totals with the vertical scale. Note, however, that he did not space the vertical lines evenly. He shows relational thinking in that he returns to the table of data and shows the total number of pets as part of the graphical representation.

(a)



(b)



(c)

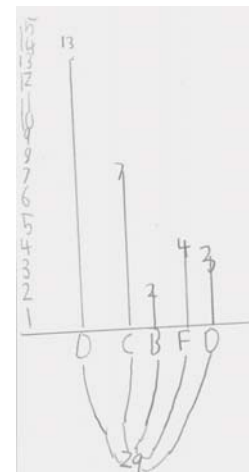


Figure 2. Mark's second set of graphs.

<sup>2</sup> Pseudonyms have been used to preserve anonymity.

In the second term of the program, students focussed on exploring representation of continuous data. The first investigation involved recording the daily temperature range in winter at various time intervals during the school day. Data for that day was retrieved from <http://www.weatherzone.com.au/nsw/sydney>. After interpreting the predicted minimum and maximum temperatures, the students then estimated the temperature at their morning session and predicted changes in temperature at 2- or 3-hour intervals for the rest of the day (some until midnight). Students used a considerable variety of representational strategies.

Edward's first graph (Figure 3a) used vertical lines instead of bars. On each line he drew a scale instead of numbers and appears to have attempted to use the same interval on all five lines. Edward also attempted to represent the temperature variation by outlining the pattern formed by the six scales—not, however, joining the tops of all of the lines.

Edward's second graph (Figure 3b) was a considerable advance. Not only did he use a common vertical scale but he recognised that it is not necessary to number every point on the scale and only labelled it at 5° intervals. It is now clear (as it was not in Figure 3a) that he was representing temperature by a point on a scale rather than an interval. Also, he correctly joined the tops of each line to show the temperature variation, but the horizontal spacing was still not correct.

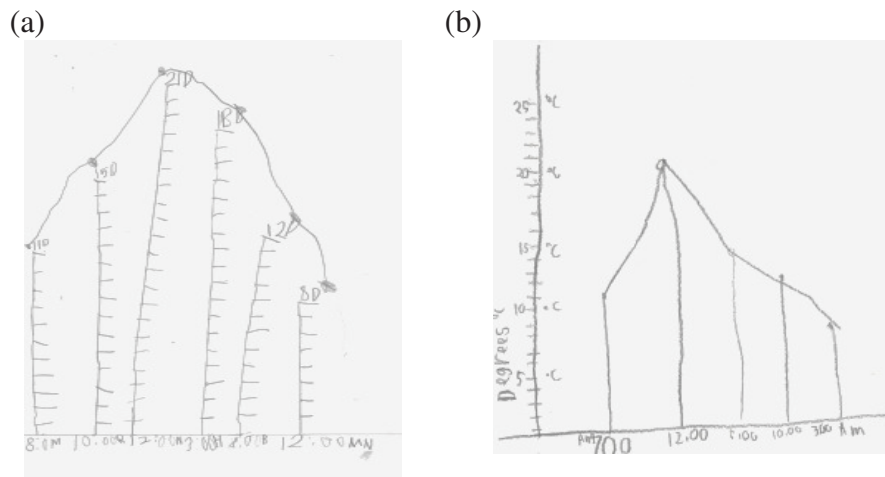


Figure 3. Edward's representations of the temperature variation.



Figure 4. Theo's temperature graph.

Figure 4 shows Theo's graph. He did not need to draw vertical lines to show each temperature point, showing that he could coordinate the vertical and horizontal axes. Notice that he has started his vertical axis at 10 instead of 0, presumably to save space, but he has again not scaled the horizontal axis correctly. Notice the students' difficulty of representing temperature variation between the measured times. They tend to 'join the dots' rather than constructing a smooth curve.

## Discussion

Our data indicated there are common structural features that must be learned about frequency (and other categorical) charts and continuous graphs. The representation of a quantity is made by vertical bars/lines of various lengths (or points that represent their maximum). A common scale must be used on each bar or line, conveniently drawn on a vertical axis to the left. This scale defines points, not intervals. Not all values on the vertical axis need to be labelled, and the bars/lines/points should be appropriately spaced horizontally.

It was also clear that there are some differences between the two types of data and a danger of inculcating false ideas using bar charts. 'Interval scales' are natural for categorical data, but it is important to construct 'point scales'. The process of drawing bars/lines of a specific height should facilitate this transformation. Equal spacing on the horizontal axis is natural for categorical data (using abbreviated labels if necessary) but is not always appropriate for continuous data. 'Joining the dots' is natural for continuous data but usually inappropriate for categorical data.

In earlier PASA studies several links to aspects of structuring were found to be crucial. For example, equally spaced scales are used for spatially representing numbers (number lines), length (ruler) and time (analogue clock); skip counting and equal spacing in 2s or 5s are needed when deciding on scales to use. The vertical-horizontal structure of graphs is identical to the structure of a rectangular grid/array and includes ideas of congruence and colinearity. Students with a good understanding of the number lines and the rectangular grid structure may therefore be able to learn graphing skills more quickly than others.

An important observation in this study was students' ability to notice and then integrate all of the elements needed to create each type of graph. The use of meaningful real-life contexts, developed as a series of topics, meant that the concept of graph was built over time from experiencing different examples in different contexts. Allowing young students to create their own pictographs initially, without scale, was a basis for developing concepts of attribute, frequency and variation, to which they could later add scale.

Our data support the findings of English's (2012) analysis of representations in data modelling contexts. We found early representations were critical in assisting young children to extract meaning from their data (Konold & Higgins, 2003). We found a diverse range of icons, including structural features such as grid lines and symbols that reflected student's individual forms of representation. Further, the ability of these students to reflect upon and refine (re-represent) their representations was impressive. Students' lack of understanding of structure can remain hidden when they only face tasks where the structure is provided for them. In all the examples we have shown, drawing and refinement has been more revealing. Such tasks also challenge children to rehearse the structural features they have seen, and apparently understood at a superficial level, and to use these patterns to gain a deeper understanding of structure.

## Conclusions and Implications

Our data enabled an exploratory analysis of the structural development of data modelling focused on graphing. We found that young, highly able students can develop over a short period of time critical developmental features that might be difficult to observe and describe systematically with less able students. While this sample indicated a risk of underestimating young children's capacity for metarepresentational competence, our findings do not permit generalisation. Nevertheless, we have been able to describe critical features that can be shaped into a pedagogical framework for data modelling. Implementation of curriculum priorities in statistical reasoning and associated teacher pedagogical learning may then be more easily achieved.

## Acknowledgements

The research reported in this paper was supported by Australian Research Council Discovery Projects Grant No. DP110103586, *Transforming children's mathematical and scientific development: A longitudinal study*. The authors express thanks to Nathan Crevensten and Susannah Hudson, the Grade 1 teacher and the school community.

## References

- Dunn, L. M., & Dunn, D. M. (2007). *Peabody picture vocabulary test* (4th ed.). Bloomington, IN: Pearson Education.
- English, L. D. (2010). Young children's early modelling with data. *Mathematics Education Research Journal*, 22(2), 24-47.
- English, L. D. (2012). Data modelling with first-grade students. *Educational Studies in Mathematics Education*, 81, 15-30.
- Konold, C., & Higgins, T. L. (2003). Researching about data. In J. Kilpatrick, W. G. Martin, & D. Schifter, D. (Eds.), *A research companion to principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.
- Lesh, R., & Lehrer, R. (2000). Iterative refinement cycles for videotape analyses of conceptual change. In R. Lesh & A. Kelly (Eds.), *Research design in mathematics and science education* (pp. 665-708). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Lehrer, R., & Schauble, D. (2005). Developing modeling and argument in elementary grades. In T. Romberg, T. Carpenter, & F. Dremock (Eds.), *Understanding mathematics and science matters* (pp. 29-53). NJ: Erlbaum.
- Mulligan, J. T., & Mitchelmore, M. C. (in press). *The Pattern and Structure Assessment—Early mathematics*. Melbourne, VIC: ACER.
- Mulligan, J. T., & Mitchelmore, M. C. (2009). Awareness of pattern and structure in early mathematical development. *Mathematics Education Research Journal*, 21(2), 33-49.
- Mulligan, J. T., English, L. D., Mitchelmore, M. C., & Crevensten, N. (in press). Reconceptualising early mathematics learning: The fundamental role of pattern and structure. In L. D. English & J. T. Mulligan (Eds.), *Reconceptualizing early mathematics learning*. New York: Springer.
- Papic, M., Mulligan, J. T., & Mitchelmore, M. C. (2011). Assessing the development of preschoolers' mathematical patterning. *Journal for Research in Mathematics Education*, 42(3), 237-268.
- Raven, J. (2004). *Coloured progressive matrices and Crichton vocabulary scale—Manual*. London: Pearson.
- Watson, J., & Fitzallen, N. (2010). *The development of graph understanding in the mathematics curriculum: Report for the New South Wales Department of Education and Training*. Sydney: NSW Department of Education & Training.
- Watson, J. M., & Kelly, B. A. (2005). The winds are variable: Student intuitions about variation. *School Science and Mathematics*, 105, 252-269.





Mathematics Education Research Group of  
Australasia Incorporated

## MERGA36 – 2013



### Mathematics Education: Yesterday, Today and Tomorrow

Proceedings of the 36th annual conference of the  
Mathematics Education Research Group of Australasia

Volume 1

Edited by  
Vicki Steinle  
Lynda Ball  
Caroline Bardini

Mathematics Education: Yesterday, Today and Tomorrow Volume 1

Proceedings of the 36th annual conference of the  
Mathematics Education Research Group of Australasia

Edited by Vicki Steinle, Lynda Ball & Caroline Bardini

© Mathematics Education Research Group of Australasia Inc., 2013

ISBN 978 0 7340 4844 8



MERGA Inc.  
GPO Box 2747  
Adelaide, SA 5001  
[www.merga.net.au](http://www.merga.net.au)

The 36th annual conference of the Mathematics Education Research Group  
of Australasia was held at the Melbourne Graduate School of Education,  
University of Melbourne, Victoria, Australia, from 7 – 11 July 2013

**Local Organising Committee:**

Vicki Steinle (Conference Convenor)

Lynda Ball

Caroline Bardini

Mal Cocking

John Dowsey

Gail Fitzsimons

Derek Holton

Anthony Jones

Cath Pearn

Robyn Pierce

Beth Price

Kaye Stacey

Max Stephens

Roger Wander

**Administrative assistance:**

Michelle Borzi

Emily Bowser

Pam Firth

Fiona Luck

**Conference logo designer:** Helen Chick

**Conference Sponsor:** The University of Melbourne

## PREFACE

Proceedings of the 36<sup>th</sup> Annual Conference of the Mathematics Education Group of Australasia (MERGA 2013) have been compiled in two volumes. The 2013 Conference was hosted by the Graduate School of Education at the University of Melbourne, the first time the conference has been held in Melbourne since 2005. The theme of the conference was *Mathematics Education: Yesterday, Today and Tomorrow*. One feature of the 2013 annual MERGA conference was the shared common day with the Australian Association of Mathematics Teachers. MERGA presentations comprised research papers, symposia, posters, round tables and short communications, and covered a wide variety of topics relevant to mathematics education across all countries, but with a particular focus on the Australasia region. Research into mathematics education at primary, secondary and tertiary levels of education was covered.

In accordance with the established MERGA procedures all research papers and symposium papers were blind peer-reviewed, as were the abstracts for short communications, round tables, and posters. Research papers were accepted for both publication and presentation or for presentation only. Volume 1 of the proceedings contains the keynote papers, the practical implications award paper and about half of the research papers that were accepted for publication; the remaining research papers together with the abstracts of short communications, round tables and posters, and the symposium papers are included in Volume 2.

The Editorial Team are thanked for their diligent efforts in ensuring that all papers used the MERGA conference paper template and adhered to the set page limit for all proposals. Where format changes were required the Editorial Team made modifications in consultation with the authors. Consequently the authors remain solely responsible for the contents of their papers. We believe that the proceedings will constitute a worthwhile resource for both the participants and researchers with an interest in mathematics education.

Editors:

Vicki Steinle

Lynda Ball

Caroline Bardini

# MERGA36 - 2013



## Mathematics Education: Yesterday, Today and Tomorrow

Proceedings of the 36th annual conference of the  
Mathematics Education Research Group of Australasia

### KEYNOTES

AUTHORS	TITLE	PAGE
Brian Butterworth	The Mathematical Brain and Numeracy (abstract)	<a href="#">1</a>
Yoshinori Shimizu	Working at the Intersection of Research and Practice: A Perspective on the Study and Improvement of Mathematics Lessons	<a href="#">2</a>
Kaye Stacey	Bringing Research on Students' Understanding into the Classroom through Formative Assessment	<a href="#">13</a>
Gloria Stillman	<b><i>Annual Clements Foyster Lecture:</i></b> Problem Finding, Problem Posing, Problem Solving: Mathematics Education Research - Yesterday, Today, Tomorrow (abstract)	<a href="#">22</a>

### PRACTICAL IMPLICATIONS AWARD

Peter Gould	Changes in Students' Notation When Fractions Exceed One-Whole	<a href="#">25</a>
-------------	---	--------------------

# RESEARCH PAPERS

Probing Students' Numerical Misconceptions in School Algebra <i>Zarina Akhtar &amp; Vicki Steinle</i>	<a href="#"><u>36</u></a>
Mapping Students' Spoken Conceptions of Equality <i>Megan Anakin</i>	<a href="#"><u>44</u></a>
Mathematics Teachers' Perceptions of their Students' Mathematical Competence: Relations to Mathematics Achievement, Affect, and Engagement in Singapore and Australia <i>Shaljan Areepattamannil &amp; Berinderjeet Kaur</i>	<a href="#"><u>52</u></a>
Integrating iPads into Primary Mathematics Pedagogies: An Exploration of Two Teachers' Experiences <i>Catherine Attard</i>	<a href="#"><u>58</u></a>
Respectful and Responsive Pedagogies for Mathematics and Statistics <i>Robin Averill &amp; Megan Clarke</i>	<a href="#"><u>66</u></a>
Using a Modified Form of Lesson Study to Develop Students' Relational Thinking in Years 4, 5 & 6 <i>Lei Bao &amp; Max Stephens</i>	<a href="#"><u>74</u></a>
Technology Prompts New Understandings: The Case of Equality <i>Caroline Bardini, Reinhard Oldenburg, Kaye Stacey &amp; Robyn Pierce</i>	<a href="#"><u>82</u></a>
Teacher Identity and Numeracy: Developing an Analytic Lens for Understanding Numeracy Teacher Identity <i>Anne Bennison &amp; Merrilyn Goos</i>	<a href="#"><u>90</u></a>
Translation of Data from a Real-life Context into Graphical Representations <i>Casandra Blagdanic &amp; Mohan Chinnappan</i>	<a href="#"><u>98</u></a>
Teaching Roles in Technology-Rich Teaching and Learning Environments (TRTLE's) <i>Jill Brown</i>	<a href="#"><u>106</u></a>
Identification of Hierarchies of Student Learning about Percentages using Rasch Analysis <i>Joan Burfitt</i>	<a href="#"><u>114</u></a>
Use of Learning Trajectories to Examine Pre-service Teachers' Mathematics Knowledge for Teaching Area and Perimeter: <i>Barbara Butterfield, Tricia Forrester, Faye McCallum &amp; Mohan Chinnappan</i>	<a href="#"><u>122</u></a>
Gender Differences in Children's Mathematics Achievement: Perspectives from the Longitudinal Study of Australian Children <i>Colin Carmichael</i>	<a href="#"><u>130</u></a>
Relationship Between Mathematics Anxiety and Attitude Towards Mathematics among Indian Students <i>Mini Chaman &amp; Rosemary Callingham</i>	<a href="#"><u>138</u></a>

Using Photographs and Diagrams to Test Young Children's Mass Thinking <i>Jill Cheeseman &amp; Andrea McDonough</i>	<a href="#">146</a>
Teachers' Views of the Challenging Elements of a Task <i>Jill Cheeseman, Doug Clarke, Anne Roche &amp; Karen Wilson</i>	<a href="#">154</a>
Posing Problems to Understand Children's Learning of Fractions <i>Lu Pien Cheng</i>	<a href="#">162</a>
Educating Boris: An Examination of Pedagogical Content Knowledge for Mathematics Teacher Educators <i>Helen Chick &amp; Kim Beswick</i>	<a href="#">170</a>
Translating Between and Within Representations: Mathematics As Lived Experiences and Interactions <i>Philemon Chigeza</i>	<a href="#">178</a>
Productive Mathematical Noticing: What It Is and Why It Matters <i>Ban Heng Choy</i>	<a href="#">186</a>
Designing Tasks to Promote and Assess Mathematical Transfer in Primary School Children <i>Julie Clark, Shaileigh Page &amp; Steve Thornton</i>	<a href="#">194</a>
Accelerating the Mathematics Learning of Low Socio-Economic Status Junior Secondary Students: An Early Report <i>Tom Cooper, David Nutchey &amp; Edlyn Grant</i>	<a href="#">202</a>
Thoughts Behind the Actions: Exploring Preservice Teachers' Mathematical Content Knowledge <i>Leah Daniel &amp; Josephine Balatti</i>	<a href="#">210</a>
Sticking With It or Doing It Quickly: What Performances Do We Encourage In Our Mathematics Learners? <i>Lisa Darragh</i>	<a href="#">218</a>
Pre-service Secondary Mathematics Teachers' Reflections on Good and Bad Mathematics Teaching <i>Hem Dayal</i>	<a href="#">226</a>
When Practice Doesn't Lead to Retrieval: An Analysis of Children's Errors with Simple Addition <i>Celeste de Villiers &amp; Sarah Hopkins</i>	<a href="#">234</a>
Making Connections Between Multiplication and Division <i>Ann Downton</i>	<a href="#">242</a>
How Heavy is my Rock? An Exploration of Students' Understanding of the Measurement of Weight <i>Michael Drake</i>	<a href="#">250</a>
How Do Adults Perceive, Analyse and Measure Slope? <i>Bruce Duncan &amp; Helen Chick</i>	<a href="#">258</a>
Great Expectations: Teaching Mathematics in English to Indigenous Language Speaking Students <i>Cris Edmonds-Wathen</i>	<a href="#">266</a>

Beginning Inference in Fourth Grade: Exploring Variation in Measurement <i>Lyn English &amp; Jane Watson</i>	<a href="#">274</a>
Scaffolding the Mathematics Learning of Low-attaining Students Through Whole Class Discussions <i>Sarah Ferguson</i>	<a href="#">282</a>
Inquiry-Based Argumentation in Primary Mathematics: Reflecting on Evidence <i>Jill Fielding-Wells</i>	<a href="#">290</a>
The Make it Count Project: NAPLAN Achievement Evaluation <i>Helen Forgasz, Gilah Leder &amp; Jennifer Halliday</i>	<a href="#">298</a>
Students 'Holding' the Moment: Learning Mathematics in an Inquiry Mathematics Classroom <i>Kym Fry</i>	<a href="#">306</a>
Students and Real World Applications: Still a Challenging Mix <i>Peter Galbraith</i>	<a href="#">314</a>
Students Using Digital Technologies to Produce Screencasts That Support Learning in Mathematics <i>Linda Galligan &amp; Carola Hobohm</i>	<a href="#">322</a>
Exploring the Demands and Opportunities for Numeracy in the Australian Curriculum: English <i>Vince Geiger, Merrilyn Goos, Shelley Dole, Helen Forgasz &amp; Anne Bennison</i>	<a href="#">330</a>
Children's Mathematical Knowledge Prior to Starting School <i>Ann Gervasoni &amp; Bob Perry</i>	<a href="#">338</a>
Longitudinal Progress of 6-year-old Students Who Participated in an 'Extending Mathematical Understanding' Mathematics Intervention Program <i>Ann Gervasoni, Linda Parish, Carole Livesey, Melissa Croswell, Kate Bevan, Teresa Hadden &amp; Kathie Turkenburg</i>	<a href="#">346</a>
Measuring Mathematics Teacher Educators' Knowledge of Technology Integrated Teaching: Instrument Development <i>Seyum Tekeher Getenet &amp; Kim Beswick</i>	<a href="#">354</a>
Principals' Views on the Importance of Numeracy as Children Start Primary School <i>Wendy Goff, Sue Dockett &amp; Bob Perry</i>	<a href="#">362</a>
Mathematics Education as a Practice: A Theoretical Position <i>Peter Grootenboer &amp; Christine Edwards-Groves</i>	<a href="#">370</a>
Apps for Mathematics Learning: A Review of 'Educational' Apps from the iTunes App Store <i>Kate Highfield &amp; Kristy Goodwin</i>	<a href="#">378</a>
What Teachers See When Watching Others Teach <i>Louise Hodgson</i>	<a href="#">386</a>

Pre-service Primary Teachers' Choice of Mathematical Examples: Formative Analysis of Lesson Plan Data <i>Ray Huntley</i>	<a href="#">394</a>
Mathematical Engagement Skills <i>Naomi Ingram</i>	<a href="#">402</a>
Early-Years Swimming: Creating Opportunities for Adding Mathematical Capital to Under 5 <i>Robyn Jorgensen</i>	<a href="#">410</a>
Relationships of Out-of-School-Time Mathematics Lessons to Mathematical Literacy in Singapore and Australia <i>Berinderjeet Kaur &amp; Shaljan Areepattamannil</i>	<a href="#">418</a>
Maths Education: Is There An App For That? <i>Kevin Larkin</i>	<a href="#">426</a>
Transactional Distance Theory (TDT): An Approach to Enhancing Knowledge and Reducing Anxiety of Pre-Service Teachers Studying a Mathematics Education Course Online <i>Kevin Larkin &amp; Romina Jamieson-Proctor</i>	<a href="#">434</a>
Foundation Content Knowledge: What Do Pre-Service Teachers Need To Know? <i>Chris Linsell &amp; Megan Anakin</i>	<a href="#">442</a>
Pre-service Teachers' Responses for Ratio and Proportion Items <i>Sharyn Livy &amp; Sandra Herbert</i>	<a href="#">450</a>
From Curriculum to Workplace Requirements: Do They 'Match'? <i>Gregor Lomas &amp; Kelvin Mills</i>	<a href="#">458</a>
Primary School Teachers' Perceptions of Mathematical Reasoning <i>Esther Yook-Kin Loong, Colleen Vale, Leicha Bragg &amp; Sandra Herbert</i>	<a href="#">466</a>
Pre-Service Teachers' Pedagogical Content Knowledge: Implications for teaching <i>Margaret Marshman &amp; Glorianne Porter</i>	<a href="#">474</a>
Does an Ability to Pattern Indicate That Our Thinking is Mathematical? <i>Catherine McCluskey, Michael Mitchelmore &amp; Joanne Mulligan</i>	<a href="#">482</a>
When a Mathematics Support Pilot Program Fails Miserably: Looking For Answers <i>Keith McNaught</i>	<a href="#">490</a>
Student Preferences in the Design of Worked Solutions in Undergraduate Mathematics <i>David Mendiola</i>	<a href="#">498</a>
Using Semiotic Resources to Build Images When Teaching the Part-Whole Model of Fractions <i>Paula Mildenhall</i>	<a href="#">506</a>
Insight into Subtraction from Large-Scale Assessment Data <i>Patricia Morley</i>	<a href="#">514</a>



Helpwithmaths.com: Students' Use of Online Mathematical Resources <i>Tracey Muir</i>	<a href="#">522</a>
Tracking Structural Development Through Data Modelling in Highly Able Grade 1 Students <i>Joanne Mulligan, Kerry Hodge, Michael Mitchelmore &amp; Lyn English</i>	<a href="#">530</a>
Young Children Talking in Mathematics: What is the Point of That? <i>Carol Murphy</i>	<a href="#">538</a>
How Pre-Service Teachers Integrate Knowledge of Students' Difficulties in Understanding the Concept of the Arithmetic Mean Into Their Pedagogy <i>Theodosia Prodromou</i>	<a href="#">546</a>
Coordination of Fractional Quantities: Cueing of Resources, Constraints, and Effect of Numeric Structure <i>Ajay Ramful &amp; Rajeev Nenduradu</i>	<a href="#">554</a>
Pre-Service Teachers' Understanding of Measures of Centre: When the Meaning Gets Lost? <i>Robyn Reaburn</i>	<a href="#">562</a>
Students' Understanding of Conditional Probability on Entering University <i>Robyn Reaburn</i>	<a href="#">570</a>
Using Tablet PCs For Active Learning: Learning From Others' Mistakes <i>Daphne Robson &amp; Dave Kennedy</i>	<a href="#">578</a>
Entering the 'New Frontier' of Mathematics Assessment: Designing and Trialling the PVAT-O (online). <i>Angela Rogers</i>	<a href="#">586</a>
Overcoming Challenges of Being an In-Field Mathematics Teacher in Indigenous Secondary School Classrooms <i>Satwant Sandhu, Gillian Kidman &amp; Tom Cooper</i>	<a href="#">594</a>
What Financial Dilemmas Reveal About Students' Social and Mathematical Understandings <i>Carly Sawatzki</i>	<a href="#">602</a>
iPads: Improving Numeracy Learning in the Early Years <i>Peta Spencer</i>	<a href="#">610</a>
Classroom Culture, Challenging Mathematical Tasks and Student Persistence <i>Peter Sullivan, Amanda Aulert, Alli Lehmann, Brendan Hislop, Owen Shepherd &amp; Alan Stubbs</i>	<a href="#">618</a>
Teachers' Decisions About Mathematics Tasks When Planning <i>Peter Sullivan, David Clarke, Doug Clarke &amp; Anne Roche</i>	<a href="#">626</a>
Students Understanding of Everyday English and Kimberley Kriol in Mathematics Classroom <i>Kaye Treacy</i>	<a href="#">634</a>
PCK and Average <i>Jane Watson &amp; Rosemary Callingham</i>	<a href="#">642</a>

The Influence of Mathematical Beliefs on Low-Achieving Adult Learners <i>Damon Whitten</i>	<a href="#">650</a>
High Performance, Confidence and Disinclination to Explore: A Case Study <i>Gaye Williams</i>	<a href="#">658</a>
Mature Age Pre-Service Teachers' Mathematics Anxiety and Factors Impacting on University Retention <i>Sue Wilson</i>	<a href="#">666</a>
Mathematics Networks and Curriculum Concepts <i>Geoff Woolcott</i>	<a href="#">674</a>
Pre-Service Teachers' Concept Image for Circle and Ellipse <i>Vince Wright</i>	<a href="#">682</a>
Constructing a Frame of Cube: Connecting 3D Shapes with Direction, Location and Movement <i>Andy Yeh</i>	<a href="#">690</a>

## **SYMPOSIA**

Learning the Work of Ambitious Mathematics Teaching <i>Glenda Anthony &amp; Roberta Hunter</i>	<a href="#">699</a>
Using Instructional Activities to Learn the Work of Ambitious Mathematics in Pre-service Teacher Education Settings <i>Roberta Hunter, Jodie Hunter &amp; Glenda Anthony</i>	<a href="#">703</a>
Coaching Pre-service Teachers for Teaching Mathematics: The Views of Students <i>Robin Averill, Michael Drake &amp; Roger Harvey</i>	<a href="#">707</a>
<hr/>	
Implementing the Japanese Problem-Solving Lesson Structure <i>Susie Groves</i>	<a href="#">711</a>
Mathematical Tasks and Learning Goals: Examples from Japanese Lesson Study <i>Brian Doig</i>	<a href="#">715</a>
Primary teachers' algebraic thinking: Example from Lesson Study <i>Colleen Vale</i>	<a href="#">719</a>
Creating Teacher Communities of Inquiry through Lesson Study <i>Wanty Widjaja</i>	<a href="#">723</a>
<hr/>	
Four Factors to Consider in Helping Low Achievers in Mathematics <i>Leong Yew Hoong, Tay Eng Guan &amp; Yap Sook Fwe</i>	<a href="#">727</a>
Helping Low Achievers develop a Problem Solving Disposition <i>Quek Khiok Seng, Yap Sook Fwe &amp; Tong Cherng Luen</i>	<a href="#">731</a>
Positive Feelings towards the learning of Mathematics for low achievers <i>Tong Cherng Luen, Leong Yew Hoong &amp; Quek Khiok Seng</i>	<a href="#">735</a>

The Odd Couple: The Australian NAPLAN and Singaporean PSLE <i>Jane Greenlees</i>	<a href="#">739</a>
The Classic Word Problem: The Influence of Direct Teaching <i>Tracy Logan &amp; Siew Yin Ho</i>	<a href="#">743</a>
Students' Performance on a Symmetry Task <i>Siew Yin Ho &amp; Tracy Logan</i>	<a href="#">747</a>
Cross-Country Comparisons of Student Sense Making: The Development of a Mathematics Processing Framework <i>Tom Lowrie</i>	<a href="#">751</a>
Inquiry-Based Learning in Mathematics: Designing Collaborative Research with Schools <i>Katie Makar &amp; Shelley Dole</i>	<a href="#">755</a>
Achievements and Challenges Encountered by Classroom Teachers Involved in a Research Project: A Reflection <i>Sue Allmond &amp; Karen Huntly</i>	<a href="#">759</a>
Guided Inquiry as a Model for Curriculum Resources in Mathematics <i>Christine Debritz &amp; Rhonda Horne</i>	<a href="#">763</a>
Building Relationships Between State Stakeholders and Researchers: People, Persistence and Passion <i>Rhonda Horne &amp; Katie Makar</i>	<a href="#">767</a>
Noticing Young Children's Mathematical Strengths and Agency <i>Sue Dockett &amp; Wendy Goff</i>	<a href="#">771</a>
Researchers Noticing Young Children's Mathematics <i>Barbara Clarke</i>	<a href="#">775</a>
Visual Stimuli that Prompt Young Children to Notice their Mathematical Thinking: Two Researchers' Experiences <i>Amy MacDonald &amp; Jill Cheeseman</i>	<a href="#">779</a>
Preschool and School Educators Noticing Young Children's Mathematics <i>Bob Perry</i>	<a href="#">783</a>
Learning from the Implementers in a Design Experiment <i>Toh Tin Lam, Dindyal Jaguthsing &amp; Tay Eng Guan</i>	<a href="#">787</a>
Fine-tuning in a Design Experiment <i>Ho Foo Him, Toh Pee Choon &amp; Toh Tin Lam</i>	<a href="#">791</a>
Scaffolding Cards: A Strategy for Facilitating Groups in Problem Solving <i>Toh Pee Choon, Dindyal Jaguthsing &amp; Ho Foo Him</i>	<a href="#">795</a>

## **ROUND TABLE DISCUSSIONS - Abstract only**

### **Are We Bored Yet?: Raising Attainment And Maintaining Interest**

*Kim Beswick & Rhonda Faragher*

The Australian Curriculum: Mathematics (Australian Curriculum, Assessment and Reporting Authority, 2012), with its specification of content for year levels, represents a break from stage based curricula which have become the norm in Australian educational jurisdictions in recent decades. It thus provides an opportunity to rethink the appropriateness of developmental approaches to mathematics teaching and the concept of readiness that underpins the widely accepted tenet of teaching from where students are at (Anderson, 2010). Such an approach has the risk of students who fall behind their peers remaining behind even when they make progress (Capraro, Young, Lewis, Yetkiner, & Woods, 2009). This is exacerbated in mathematics because of a prevailing belief that mathematics, to a greater extent than other school subjects, is inherently hierarchical and hence must be taught in a linear fashion that precludes access to advanced content (e.g., algebra) until more basic topics (e.g., arithmetic) have been mastered. A year level based mathematics curriculum has the potential to contribute to solving at least two major problems that currently characterise mathematics learning particularly in the middle and secondary years of schooling. These are 1) persistent gaps in attainment between various disadvantaged groups and a majority of their year level peers, and 2) impoverished curriculum offerings for low attaining students who struggle to master 'basic' content.

This Roundtable will provide a forum for discussion of these propositions and the opportunity afforded by the implementation of the year level based Australian Curriculum: Mathematics. Stimulus in the form of evidence that challenges the hierarchical and linear nature of mathematics learning will be presented and ways that these ideas might contribute to closing attainment gaps discussed.

### **Assessment Standards In Undergraduate Mathematics**

*Carmel Coady, Deborah King & Cristina Varsavsky*

This roundtable will report and seek participants' feedback on progress towards the project Developing a shared understanding of assessment criteria and standards for undergraduate mathematics, funded by the Office of Learning and Teaching. The project seeks to engage the higher education mathematics community in a conversation around assessment standards which builds upon the Learning and Teaching Academic Standards project outcomes for the sciences (Yates, Jones & Kelder, 2011), and their contextualisation within the mathematics discipline. It aims to influence assessment practices in mathematics departments, to move away from idiosyncratic marking and grading approaches that favour procedural mastery towards practices that measure the quality of all aspects of student work against external anchors, ensuring comparability of standards within and across mathematics departments. The project will result in a reference framework and toolkit to support tertiary educators in the development of quality assessment standards and criteria. The project approach incorporates the four essential elements that, according to Sadler (2009), are required to convey and apply achievement standards: (i) exemplars of different levels of achievement invoking the criteria relevant to the judgment made, each of them with an (ii) explanation of how the judgment was made; a (iii) conversation about the exemplars and their corresponding judgments to establish a common vocabulary; and (iv) the sharing of what has been tacit knowledge within the discipline community.

## **Accelerated Learning in Mathematics**

*Fiona Fox & Komathi Kolandai-Matchett*

What is acceleration and how do we achieve it? Effective classroom pedagogy occurs in classrooms where the teacher has evidence of accelerating the progress of priority group learners. Accelerated Learning in Mathematics (ALiM) is a national intervention introduced in New Zealand in 2010 aimed at accelerating the learning of those students below and well-below national expectations. It focuses on the expertise within the school to evaluate the effectiveness of current practices that support accelerated mathematics learning and to closely monitor the impact of a 10 -15 week intervention for a small group of students. The attention is on supporting teachers and schools to inquire into how an effective teacher provides a short and intensive supplementary programme alongside their classroom programme to accelerate progress. The key themes for teaching are accelerated learning; pedagogical response to individual learning strengths and needs; carefully designed mathematics task in response to identity, language and culture; genuine engagement with parents and family; collaborative inquiry; and high levels of teacher reflective practice. In this round table presentation we will present findings from schools who participated in this intervention in 2012. We will examine the main focus for teaching these students and the impact this intervention had on the rest of the school. We will look at how these schools engaged the parent/family and what effect this had on the rate of acceleration. Finally we will analyse to what extent the teachers were engaged into inquiring into their own teaching practice and to what extent this impacted on the learning of the students.

## **Teacher Judgements in Mathematics**

*Christine Hardie*

National Standards, introduced into New Zealand schools in 2010, require teachers in years one to eight to make overall teacher judgments in mathematics. This new assessment policy asks teachers to use the standards and exemplars to make defensible and dependable holistic judgments about whether a student is above, at, below or well below their year standard. The centrality, complexity and nature of teacher judgment practice in mathematics in such a policy context need to be understood. My study drew from principals' and teachers' perspectives about how teachers approach and make overall teacher judgments in mathematics and was gathered using semi-structured interviews and from document analysis. Participants included four principals and seven teachers of students in years three to six. A range of approaches to judgment making emerged from exploring the beliefs, understandings and judgment practices teachers adopted. Teachers utilised both explicit and tacit knowledge in the decision making process and valued their relationship with and knowledge of their students, giving attention to features other than those specified in the mathematics standards. This round table forum will begin with a short presentation of findings to initiate discussion regarding influences that could be considered to ensure teacher judgments in mathematics are dependable and whether exemplars and standards are sufficient to inform professional judgments in mathematics.

## **Students' Transition From Number To Algebra**

*Christina Lee & Christine Ormond*

In the 21st century algebra continues to be seen as a "gatekeeper course" for mathematics (Rand Mathematics Study Panel, 2003). Many future career opportunities are lost to students who do not have a good understanding of algebra at some level. The Australian Curriculum, in its strand Number and algebra, introduces formal algebra to students at an earlier stage than has been the case in most Australian states in the past. In this round table presentation we will firstly examine some aspects of what the curriculum says about early algebraic ideas and reasoning. We will then examine three lesson plans designed to introduce students to foundational algebraic concepts, also

discussing some current doctoral research. This research asks: What strategies do teachers use when teaching algebra in the transition years, and how do these choices reflect their beliefs about mathematics teaching and learning? Participants will have the opportunity to discuss the results of some current research on teachers' beliefs and practices in this area of teaching. They will also review some research findings in current literature, and what this says about the teaching and learning of early algebraic concepts.

### **National Testing: Is it valid**

*Fiona McDiarmid & Deb Gibbs*

The recent publication of the Trends in International Mathematics and Science Study (TIMSS) 2011, has raised much debate in the public and political arena in New Zealand. Analysis of the data indicates that New Zealand students performed less well than most developed countries, and performance of ten year olds has declined since 2001. The question being asked is, 'Why are New Zealand's ten year olds not performing as well as those in other developed countries?' In 2010, New Zealand introduced National Standards in mathematics, reading and writing. The mathematics standards rely on teachers making judgments about a student's overall learning from a wide range of relevant evidence. Other countries such as Australia, England and the United States of America have introduced national testing. The notion that New Zealand students aren't practised in taking tests in this manner has been offered as an explanation for the decline. How does a student's prior test-taking skills and experience impact on results in such a high stakes activity? Do international tests like TIMSS provide an accurate measurement of a student's mathematical understanding and ability to solve complex problems? Should teachers be investing some time in practising the techniques for tests of this type?

This round table forum presents a small-scale study investigating the impact of practiced skills involved in test taking in relation to mathematics standard data. Discussion will focus on high stakes testing versus overall teacher judgments in assessing mathematical competence.

## **SHORT COMMUNICATIONS - Abstract only**

### **Student Engagement in Mathematics: Switching Students On to Mathematics**

*Janette Bobis, Jenni Way, Judy Anderson & Maryam Khosronejad*

Research indicates that students are 'switching-off' mathematics from as early as Year 5. This presentation reports on an intervention study aimed at improving middle year students' engagement in mathematics. Twenty middle year teachers and their students (N=339) from seven schools were involved in a year-long professional development program. Student motivation and engagement levels in mathematics were assessed prior to and at the completion of the intervention. Comparison of student data with those from a similar cohort not involved in the intervention indicates that it is possible to reduce, and even reverse, the downward shift in student engagement levels in mathematics.

### **What Does Numeracy Mean to Teachers of Subjects Other Than Mathematics?**

*Elizabeth Ferme*

Although there has been considerable research into the importance of teaching numeracy and being numerate, little is reported on how numeracy is regarded in the secondary school setting by non-mathematics teachers. This paper reports on a preliminary study into the prominence of numeracy in Australian curriculum documentation and teacher perceptions of numeracy in their daily practice. Results indicate that secondary teachers have a narrow view of numeracy and have limited access to professional learning in that area.

## **How Is 'Teaching As Inquiry' Impacted By Cross-Grouping In Mathematics?**

*Rosemary Golds*

The New Zealand Curriculum advocates a reflective strategy termed 'teaching as inquiry', which encourages teachers to plan for their learners, then continually reflect and respond to their learners' needs (Ministry of Education, 2007). The February 2013 ERO report, *Mathematics in Years 4 to 8: Developing a Responsive Curriculum* (Education Review Office, 2013), has questioned the ability of some schools to be able to provide a responsive mathematics curriculum, particularly for students who are under-achieving. One of the factors which may be having a negative impact on teacher ability to foster 'teaching as inquiry' is the practice of streaming which has become quite common in recent years in New Zealand primary school mathematics (Years 1-8). This paper looks at the background of streaming in classrooms, and explores the connections that can be made with current research in regards to effective classroom practice for all learners of mathematics.

## **"Am I a Maths Type of Person": Responses of Top Stream Year 8 Students**

*Gavin Little*

As part of a longitudinal study on mathematics identity formation and senior subject selection, responses from five top streamed classes of Year 8 students, to the open-ended question "Am I a maths type of person?" have been thematically analysed through examination of key words. Consideration is given to the type of mathematical identity these top streamed students are constructing and how this is related to their intended mathematics pathway in Years 11 and 12.

## **Narrative Inquiry and the Formation of Mathematics Identity**

*Gavin Little*

Mathematics identity, as a specific type of identity, may be considered through a variety of paradigms. If identity is defined as a narrative, analysis of the formation of mathematics identity may be undertaken through narrative inquiry. A narrative approach allows the researcher to consider both personal understandings and meanings relating to mathematics identity, in the participants' spatial and temporal location. Narrative inquiry allows the consideration of the "why" behind participants' statements and actions, within their particular context, over a period of time.

## **Utilizing Open-Source Dynamic Mathematics Software in Teaching Geometry: an**

*Mailizar*

This paper discusses the differences of students' achievement between using open-source dynamic mathematics software (GeoGebra) and Geometer's Sketchpad in learning geometry. There were 43 participants taken from two secondary school classes in Indonesia. The GeoGebra group consists of 21 students, and the Geometer's Sketchpad group consists of 22 students. The findings show that the use dynamic mathematics software can have positive effect on students' achievement. However, findings do not show any significant difference between the two groups.

## **Impact on Identity and Self-Efficacy of Primary Pre-Service Teachers: Experiences In the Mathematics Practicum Classroom**

*Karen McDaid*

Developing quality teachers of mathematics is a global concern and research into mathematics teaching, early career primary teacher identity and teacher self-efficacy often focused on teachers' beliefs and the relationship between beliefs and teaching practice. While some studies have looked at early career teachers and mathematics, none have focused solely on pre-service teacher beliefs about their teaching identity as teachers of primary mathematics as it is constructed over the duration of the practicum. The proposed longitudinal case study aims to track the impact on self-efficacy and identity of pre-service

primary teachers as they participate in their practice teaching.

### **Worksheets vs. Practical Activities in Mathematics in the Primary Classroom**

*Bilinda Offen*

As a teacher educator in primary mathematics, I am intrigued by the number of 'worksheets' used; this is the antithesis of my philosophy of how primary mathematics should be implemented. My proposed research is informed by a study by Marcia L. Tate (2009). My study will compare the engagement of students, concept retention and practical application of numeracy skills of children using worksheets to those involved in practical hands on activities.

The children will be taught using a range of activities. Their learning behaviours will be monitored, they will be interviewed regarding their attitudes and formative assessment will be administered.

### **The Implementation of the Patterns and Early Algebra Preschool (PEAP) Professional Development (PD) Program in Indigenous Communities across New South Wales**

*Marina Papic, Kate Highfield, Joanne Mulligan, Judith McKay-Tempest, Deborah Garret, Monique Mandarakas, & Elizabeth Granite*

This short communication outlines a three-year study with 15 Aboriginal Community Children's Services across New South Wales and the Australian Capital Territory. The project engaged more than 60 early childhood educators and approximately 240 children aged 4 to 5 years. Following an Early Mathematical Patterning Assessment (Papic, in press; Papic, Mulligan, & Mitchelmore, 2011) the project implemented an early patterning framework that developed young children's mathematical thinking and problem-solving skills. Follow up interviews with kindergarten teachers, supported by data from Best Start assessments (NSW Department of Education & Training, 2009), provides evidence of the potential impact of this program on children's mathematics learning. A key finding is the increased confidence and pedagogical content knowledge of early childhood educators.

### **"Teacher's Dilemma" In Using The Internet As A Mathematical Resource In Multilingual Settings**

*Sitti Maesuri Patahuddin*

Indonesian government policy stipulating English as the language of mathematics instruction has created dilemmas for mathematics teachers since they are themselves not proficient in English communication, or with the English mathematics register. The question thus arose as to how mathematics online learning resources (in English) could support the development of learners' "English Maths" proficiency. Would the language in which mathematical ideas are communicated deny learners' access to mathematics learning and constrain teachers' capacity to develop rich mathematical talk? Both questions will be discussed through critical incidents from video data analysis of one teacher, teaching fractions in a secondary school.

### **Mentoring Undergraduate Primary Education Students In The Mathematics Classroom ? The Development Of A New Model To Help Reduce Mathematics Anxiety**

*Timothy Perkins*

Increasing numbers of students enrolled in primary pre-service teacher Education degrees in Australia enter university with insufficient mathematical content knowledge (Livy & Vale, 2011) and low confidence levels about their ability to teach and do the mathematics required for their intended role as classroom teachers (Wilson, 2009). Teachers need to have the knowledge and teaching skills to improve student outcomes in the mathematics field (Beswick, 2012). This research project explores the development of a mentoring model aimed at increasing the confidence and competence of pre-service primary teachers by matching them with well trained, highly capable, confident and supportive primary mathematics teachers as mentors.



## **Students' Preferences When Learning How To Use Advanced Calculators To Solve Mathematics Problems**

*Hazel Tan*

In this presentation findings from part of a PhD study on students' learning preferences and their use of advanced calculators such as graphics calculators and CAS calculators will be shared. Students' responses to a question asking for their preferred method of learning how to use the calculators to solve mathematics problems will be shared. Amongst the different methods, the highest percentage of students indicated that they most preferred to try out the calculator steps while receiving instructions such as observing a demonstration, listening to an explanation, or reading the instructions. The implications of the findings will be discussed.

## **POSTERS – Abstract only**

### **Investigating the effect of the second-order use of context on Mathematics literacy tasks**

*Felipe Almuna-Salgado & Caroline Bardini*

The incorporation of contextualised tasks has been highly recommended by reform documents and curricula. Nevertheless, the role that task context plays in assessments is an unsolved matter because there are arguments relate to whether it makes a task easier or harder for students. This study represents an attempt to scrutinise to what extent the nature of demand of the second-order use of context may affect students' performance on literacy tasks. It is anticipated that this study can provide a deeper understanding of how task context impacts students' performance, thereby contributing to the improvement of contextualised assessments among teachers, policy makers, and assessment writers.

### **Exploring secondary school mathematics teachers' understanding of statistical graphs**

*Ajeevsing Bhoola & Leena Ramkalawon*

One of the most basic tasks in statistics is to represent data graphically and this suggests that teachers need to possess graphical competence. We explore the statistical graph comprehension of one pre-service and one in-service secondary school mathematics teachers through a series of video recorded interviews. Initially, both teachers claimed strong self-efficacy towards teaching statistical graphs conceptually. However, thinking processes deployed by them to selected statistical tasks revealed procedural knowledge rather than the claimed conceptual knowledge. These consequences suggest that the focus should be on developing the necessary competencies of teachers to work with statistical graphs effectively.

### **Designing a detailed instructional framework: A teaching experiment in multiplication and division**

*David Ellemor-Collins*

Within a larger design research project, we developed an instructional framework for multiplication and division, to be refined through a teaching experiment with low-attaining primary students. We describe the instruction at multiple scales, from the broad organization into domains and phases, through the sequencing of small topics, to the details of specific instructional activities. We also map the multiple dimensions of mathematisation involved: progressions toward larger numbers, more abstract settings, more formal notations, more sophisticated strategies, and so on. The framework contributes to research on arithmetic instruction; and also to our developing notions of frameworks, learning trajectories, and instructional design.

## **Testing a Framework of Cognitive Ability and Student's Thinking Process in Geometric Argumentation**

*Tsu-Nan Lee & Caroline Bardini*

This study aims to analyse student's thinking process in geometric argumentation from geometric examples and counter-examples between Grade 3, 5 and 7 students in Victoria, Australia and Taiwan. There are two experiments in this study. The first will test and compare cognitive frameworks of geometric argumentation. The second will analyse student's thinking process through geometric examples. It is anticipated that this study can provide a better understanding of thinking process in geometric activities and assist students enhance their abilities in geometry.

## **Pattern-based learning in Linear Algebra**

*Rosemarie Mohais*

In the traditional Mathematics classroom, usually a small fraction of students are able to form or recognise patterns which are core to solving problems, however, many other students never get as far. Pattern-based learning is a new developing strategy that aims to promote effective teaching/learning of Mathematics by enabling all students to recognise patterns. The technique involves presentation of the solutions to standard well-known problems through software. Once the student has gained experience in solving multiple problems using a clear pattern of solution, he/she can then independently apply the technique. In this poster, Pattern-based learning is applied to Linear Algebra.

## **Effects of using different types of display and rules on pre-schoolers patterning recognition in Malaysia: A preliminary study**

*Sharifah Norul Akmar Syed Zamri & Nor Adlina Fadil*

The aim of this preliminary study is to explore the effects of using different types of display and pattern rules on achievement in pattern recognition among pre-schoolers in Malaysia. A total of one hundred and fifty six pre-schoolers were involved in this study. The instrument used was adapted from Gadzichowski (2012). It contains 25 patterns which were divided into five different groups based on display; colour, shape, object, letter and number. Each group comprised five different patterns with rules of increasing difficulty. Each child was interviewed individually. A correct answer was given 1, otherwise zero. Descriptive statistics and a two factor ANOVA for correlated measures were conducted. Results show that the overall achievement of the children was rather low. Children find certain rules easier than others. The different displays had no significant impact on the achievement of pattern recognition amongst these children.