1. An Ethic of Care

Cultural Responsiveness An ethic of care requires cultural responsiveness in teaching that enables all students to participate, contribute and learn within the mathematics classroom. The 2009 NEMP findings show persisting and worsening achievement gaps respectively for Māori and Pasifika students in English medium. The recent International assessments (TIMSS) show markedly worsening gaps for Māori and Pasifika students. The 2007 Numeracy evaluation shows widening gaps for Māori and Pasifika students. Teacher professional development has not sufficiently addressed this priority. A 2007 Numeracy Development Project report identified targeted Māori achievement. ongoing school-wide professional development (PD), responsiveness to taonga Māori including use of Te Reo Māori, safe environments, elimination of labelling, structured support for Māori student mathematical talk, educationally powerful connections with parents and whānau and a wide culturally responsive approach to be linked to much higher achievement for Māori students.

Caring about Students' Mathematical Identities Effective teaching requires that teachers care about their students having positive mathematical identities and organise all of their teaching to advance this goal. A range of current practices risk undermining students' mathematical identities. For example:

- Widespread use of ability streaming within and between classes in mathematics teaching in New Zealand
- Te Kotahitanga data shows that Māori students are more likely than Pākehā to be placed with teachers who score most poorly on the Effective Teaching Profile (measuring variables of care for students, care for cultural identity and care about their learning).
- Widespread use of the least trained adults (teacher aides) to teach the lowest achieving students
- Potential for harm when teachers report to parents on students' under-achievement against standards without a strengths-based account of progress. If students develop a view of themselves as low achievers without confidence in the next steps this becomes highly predictive of future performance. Hattie (2009) found student self-report against previous achievement levels to be the largest of all specific influences on future achievement.

Peer Culture Evidence in TIMSS reveals that New Zealand primary students have the 2nd lowest rate of student safety in the classroom peer culture of 35 countries. This makes it prohibitive for students to take the intellectual risks needed for learning. A negative peer culture makes it difficult to build a peer learning community through which students support each other’s learning. Building an active peer learning community is critical to achievement acceleration because it intensifies learning supports to students. Creating a peer learning community requires teachers to explicitly teach students how to communicate and collaborate without engaging in exclusionary or bullying behaviour.

2. Arranging for Learning

Skilled Whole Class Teaching The most recent Education Review Office (2002) national mathematics report noted that NZ teachers make less use of highly effective whole-class sessions than teachers in other countries. Skilled whole class teaching can enable greater access to mathematical ideas for low achievers if complemented by intensive group and individual work.

Effective Scaffolding of Collaborative Group Work Mathematics group work in NZ typically involves grouping students by achievement levels to work on the same task independently. Heterogeneous grouping and opportunities to work collaboratively using mathematical argumentation practices are less common. Optimal approaches use flexible grouping practices (not fixed streaming into groups by ability). ERO (2002) noted that given the frequency of use of group organisation in mathematics teaching in New Zealand more needs to be known about the effectiveness of small-group work in mathematics. Students do not naturally work collaboratively in classrooms. New Zealand students engage in high levels of intimidatory, exclusionary, name-calling and other bullying behaviours that undermine effective collaboration. These behaviours are rarely visible to teachers. If teachers use small group approaches without teaching students the skills to participate productively, and without designing and using effective group tasks, social engagement can undermine and displace rather than support intellectual engagement. A 2004 Numeracy Development Project study found students’ attitudes towards peer communication to be negative and proposed that teachers be encouraged to make reciprocal communication a goal for their teaching. Another 2004 Numeracy Development Project study identified the need for more effective use of collaborative group work with Māori students. A 2005 Numeracy Development Project study found insufficient attention to effective teaching of small group participation to be a major barrier for Pasifika students in their mathematics learning and goal for the Numeracy Development Project as a whole. Collaborative and co-operative peer approaches to learning are highly effective in accelerating achievement when well-implemented, informed by the findings from research and carefully monitored and strengthened through teacher inquiry and knowledge building approaches. New Zealand teachers need knowledgeable professional learning support informed by research and development to build the kinds of collaborative learning capabilities in students that result in effective group work in mathematics. To date professional development has not sufficiently addressed this issue.

High Quality Independent Learning Time Teachers also need to ensure that students have opportunities for productive independent time to think and work quietly by themselves. For example, collaborative learning activities may include opportunities for independent time for student to formulate their initial thinking without pressure from more dominant students, or without concern of matching 'experts' strategies. Independent learning time can provide opportunities for practice activities and support students to reflect on their own learning. The TIMSS (2007) report indicates New Zealand students get more time to work independently (without teacher guidance) than the international mean. The quality of this opportunity is dependent upon teacher guidance, task quality, and what has been learned in whole-class and group contexts.

Iterative Best Evidence Synthesis Programme, Alton-Lee, A. January 2011 – Draft for feedback to best.evidence@minedu.govt.nz
<table>
<thead>
<tr>
<th>BES Findings</th>
<th>Challenges for Effective Mathematics Teaching in New Zealand Years 0 -10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arranging for Learning cont.</strong></td>
<td><strong>Homework Challenges &amp; Opportunities</strong> Student individual work in mathematics homework is another area of challenge. Longitudinal data reported in the <em>School Leadership BES</em> reveals a negative association between parent help with mathematics homework and student achievement. When parents inadvertently pressure their children help can be negative but when parents support their children’s learning help can be positive. Overseas evidence reveals that when families play and enjoy mathematical (e.g. board) games this has more positive effect on achievement than other any other form of mathematics homework help. School provision of mathematical games libraries and support for parents and whānau can be critical to homework succeeding. A 2007 evaluation of the Home-School Partnership - Numeracy found significant challenges in implementation and sustainability given the models adopted (e.g. lead parents). The NZ Home-School Partnership work in mathematics has not yet had sufficient focus on student outcomes.</td>
</tr>
</tbody>
</table>

| **3. Building on Students’ Thinking** | **Effective Teaching Builds on what Students Already Know and Can Do.** Teachers use students’ existing thinking as a resource for learning. This requires an inquiry approach to teaching. Teaching needs to make connections to what students already know and to real life applications that make sense to students. Teachers need to implement a range of classroom practices that enable students to make their mathematical thinking and reasoning visible. Only then can the teacher (and peers) make connections to what students already know, their informal knowledge, and to real life applications that make sense to students.  

**Negative Effects of a Deficit Focus** If teachers start from a focus on what students’ can’t do or view students as ‘blank slates’ and see themselves as fixing weaknesses and/or filling gaps in students’ knowledge then teaching is likely to be less effective and counter-productive. A 2007 evaluation shows tenuous links between early childhood centres and schools resulting in a blank slate approach rather than effective transitions and information use for mathematics learning. The national standards provide a resource to help identify what students can do and where they need to go next. If professional supports for implementation of standards inadvertently orient teachers to a gap-fixing mentality rather than a next-steps approach then teaching will risk failing to build on students’ thinking. A 2007 Numeracy Development Project evaluation found problems with Year 6 to Year 7 (intermediate) school transitions with a lack of curriculum continuity and ‘fresh-start’ practices.  

**Understanding Likely Misconceptions** A 2006 Numeracy Development Project evaluation of Māori students’ needs called for more exploration and development of students’ ideas. Teacher content and pedagogical content knowledge of mathematics is critical to teacher effectiveness in being responsive to students in the design and adaptation of classroom tasks and activities. Teachers need to be aware of common misconceptions and partial understandings in student thinking so that these can be used as building blocks in learning. Teachers need to be constantly inquiring and diagnostic about students’ mathematical sense making by providing opportunities for students to make their thinking visible. When teachers are unaware of the sources of students’ thinking classroom time can be wasted in teaching that inadvertently reinforces misconceptions and errors.  

**Fostering Understanding** A 2007 Numeracy Development Project study showed a continuing problem of teachers failing to focus sufficiently on student understanding and thinking. Effective pedagogy presses students for understanding through thinking and speaking in ways that are mathematical. A 2008 Numeracy Development Project evaluation found that Year 7 students saw the strategies they had learned as knowledge to be mastered rather than problem solving tools. Across Numeracy Development Project evaluations there is a pattern of teacher design adherence that risks a procedural rather than a conceptual focus even in the use of strategies. A range of Numeracy Development Project studies have identified common misconceptions in student mathematical thinking (e.g. a 2006 study of year 7 and 8 students’ approaches to adding fractions). Teachers can focus on task completion at the expense of mathematical understanding. These studies are progressively providing a valuable resource for informing professional learning. The evidence we have suggests mathematics teaching could be further strengthened by an R & D & linked professional learning focus that strengthens teachers’ capability to build on students’ thinking especially at the transition points in schooling.  

**Building on Proficiencies of Lowest Achievers** Successive Numeracy Development Project evaluations and 2004 and 2006 evaluations of Te Poutama Tau highlighted urgency in working responsively with older students who have made minimal progress. |
4. **Worthwhile Mathematical Tasks**

**Etahi ngōhe pāngarau whaihua**

Effective teachers understand that the tasks and examples they select influence how students come to view, develop, use and make sense of mathematics. Worthwhile Mathematical Tasks build students’ problem solving capabilities. Worthwhile tasks require students to think deeply about mathematical ideas and connections in ways that encourage students to think for themselves. Teachers need to be able to design, select and sequence mathematical tasks that support the development of big ideas of mathematics rather than isolated strategies and skills. Effective teachers adapt learning goals and task design using ongoing evaluations of student performance. Embedded contexts in authentic tasks need to be accessible to all students to ensure equitable learning opportunities.

**Default to Procedural rather than Conceptual Focus**

Business-as-usual in teaching can frequently revert to a focus on procedural tasks rather than conceptual thinking. Poorly designed tasks can divert student attention away from mathematical goals. Equally, instruction that inappropriately reduces the cognitive tasks demands denies students opportunities to engage in higher order mathematical thinking.

**High Quality Tasks Across Curriculum Requirements - R & D ERO (2002)**

Expressed concern at the burden on New Zealand teachers to develop mathematical tasks directly from curriculum statements. A 2006 evaluation of Te Poutama Tau showed the need for more challenging problem-solving and investigative tasks in Māori medium. The Numeracy Development Project has produced a wide range of resources and tasks for New Zealand primary and lower secondary teachers to use. There is an emerging body of evidence and evaluation interrogating the effectiveness or not of these resources. Monitoring data shows some areas of national shift in student proficiency. For example NEMP showed a gain in student achievement on number line tasks at Year 4 level that likely reflected improved teaching through Numeracy Development Project facilitator focus. In 2003 an evaluation of Te Poutama Tau showed an effect size of $d \approx 0.88$ for stage gains occurring after an intensified focus on grouping and place value. Systematic attention needs to be given to the issue of task design and implementation that is responsive to areas of weakness in monitoring data. The latest monitoring data from TIMSS shows national weakness in number at middle primary. A 2005 Numeracy Development Project evaluation shows that students experienced difficulty in transitioning from early additive to part-whole thinking. NEMP shows weakness in estimation and a sharp decline in student achievement in complex multiplication. Numeracy Development Project evaluations reveal where there are specific challenges for task design e.g. the challenges for students moving to multiplicative and proportional thinking.

**High Quality Practice Opportunities**

Effective teaching carefully integrates sufficient practice activity including the use of games for specific mathematical purposes. Insufficient practice opportunity can undermine student opportunity to learn. Practice activity that is not tailored to mathematical goals can be a time-filler and a wasted opportunity.

**Teacher Capability and Professional Learning**

Implementing cognitively challenging tasks in ways that maintain students’ opportunities to engage in high-level thinking is dependent upon teacher knowledge and responsiveness to student need. Effective, ongoing professional learning is a significant factor in teacher capability to design and use effective mathematical tasks.

5. **Making Connections**

**Kō te Tūhonohono**

Effective teachers support students in creating connections between different ways of solving problems, between mathematical representations and topics, and between mathematics and everyday experiences.

**Big Ideas in Mathematics**

While fractions, decimals, percentages, and proportions can be thought of as separate topics, teachers need to provide experiences that enable students to see how they are connected. A 2005 study found students did not consider they were engaged with or understanding big ideas in mathematics in their classroom lessons.

**More Powerful Strategies as a Goal**

Students need to learn multiple strategies to develop more powerful and accurate mathematical thinking. Numeracy Development Project evaluations indicate strategy focus can become procedural for students rather than a way to develop more powerful and accurate mathematical thinking.

**The Need for Pedagogical Focus on Making Connections**

The Numeracy Development Project evaluations do not focus strongly on the ways in which teaching makes connections – but many identify the need for a greater focus on this issue. Currently many teachers have increased their focus on students sharing a range of strategies, but are unsure how to make the next step. That is they are unsure how they can best use students’ responses in ways that advance the mathematical learning of the whole class. Helping students to draw connections between the mathematical ideas that are reflected in the strategies and representations that they used, and helping student make judgments about the consequences of different approaches requires professional learning focused on productive mathematical discussions.
6. Assessment for Learning

He Aromatawi Hei Tikanga Ako

Effective teachers use a range of assessment practices to make students' thinking visible and to support students' learning.

Assessment for Learning Supporting Improved Teaching

The use of assessment for learning should inform teaching. This is a big shift of orientation from assessment that does not immediately inform further learning to the use of assessment to inform teaching and learning. Assessment for learning avoids much wasted time when teachers re-teach what students already know and understand. Using assessment in ways that label, sort or otherwise publicly humiliate students, risks de-motivating learners.

Strengthening the School-Wide Use Diagnostic Tools

A significant tool to support formative assessment in Numeracy Development Project has been the diagnostic interview. Diagnostic interviews or student think alouds can be effective strategies within an assessment for learning approach but are dependent upon teacher knowledge for their impact. A 2008 evaluation found consistent, school-wide use of the Numeracy Development Project diagnostic interview and its resultant achievement data to strengthen a focus on improvement.

National Standards/ Ngā Whanaketanga

Progressions and frameworks can strengthen teacher knowledge of student thinking. These tools need to be used as assessment for learning opportunities. Hattie (2009) found that student’ self-report on grades is the strongest predictive factor in future achievement. If students who are not achieving national standards do not experience the feedback they receive in ways consistent with an assessment for learning orientation they are likely to develop identities as mathematics failures and lose motivation.

Disjunctions across Transitions

Other areas for improved practice are the strengthening of focus on mathematics in the narrative assessments from ECE that are passed on to schools. An evaluation of the Secondary Numeracy Development Project showed weaknesses in teacher capacity to accurately assess student achievement at Years 9 and 10. Disjunctions have been found between NCEA assessments and SNP approaches in a 2007 study.

Developing Effective Practice in Feedforward and Feedback

Feedback needs to engage students constructively in further learning. There is little information across the Numeracy Development Project studies of ways in which teachers strengthen their approaches to giving formative feedback to students. Evidence across BESs indicates that effective feedback is one of the most powerful positive influences on learning – but ensuring feedback is effective is a significant challenge. Non-specific praise is widely used but ineffective. Feedback can have inadvertent negative effects.
<table>
<thead>
<tr>
<th>BES Findings</th>
<th>Challenges for Effective Mathematics Teaching in New Zealand Years 0 -10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7. Mathematical Communication</strong></td>
<td>Modelling and Scaffolding High Quality Mathematical Dialogue. Effective teachers model mathematical discourse and scaffold student attempts at mathematical ways of speaking. Teachers need to effectively scaffold communication and participation and guide students in mathematical argumentation rather than relying on teacher talk. Revoicing can be an effective way of guiding students’ mathematical communication through highlighting students’ ideas, helping to identify understandings that are implicit in those ideas and adding new ideas or developing the discussion in a different direction. Teacher effectiveness relies on teacher content knowledge and pedagogical content knowledge – areas of weakness apparent in the Numeracy Development Project evaluations.</td>
</tr>
<tr>
<td>Te Whai Pūkenga Mō te Whakawhiti Kōrero Pāngarau</td>
<td>Establishing Participation Process, Rules and Responsibilities for Classroom Discussion is a Challenging Pedagogical Task. Public speaking in mathematics can humiliate and de-motivate students within the peer culture. There is evidence of too much teacher talk that is not accessible to students, too little thoughtful student participation, ‘cultures of niceness’ that are prohibitive of genuine cognitive engagement and so on. The task of establishing structured procedures and supports for mathematical communication and productive dialogue is a major pedagogical challenge. Teachers need to socialise students into a larger mathematical world that honours standards of reasoning and rules of practice such as inference, analysis and modelling. Students need to be supported to take intellectual risks and articulate mathematical explanations, justification and argumentation.</td>
</tr>
<tr>
<td>Effective teachers are able to facilitate classroom dialogue focused on mathematical argumentation.</td>
<td>Productive Mathematical Argumentation. Teaching needs to explicitly guide students about how to move thinking forward through productive mathematical discourse/argumentation. Students are frequently silent or participate without engaging with other students’ ideas. Successive evaluations across the Numeracy Development Project show that the facilitation of classroom dialogue focused on mathematical argumentation is a weakness in NZ mathematics teaching (e.g. 2004, 2005, and 2006).</td>
</tr>
</tbody>
</table>

| **8. Mathematical Language** | Effective Teachers foster Students’ Use and Understanding of Mathematical Language. Effective teaching requires explicit language instruction. Effective teaching makes students aware of the variations and subtleties to be found in mathematical language. This requires making links between students’ intuitive understandings and mathematical language. Across the Numeracy Development Project evaluations issues of mathematical language are identified as significant. |
| Te Reo Pāngarau | Mathematical Language Proficiency in Te Reo Māori. Successive longitudinal evaluations of Te Poutama Tau show language proficiency in Te Reo Māori to be linked to mathematics achievement. |
| Effective teachers shape mathematical language by modelling appropriate terms and communicating their meaning in ways that students understand. | Making Effective Connections to Students’ Home Languages. Teachers need to be able to be responsive in multilingual contexts and make connections between specialised mathematical terminology and home languages through code switching and other strategies. A 2004 Numeracy Development Project study showed need for much more attention to mathematical discourse and appropriate support for the use of advanced mathematical terms with Pasifika students. A 2008 Numeracy Development Project evaluation shows the need at the upper primary level for increased teacher proficiency in developing their own, and supporting students’ use of mathematical language to improve multiplicative thinking. |
| Developing Mathematical Learning Communities. Because the development of proficiency in mathematical language is intensified through effectively scaffolded collaborative group work, the challenge of developing classroom peer learning communities in mathematics is a pressing one. |

Iterative Best Evidence Synthesis Programme, Alton-Lee, A. January 2011 – Draft for feedback to best.evidence@minedu.govt.nz
Effective Conceptual Use of Tools and Representations Critical for Equity and Acceleration

Effective teachers draw upon a range of representations and tools to support diverse students’ mathematical development. These include the number system itself, algebraic symbolism, graphs, diagrams, models, equations, notations, arrays, images, analogies, thermometers, other artefacts, metaphors, stories, textbooks, learning logs and technology. Effective tools enable learning and become part of students’ mathematical reasoning. Teachers need to provide visible representations that connect to students’ everyday experiences. Multiple representations can lighten the cognitive load on the learner by providing conceptual tools for thinking. Teachers need to be diagnostic in using tools because often students experience representations and tools in very different ways from adults or there are cultural differences that affect accessibility of meaning.

Sustainability of Improved Practice

A 2006 Numeracy Development Project study of sustainability issues reported quality resources as a key to sustaining effective numeracy practices. The importance of smart tools to the spread and sustainability of reform was highlighted also in the School Leadership BES.

Dearth of Tools and Representations with Previous Curriculum

In 2002 ERO raised the concern that New Zealand teachers had to create their own tools directly from the curriculum without even a text. A 2004 Numeracy Development Project evaluation showed a particular need for tools in Māori medium.

Generation of a Range of Tools in Numeracy Development Project & Poutama Tau - Variable Effectiveness - Formative Evaluation and Refinement in Progress

The Numeracy Development Project and Te Poutama Tau have generated a substantial range of tools to support teaching and learning. The early Numeracy Development Project required significant teacher engagement in creating tools but often without sufficient depth of professional development. Substantial data shows variable effects: e.g. positive impact of smart tools on student outcomes, flawed tools and misuse of tools. Numeracy Development Project evaluations show for both English and Māori medium challenges for students in the use of specific representations, e.g. mathematical symbols, negative numbers. Whilst the wider research community has been engaged in evaluating and revising some tools it is timely to review and update the tools to optimise effectiveness.

Further Smart Tool Development Needed in English & Te Reo Māori

The new NZ Curriculum, Te Marautanga and aspirational National Standards/ Ngā Whānaketanga require new smart tool development.

Teacher Knowledge Critical to Tool Use and Adaptation

Numeracy evaluations have shown that the effectiveness of teaching tools is dependent upon whether teachers use these in a procedural or ‘design adherence’ manner or whether such tools are used thoughtfully and diagnostically with students (a contextually responsive approach). Effective usage depends upon the quality of professional learning. Findings from the Numeracy Development Project evaluations show a need for a lift/consistency in facilitator/teacher educator capability nationally to ensure a contextually responsive approach. A 2004 Numeracy Development Project evaluation showed the importance of teacher knowledge in the effective use of equipment to introduce mathematical ideas.

Effective integration of ICT into Mathematics Teaching an Area of Weakness

The 2005 and 2007 Numeracy Development Project studies show more need for connections to be made between ICT professional development and Numeracy Development Project to strengthen integration of the use of ICT in mathematics (e.g. Computer Algebraic Systems). Innovation in the use of technological smart tools such as Tinkerplots would strengthen teaching. An area of weakness has been teachers providing students with hands-on materials without sufficient attention to mathematical understanding – especially with both Māori and Pasifika students. A 2005 Numeracy Development Project study proposed the use of modelling books and student co-operative mathematical inquiry to support a conceptual focus in the use of materials in mathematics teaching.

Strategic Alignment in School-Wide Use of Tools and Diagnostic Data

A 2007 Numeracy Development Project evaluation showed the need for consistency in school-wide use of the diagnostic interview as an assessment for learning tool that aligns practice across the school.
Sound Teacher Knowledge Foundation for Effective and Equitable Teaching
International research shows that teachers need content knowledge of mathematics and pedagogical content knowledge to anticipate the developmental progressions and difficulties for their learners. A 2007 longitudinal evaluation of Te Poutama Tau showed the biggest influence on student achievement in Māori medium to be the teacher. The 2007 and 2007 evidence from Numeracy Development Project evaluations shows mathematics content knowledge of teachers significantly linked to student achievement.

Overall Strong Teacher Content Knowledge but Wide Disparities at Secondary Level in NZ
PISA results showed the proportion of teachers in a school with university tertiary-level qualification, with a major in the respective subject domain taught, to be statistically significantly related to student achievement in mathematics, science and reading literacy at the Year 11 level across countries. The Teacher Census showed mathematics qualifications to be strong relative to other curriculum areas at secondary level in New Zealand. New Zealand students who are retained until Year 11 in New Zealand perform above the international mean in the second band of high performing countries in PISA. PISA data show one of the widest within school patterns of disparity at secondary level in NZ. There is a question about how often students are taught by teachers working out of their subject field (i.e. not mathematics teachers but covering mathematics classes). New research shows a large Departmental (i.e. likely Head of Department professional leadership) effect for mathematics achievement at secondary level.

Weak Mathematics Knowledge of NZ Teachers at Primary and Intermediate Level
Teacher mathematical knowledge at primary and intermediate level has been an ongoing area of systemic weakness in New Zealand. New Zealand mathematics achievement at middle primary level is significantly below the international mean. TIMSS (2007) showed of those teaching mathematics fewer New Zealand middle primary teachers had postgraduate degrees (9%) than the international mean (17%) and more teachers had no University study (25%) than the international mean of 18%. The larger issue is the nature and amount of specific support to develop specialised mathematics content and pedagogical content knowledge teachers receive within initial teacher education. Teacher mathematical knowledge is critical to teachers' capacity to keep a focus on the big ideas in mathematics. Only 12% of primary teachers had a specialisation in mathematics compared to the TIMSS average of 25% of teachers. ERO (2002) highlighted the need to increase New Zealand teachers' mathematics content knowledge. Results across Numeracy Development Project studies show teacher mathematical content knowledge to be a continuing challenge (e.g. 2006 Sustainability report, 2007 Numeracy Development Project evaluation). One 2007 Numeracy Development Project intervention showed variable results in improved teacher content knowledge with only 18% of the 60 teachers participating in the professional development achieving the level of mathematical knowledge expected of Year 8 students. A 2006 Numeracy Development Project evaluation found around a third of teachers indicating a lack of conceptual understanding about the addition of fractions, division with fractions and proportional reasoning. A 2005 study found marked teacher differences in the teaching of algebraic thinking within the Numeracy Development Project. A 2008 Numeracy Development Project evaluation concluded 'clearly much more work is needed to help teachers develop a deeper understanding of the proportional structure of multiplication, division and fractions.'

Pedagogical Content Knowledge – A Challenge
There is a need for stronger research to inform understanding of what is effective pedagogical content knowledge in mathematics teaching in New Zealand.

Professional Development (professional development (PD))
Because the quality of teaching is the key system lever for improved outcomes, highly effective professional learning and development is the highest impact policy lever for improved outcomes. Most other policy interventions rely on teacher change that implicitly requires teacher learning for student achievement to lift but risks unintended negative effects if professional development is not explicitly and effectively addressed.

Students of Teachers Participating in Numeracy professional development Achieve More Highly
Around 97% of primary and intermediate schools have participated at some level and at some time in the Numeracy Development Project or Te Poutama Tau professional development between 2001 and 2010. There is evidence from the international trends in Mathematics and Science Study that those students whose schools participated in the Advanced Numeracy Project had higher achievement than those in schools that had not. A 2007 evaluation of a pilot Te Poutama Tau professional development project for 9 teachers in wharekura showed impressive achievement gains by the students of participant teachers. The 2004 studies revealed initial achievement advantages for low decile schools that were the first with access to Numeracy Development Project (but associated challenges for sustainability after the external resource was withdrawn from low decile schools that participated early).
Cumulative Effect for Younger Students

It matters if junior class students are in the classes of teachers who have not had Numeracy Development Project. The 2007 and 2008 Numeracy longitudinal evaluations showed students involved in the earliest Numeracy Development Project trial from school entry showing stronger performance by years 5 - 7 than comparison groups. The early impact of highly effective teacher professional development has a cumulative effect as students of those teachers go through the school system. Numeracy Development Project evaluations consistently show that the younger a student is when receiving the benefit of teacher professional development in Numeracy Development Project the more positive the long-term effect. As the Numeracy Development Project was rolled out many students across NZ did not receive the benefit of their teacher’s participation in Numeracy Development Project until they were much older. ERO (2009) reported on the prevalence of newly trained, inexperienced teachers allocated to junior classes in NZ primary schools. Given their lesser experience these new teachers are less likely to have had opportunities to integrate Numeracy Development Project theory and practice through in-school professional development (PD).

Variability in Effectiveness of Professional Development – the Challenges of Professional Development Effectiveness

The effectiveness of Numeracy Development Project has been found to be associated with the expertise of external professional development facilitators for both English and Māori medium. A major challenge is that of strengthening facilitator expertise. A 2007 evaluation revealed a video-link approach to strengthening facilitator expertise was insufficient. Successive Numeracy Development Project evaluations have revealed the role and capability of lead teachers to be critical. The nature and quality of professional development is also a critical factor. The 2005 and 2007 Numeracy Development Project studies found structured reflection using analysis of videoed lessons was likely to enable deep change in practice – ‘the evidence you can’t ignore.’ A 2005 Numeracy Development Project study showed contextually responsive facilitation that involved facilitators co-teaching with teachers in their own classroom was highly effective in teacher change and in the sustainability of changes to practice. The development of an intensive professional community of practice focused on improving student outcomes has been found to be critical to success. A 2007 exploratory study shows the importance of teacher release time to support professional learning community and networking. A 2007 study of a 2-year Professional Learning and Development Cluster focused on statistics found associated gains for students. A 2007 study focused on sustainability demonstrated how highly effective lead teachers were forging and sustaining communities of practice in two schools. The 2007 evaluation showed teachers who received partial funding for tertiary mathematics study were constrained by lack of time and lack of school support for study. A 2007 evaluation showed achievement gains for Year 9 students but a very small impact on Year 10 student achievement of Secondary Numeracy Development Project. A 2007 Numeracy Development Project pilot found mathematics coaches to be one way of deepening content knowledge of Year 6-8 teachers.

Professional Development Sufficiency

The findings of the Teacher Professional Learning and Development Best Evidence Synthesis indicate the report the conditions necessary for professional development to lift the achievement of students of participating teachers. That BES indicated the importance of mathematics specific content rather than generic professional development to student outcomes. A 2007 evaluation showed one year of Numeracy professional development insufficient for upper primary and intermediate teachers to enable students to meet curriculum goals. A 2008 Numeracy Development Project evaluation showed students whose teachers had only one year of Numeracy Development Project professional development did not reach curriculum expectations. A 2006 study found that even after access to Numeracy Development Project teachers need more help in understanding multiplicative thinking and proportional reasoning. A 2008 study found that two years of professional development provided by Numeracy Development Project for teachers at Year 7 and Year 8 was not sufficient for most teachers to understand the complexities of multiplicative thinking, or even become familiar with the ‘superficial aspects of the Number Framework and assessment tools, let alone build an in-depth understanding of the Numeracy Development Project approach overall.’ A 2007 study showed teachers need continued support after doing Numeracy Development Project because of radically different way of teaching. A 2007 evaluation of a pick-up professional development programme for teachers who missed out on Numeracy Development Project showed the programme was related to higher student achievement.

Professional Leadership and Alignment Critical to Professional Development Effectiveness

A 2005 study found principal pedagogical leadership to be crucial to the effectiveness of Numeracy Development Project. Proactive principal involvement was associated with higher student gains in Numeracy Development Project but many principals delegated the Numeracy Development Project to others in leadership roles and did not participate in the professional development (PD). The 2005, 2006 and 2007 Numeracy Development Project studies indicate facilitators, lead teachers and others in leadership roles need to ensure a transition from working with individual teachers to organisational redesign to embed and sustain improved practice at a school-wide level including through distributed leadership and collegial accountability. A focus on student achievement data at the school level has continued to be critical to the effectiveness of professional development (PD). TIMSS found NZ principals to spend much more time than overseas colleagues in administrative duties (in a self-managing school system) and far less time than the international mean supervising and evaluating the work of teachers (NZ 11% of time; international mean 19% of time).
Notes to Appendix B. 10 Key Findings for Making a Bigger Difference in Mathematics Teaching: Challenges for New Zealand Schooling

1. The BES findings in column 1 are the ten major findings of the New Zealand Ministry of Education’s Effective Pedagogy in Mathematics/Pāngarau BES. This BES was selected as ‘definitive research on effective practices’ by the International Academy of Education to inform a summary for the Educational Practice Series on the UNESCO website. The ten findings are those highlighted in the Educational Practice Series – 19: Effective Pedagogy in Mathematics and Te Ako Pāngarau Whaihua.

2. The key points outlined in Challenges for Effective Mathematics Teaching in New Zealand (Years 0 -10) have been derived from a range of national and international monitoring data and research including NEMP, TIMSS, PISA and ERO Reports; the 103 Numeracy Development Project and Te Poutama Tau evals and associated studies, the Effective Pedagogy in Mathematics/Pāngarau BES and other relevant data. A full bibliography of the Numeracy Development Project/Te Poutama Tau publications and electronic links to these are available on the New Zealand Maths website http://nzmaths.co.nz/annual-evaluation-reports-and-compendium-papers. In this table the Numeracy Development Project evaluations and studies have been dated for the year they were completed rather than the year they were published. This overview of evidence and challenges has been developed for two reasons. (1) Evidence about the use of evidence to inform policy and practice reveals that a common reaction to the what works and why findings is one that over-associates new evidence back into the views people already have (I already know that) resulting in little change. Systemic change is needed to raise achievement and reduce disparity. The focus on the on systemic challenges creates dissonance necessary to support deeper engagement for real change. (2) Appendix B is a tool to inform a strategy for systemic improvement that builds upon the now substantial evidence available about what makes a bigger difference in mathematics education. It is anticipated that this tool would develop iteratively as new evidence becomes available within a collaborative inquiry and knowledge building approach to sustainable improvement in mathematics education.

Bibliography

Note 1: A full bibliography of 103 Numeracy Development Project/Te Poutama Tau publications and electronic links to these are available on the New Zealand Maths website http://nzmaths.co.nz/annual-evaluation-reports-and-compendium-papers I have used where possible the year of data gathering rather than report publication to enable careful consideration of the impacts on schooling.

Note 2: The New Zealand Education Theses Database includes almost 300 theses focused on improving achievement in mathematics on the BES website http://www.educationcounts.govt.nz/goto/BES. These theses provide a further resource to inform improvements in mathematics education at primary and secondary level.


