Exploring Mathematics Interventions:

Exploratory evaluation of the Accelerating Learning in Mathematics pilot study

Report to the Ministry of Education

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Executive summary

This report presents the findings of an exploratory evaluation conducted by the New Zealand Council for Educational Research (NZCER) for the Ministry of Education in 2010. The evaluation was of a pilot study that aimed to accelerate the mathematical performance of low performing students. The report presents findings on shifts in student achievement and attitude, sustainability, and possible areas for further research.

Students completed: a survey on their attitudes to mathematics and school more generally; NumPA (a diagnostic interview); and a PAT:Mathematics test. These were administered just before the intervention, and about ten weeks later—after the intervention had come to an end. Teachers and facilitators responded to an online survey of their experiences and views of the intervention.

Achievement

Achievement levels have increased. The majority of students gained at least one numeracy stage as measured by NumPA. This included overall gains in areas such as knowledge of fractions even though they were not a target area of many schools. Overall PAT:Mathematics scores have also increased by an average of eighty percent of a year's growth over the ten weeks of the intervention. This indicates growth not just in the specific target areas of mathematics but more widely, including in the Geometry and Measurement, and Statistics strands. A relatively large shift in achievement for Pasifika students was seen, and reasons for this should be explored. While Mäori students made smaller gains than other groups, they still gained an average of forty percent of a year's growth in the ten weeks.

Major reasons identified by teachers and facilitators for shifts in achievement included:

- lessons that were well structured, regular, consistent, and made effective use of equipment;
- lessons that addressed deficits in knowledge as well as in strategies;
- group work which allowed focussed, safe environments where individuals could be actively involved, take risks, and have their needs addressed;
- teachers who were motivated, caring, and reflective;
- teachers with the necessary pedagogical content knowledge through professional development(PD) and input from the facilitators;
- an emphasis on memory of basic facts, and on the language of mathematics;
- coherence of the programme within the school;
- increased student confidence and self-efficacy, leading to more success in mathematics; and
- high levels of support from the home.

Of these, the emphasis on memory and mathematical language; the increased confidence and self-efficacy of students; and high attendance and engagement were features of schools with strong gains in achievement. On the other hand, low attendance, lack of self-belief, or behaviour issues as well as lack of continuity or communication within schools were associated with schools which showed no shift or negative shifts in achievement (as measured by PAT: Mathematics).

Attitudes

Student attitudes towards mathematics have become somewhat more positive overall. This change is far less marked than the improvement in achievement levels. Numbers of students showed no change in their attitudes towards mathematics (as measured by the student survey), and some showed a decline. Significantly fewer students reported feeling that "mathematics confused them". Attitudes towards school in general or ways in which students learn have remained static.

Major reasons identified by teachers and facilitators for positive shifts in attitude were:

- the relationships between teachers and students, including the safe nature of the small group, and the valuing of students' voice;
- support from home; and
- experiencing and celebrating success in mathematics.

Sustainability

Overall, teachers and facilitators were optimistic about students sustaining their learning from the intervention as a result of changed self-belief, increased confidence, and overcoming learning barriers. They identified the following conditions that would be needed for the gains to be retained: ongoing student monitoring, continued alignment with their classroom work, revisiting learning, and ongoing professional development for teachers. Some teachers had already noted evidence of sustained learning well after their intervention, though this was over a relatively short time frame. A longitudinal study or continued follow-up of these students would be needed to monitor long-term gains.

Areas for future research

These are exploratory findings, and need continuing research. This could also include a more rigorous follow-up of the potential factors influencing student achievement and attitude identified in this report; seeing if the achievement gains can be replicated in a different group of schools; and issues that need to be addressed for a full roll-out to all schools. The Reading Recovery programme and its evaluations give valuable guidance for this.

Introduction

This report presents the findings of an exploratory evaluation that was conducted by the New Zealand Council for Educational Research (NZCER) for the Ministry of Education (MOE) of the Accelerated Learning in Mathematics (ALiM) pilot study.

In early 2010 the Ministry of Education recruited 39 schools to take part in the Accelerated Learning in Mathematics (ALiM) pilot. The purpose of the pilot was to see if the learning of students who were low achievers in mathematics could be accelerated by targeted teaching and learning for a short period of time.

The pilot explored a range of interventions in numeracy to answer the question "What do we do with students who are below the expected standard for their year level?" The interventions in this project were focussed around two classroom-based "waves" of intervention: effective classroom teaching; and targeted focussed support for students by the teacher.

Schools were able to select any area of mathematics and it was suggested that some may have a measurement, geometry, or statistics focus. However, almost all of the interventions were in the Number strand. Intervention teachers could also decide on what specific maths concepts to target, how they explored these (instructional foci), and the nature of the target group/s involved in the ALiM pilot. Intervention teachers received release time (0.2) for a term while the intervention was underway and each school was allocated a numeracy facilitator (20 hours per school) to assist in the intervention. Generally, the interventions were in addition to the classroom mathematics programme. The bulk of the interventions ran throughout Term 3 of 2010. Teachers were encouraged to keep journals of the intervention to help them identify and document what worked well.

Importance and strategic impact of the research

New Zealand has a long tail of underachievement in mathematics. This has been noted in the Programme for International Student Assessment results (Ministry of Education, 2004) as well as in the Third International Mathematics and Science Study (Chamberlain, 2001). Research indicates that, given certain conditions, mathematics learning could be accelerated or enhanced (Empson, 1999; Dowker, 2001; Wright, Maitland, & Stafford, 2003; Anthony & Walshaw, 2007).

There is relatively little New Zealand research on intervention in mathematics. The aim of the ALiM pilot study and the evaluation presented here is to help address this gap. New Zealand does have the Reading Recovery intervention programme that is strongly rooted in schools[1]. Lessons

[1] Around 67 percent of state and state integrated schools run the Reading Recovery programme (Lee, 2010).

learned and recommended changes to Reading Recovery (McDowall, Boyd, & Hogden, with van Vliet, 2005) could be explored to enhance ALiM interventions.

Research aims and questions

The overall aim of the intervention was to explore how a range of interventions may influence mathematics achievement and attitude, and to identify enablers and barriers.

The specific research questions for the study were:

1. How does achievement change for each school's intervention?
2. How do student attitudes towards mathematics change for each school's intervention?
3. What aspects of the interventions are likely to influence student attitudes and achievement?
4. What other influencing factors may be useful to further investigate?

Method

The methods of data collection used in this exploratory study included:

1. pre and post intervention measures of students' achievement;
2. pre and post intervention survey of students' attitude; and
3. an online survey for teachers and numeracy facilitators about their experiences and views of the intervention.

The measures of achievement and attitude were conducted by the teacher involved in the intervention at the beginning of the intervention, and about eight to ten weeks later, after the intervention at their school had finished.

Student achievement instruments

Students were asked to complete:

- A PAT:Mathematics[2] test at the appropriate level for that group of students (students who are Year 3 or above); and
- NumPA[3] (numeracy diagnostic interview).

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[2] The PAT:Mathematics tests (Darr, Neill, Stephanou, & Ferral, 2009) give an overall measure of student ability in mathematics on a linear measurement scale The post-intervention PAT test was not the same as the pre-intervention test. This avoided students benefiting from their recall of the initial test.

Student attitude instrument

Students were asked to complete a survey that looked at: resources that were available to them at home; attitudes to school in general; attitudes towards mathematics; aspects of their mathematics lessons; and aspects about their lessons and learning in general.

Teacher and facilitator survey

An online survey was sent to all teachers and numeracy facilitators toward the end of the pilot study to gather further information about: their experiences and views of the intervention; perceived shifts in students' achievement and attitude; and possible influencing factors on these shifts.

Data analysis

The pre and post PAT:Mathematics scores were compared to find any overall shifts in student achievement at each year level. These shifts were broken down by a number of variables (gender, ethnicity, year level) to see if any shifts were significantly related to these variables. Tests of differences between means based on the normal distribution were used.

Analyses of NumPA results (which tests the movements of each student's stage on the Number Framework) were also made on each of the eight strategy and knowledge domains. Chi-squared goodness-of-fit tests (based on the null hypothesis of there being no change) were conducted on these to test if any changes were significant.

The relationships between the magnitude of the shift in achievement (as measured by PAT:Mathematics) and features of the intervention (such as maths or instructional foci, group size, frequency, duration of sessions, and other factors identified by teachers or facilitators) were analysed for possible common themes across successful interventions.

A factor analysis of the data for the initial student attitude survey was conducted to identify groups of variables (factors) that summarise the students' responses. Four factors emerged. The pre and post measures of the student attitude surveys were compared to identify any changes in student attitude based on these factors, using the chi-squared tests mentioned above.

Teacher and facilitator surveys were analysed for common themes on students' characteristics or aspects of the intervention that may have influenced student achievement or attitude. These were then used to match other influencing factors to shifts in student achievement or attitude.

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[3] NumPA is a diagnostic tool which measures at what stage students are at on each of the eight domains of the Number Framework (Ministry of Education, 2008b).

Sample

A total of 276 students returned their survey information. This comprised 132 boys and 144 girls. Most students were Year 4—Year 6, with fewer being at Year 7 or 8, and five Year 3 students (see Table A2 in Appendix A). Of these students 45.3 percent were New Zealand European; 31.2 percent Mäori; 28.6 percent Pacific people; 2.2 percent Asian; and 2.9 percent other ethnicities.

There were returns of the teacher survey from 37 of the 39 schools involved. All of the schools had one teacher who was released to run the intervention, with one school involving a second teacher. There were returns from 30 numeracy facilitators who were involved in supporting these teachers. Some facilitators were supporting more than one school.

Interventions

Each teacher and facilitator developed the particular form of the intervention for their own school. This involved choosing the target year level, the area of mathematics to be addressed, and the form of the intervention. Most schools (28) opted for either four or five sessions per week. Virtually all session lasted between 20 to 60 minutes, with an average of about 40 minutes (apart from one school who had a whole day session once each week for five weeks[4]). The total number of sessions in each school varied from 14 to 39 (apart from the school with five whole-day sessions). Most schools had small groups of students (from 4 to 9), however some schools had larger groups of around 12, and one had over 20 students involved.

The major focus of most schools was on Stages 3—5 of the Number Framework, with very few targeting Stages, 0, 1 or 7. The most common mathematical concepts were place value and basic facts, with over 80 percent of schools targeting these. Subtraction, addition, and patterns were each covered by half to two-thirds of schools. The most common instructional foci were on mathematical language, memory, visualisation, and the affective domain, with over half the schools emphasising these. See Appendix A for more complete tabulations.

[4] This school thought that they would not repeat this model for future interventions.

Results

Student achievement

Two assessment instruments were used: PAT:Mathematics, and NumPA. Each student had their numeracy level tested prior to, and straight after the intervention, typically about eight to ten weeks later. The results from both assessment instruments show many students in most schools made significant gains and that these gains were particularly large given the short period of the intervention. Of course within this there was range of positive, neutral and negative shifts in achievement at the student level and also at the school level.

The interventions and the NumPA assessment instruments focus on aspects of mathematics closely linked with the Numeracy Project and the Number Framework. For this reason it was considered that a separate, independent measure of student achievement should also be used. This allowed for a "bi-focal" look at student progress as well as avoiding potential criticism of "teaching to the test".

The second instrument used was PAT: Mathematics. While this was administered by the teachers, it requires no judgements of student responses to be made by them. The PAT tests were only used with students in Years 4–8, and are therefore not fully comparable with the numeracy assessments. A total of 213 students did a PAT test both before and after the intervention. The change in the patm[5] score for each of these students was analysed.

What follows is a detailed description of shifts in student achievement, and potential explanatory factors.

Numeracy project assessments (NumPA)

Progress on each domain of the Number Framework[6] was mapped. Table 1 shows the changes made in the additive domain by the 224 students with full data available. The shaded diagonal shows the 87 students who stayed at their original stage. A total of 102 students shifted up one stage, 27 shifted up two stages, and four moved up by three stages. Four students dropped one stage. This table shows a highly significant upwards shift in the numeracy stages that students are at post-intervention compared with their pre-intervention stages.

[5] patm is the unit used by PAT:Mathematics to measure mathematical ability. It is a linear scale (see Darr, et. al., 2009, pp. 12–14)

[6] The domains of the Number Framework are given in Book 1 of the numeracy booklets (Ministry of Education, 2008a).

Table 1 **Shifts in addition stages over the intervention**

Pre-Study Stage			**Post-**	**Study**	**Stage**		**Average growth (stages)**	**TOTAL**
	2	**3**	**4**	**5**	**6**	**7**		
1	1	0	2	0	0	0	2.3	**3**
2	1	3	19	0	0	0	1.8	**23**
3	0	0	8	2	1	0	1.4	**11**
4	0	0	34	72	5	1	0.8	**112**
5	0	0	4	52	18	1	0.2	**75**

A salient feature of Table 1 is the large number of students (72–64 percent of the 112) starting at advanced counting (Stage 4) who moved to early-additive part-whole (Stage 5). This shift from Stage 4 to 5 involves a major change in thinking from using counting strategies to part-whole strategies.

Another noteworthy shift was for the 18 students (24 percent of the 75) who moved from early additive strategies (Stage 5) to advanced additive (Stage 6). This again is a large conceptual jump, with early multiplicative thinking emerging from additive thinking. There were also 19 students (83 percent of the 23) who began at Stage 2 and moved up to Stage 4 (advanced counting). This is a smaller conceptual shift than the previous two.

There was highly significant growth for all eight knowledge and strategy domains (see Appendix B, which shows equivalent tables to Table 1). Generally, the lower the student's initial stage, the more likely they were to move up at least one stage. It needs to be remembered that shifts in Stages 1–4 are easier to achieve than shifts at the higher stages and that the scale is non-linear (Thomas, Tagg, & Ward, 2002; Irwin & Niederer, 2002). For example, students in this evaluation who started at additive Stage 1 grew an average of 2.3 stages, whereas students who started at Stage 5 grew an average of just 0.2 of a stage[7]. These same calculations across all of the eight tables in Appendix B reveals a consistent pattern, where students who were at Stages 1 or 2 gained about two numeracy stages on average; those at Stage 3 gained an average of one stage; those at Stage 4 gained three-quarters of a stage; and those starting at Stage 5 gained about a third of a stage. While this is broadly consistent with the movement of stages given on the bottom of the National Standards poster, Stages 1–3 may be more non-linear. This contrasts with the findings of Johnston, Thomas, and Ward (2010) which, in the additive domain for example, indicates that Stage 2 spans an equal range of mathematical ability[8] as Stage 5, and more than Stage 4. This exploratory evaluation, however, suggests a consistent drop-off in the amount of movement in the higher

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[7] The numbers of students at some stages is low, giving larger confidence intervals on the growth.

[8] Mathematical ability measured in logit units by Johnston et. al., (2010).

stages. Relative shifts can also be obtained by taking percentages of each row total. These also indicate that movements are more likely at the lower stages (with most students shifting upward), but are lower, especially for students starting at Stage 5.

Table 2 shows the overall gains made in each of eight knowledge or strategy domains. This gives a picture of gains without spelling out as much detail as Table 1. It is obtained from Table 1 (and Tables B2–B8 in Appendix B) by summing along each diagonal, which represent different shifts in numeracy stages. The shaded column shows the number of students remaining at their original numeracy stage. This does not imply that these students made no progress. Given the large overall shift, it seems reasonable that many of them advanced within that stage.

Table 2 **Changes in stages with each numeracy domain**

Numeracy domain[9]	Up 2+ stages	Up 2 stages	Up 1 stage	No change	Drop	Average Incr.* (stages)	Percentage increasing stages	TOTAL
Addition	2	27	101	87	4	0.71	59%	**221**
Multiplication	1	21	89	65	3	0.73	62%	**179**
Proportions	2	23	67	61	0	0.78	60%	**153**
FNWS	2	6	70	133	8	0.37	37%	**219**
BNWS	1	15	76	120	5	0.50	43%	**215**
Fractions	1	29	75	48	0	0.89	69%	**153**
Place value	17	35	77	80	3	0.92	61%	**212**
Basic facts	8	45	97	66	7	0.91	67%	**223**

* Average shift assuming the drop is of 1 stage, and the 2+ shifts are all of 3 stages

This table shows that large numbers of students made gains of at least one stage in each of the domains and substantial numbers made gains of two stages. A few students made gains of more than two stages, and these were generally in place value or in basic facts. The biggest gains were made in fractions, place value, and basic facts. The latter two are consistent with them being the areas which had the major focus (see Table A3, Appendix A). The result for fractions is somewhat more surprising, as relatively few schools specifically addressed proportions and ratios, or fractional numbers. Students were more likely to remain at the same stage in two of the domains of the Number Framework, the Forwards Number Word Sequence (FNWS) and Backwards Number Word Sequence (BWNS). There is a ceiling effect here, as most students were already at Stage 5 in these two domains. Virtually no students moved to Stage 6 in these domains, which means that they were not progressing onto numbers larger than one thousand, which is potentially the real test of whether place value understanding of whole numbers is mastered.

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[9] The domains of the Number Framework are given in Book 1 of the numeracy booklets (Ministry of Education, 2008a).

Progressive Achievement Tests (PAT) assessments

The mean scale score for all the 213 students completing PAT:Mathematics moved up by 4.66 patm units over the eight to ten weeks of the intervention. This is equivalent to an average of about 80 percent of a full year of growth for students. These results are consistent with the shifts in achievement detected by the NumPA tests. Table 3 compares the mean growth of individual students over the intervention with the mean growth in the norms between year level cohorts.

Shifts in achievement by subgroups

The shifts in PAT:Mathematics scores were broken down by gender, by ethnicity, and by year level to see if these were related to achievement gains. There was no significant relationship found for gender.

Year level

The amount of growth differed somewhat by year level. The growth is most pronounced for Year 8, where overall student scores increased by more than a full year's growth. It is substantially smaller for Year 5 students, and is reasonably similar for the other years. All the shifts are statistically significant except for Year 5.

Table 3 **Growth in patm scores by year level of students**

Year level	Number of students	Mean growth of students (patm units)	Yearly growth in Norms* (patm units–2009)	Percentage of yearly growth
4	55	6.85	7.7	89%
5	44	2.63	6.2	42%
6	56	3.64	4.5	81%
7	35	4.57	5.4	85%
8	23	5.94	5.6	107%
TOTAL	**213**	**4.66**	**5.9****	**79%**

* The difference between successive yearly norms (Darr et.al., 2009, p.30)

** Average growth per year.

Ethnicity

Students who identified themselves as Pasifika made the greatest gains in their PAT performance, increasing by an average of 6.02 patm units. NZ European students increased by 4.88 patm units, slightly more than Asian students (4.37 patm), and other ethnicities (4.63 patm). While none of these results were statistically significant, the gain for Pasifika is noteworthy given that these students typically perform lower than all other groups, including Mäori (Crooks, Smith & Flockton, 2010; Irwin & Woodward, 2006). Progress for Mäori students was statistically significantly lower than for the other ethnicities, with an average increase of 2.30 patm units. However, this still translates to about forty percent of a year's growth over the approximately ten weeks of the intervention.

These results were mirrored in the increases students made in Numeracy stages, with Pasifika students most likely to move up at least one stage over all domains, but Mäori students less likely to do so. A greater proportion of Pasifika students than other students made shifts of two or more stages, and they were also more likely to move up to Stages 6 and 7. This was particularly pronounced in the place value domain.

Teacher and facilitator views on shifts in achievement

The pre and post test scores of student achievement are consistent with the observations of both teachers and facilitators. Of those who gave a response, 97 percent and 93 percent respectively thought that a big or some positive shift in achievement had been made by students (see Appendix D, Table D1).

Many teachers saw the intervention as being successful, with a relatively large number of them expressing real excitement. This led for a strong call to see the initiative continue.

> I thought this was fantastic, having the chance to work with these children and see their attitudes change as they realised they could do maths …, and the improvement in knowledge and use of strategies has been fantastic. (Teacher)

Teachers and facilitators saw "teaching the language of mathematics" as an important part of the intervention. This led to "more mathematical language use" and students being more "able to explain their understanding". This indicates that emphasis on mathematical language was effective. They also made comments about oral and written language deficits of students in the intervention.

Their views on what may have led to the shifts in student achievement follow.

Views on potential reasons for improvement in achievement

An aspect of the intervention that teachers and facilitators most frequently saw as having a positive influence on achievement was well planned, structured, regular lessons emphasising repetition of ideas, and consistency. Other commonly mentioned aspects included: the effective use of equipment; fun activities; opportunities for discussion; and student involvement. Teachers, in particular, also mentioned the value of using small groups, specifically targeting student needs, and pitching teaching at "the appropriate level, not too easy, but not too hard", along with the use of good formative assessment practices and quality feedback to students aimed at enhancing learning.

> Withdrawal from the classroom. Being part of a small group of students with similar learning needs. Having the time and support to problem solve in a shared situation. Scaffolded learning. Using materials to show their thinking. Talking about their learning; what helps them to learn what gets in the way. (Teacher)

> Regular, predictive, involved oral, hands on activities, built on students knowledge, fun, lively, some recording, exploration of ideas, teacher and student modelling. (Teacher)

Facilitators affirmed the central role of teachers as being motivated, caring, knowledgeable, reflective, and in providing feedback. Both teachers and facilitators mentioned the need for teachers to have strong pedagogical content knowledge, and this required ongoing professional development (PD). Both teachers and facilitators commented on the marked improvement in teacher content knowledge. Some saw that this active model was excellent "real time" PD.

> Teacher knowledge and teacher mentoring [are important]. (Teacher)
>
> The time allowed through this intervention enabled the teacher to develop her knowledge and understandings and used it in her practice, not only with the students in her ALiM target group but also with the rest of students back in the classroom. (Facilitator)
>
> I personally have learned so much as I am a junior teacher and have taken my learning to new heights. (Teacher)
>
> The attitude and ability of the specialist teacher—[their] maths content and pedagogy grew during the process. [They] became very skilled at formatively assessing the students while teaching them and making decisions on the spot whether to advance them or consolidate their learning after listening and observing their discussion and actions. (Facilitator)

Teachers commented on the importance of resourcing both for facilitator involvement, but also for teacher release time. This also allows teachers to deepen their pedagogical content knowledge and to try new ideas.

> The support from our facilitator has been tremendous and vital to the success of the programme. (Teacher)
>
> The 0.2 time was needed to plan, assess and reflect daily on this group of students. It would not have been possible without it. (Teacher)

The emphasis on basic facts and aspects of memory work was also seen as helping lift achievement, not just in basic facts recall, but in the strategy domains as well. They saw basic facts as important because "knowledge related to strategy".

> Students picked up on knowledge aspects they had previously missed out on like combinations of tens, patterns of subtraction of tens, place value knowledge—once these gaps were filled the students were able to master strategy. (Facilitator)

Several teachers mentioned the value of having "coherence" (Newmann, Smith, Allensworth, & Bryk, 2001) between the intervention and a school-wide emphasis on mathematics that was already underway. A related issue was the support of school leadership for the model, and the interaction of other staff with the intervention. This is consistent with the findings of Timperley, Phillips, and Wiseman, (2003), who found that schools that were most successful in lifting student achievement had strong, well linked learning communities, which focus on improving student learning. The "connections between [the] ALiM and [the] classroom teacher" were seen as particularly important—a finding consistent with McDowall et. al. (2005) in their evaluation of Reading Recovery.

Both teachers and facilitators identified changes in student attitudes as another major reason for improved performance. In particular, many comments were made about the increase in students' confidence. Student involvement in the lessons, and their willingness to share their ideas with others was also noted. Another aspect relating to improved achievement was the non-threatening nature of the small groups. Teachers observed increased self-efficacy.

> Excitement to be in a special maths group, home support, positive attitude to learning, able to work at home independently, they all wanted to be better at maths. (Teacher)

> [Students] were more confident, [had] improved self-efficacy, [and] improved self-belief in attempting problems, [plus a] willingness to have a go and share ideas in a non threatening environment. (Facilitator)

> The students were more willing to take risks and share their developing understandings. The small group situation meant that for three of the children who are normally reluctant to share their ideas felt safe to do this. (Teacher).

In some schools, the project expectations of accelerating progress in mathematics were explicitly shared with students, who were then able to take ownership of their own learning. Tied to this was the emphasis on high teacher expectations. A number of aspects relating to students becoming more self-regulated learners with their own self-expectations were also identified as influencing increased achievement. Some teachers commented that students were keen to know their own progress, that they could identify their own progress, and that they were willing to work independently, or that their students had "developed resilience to persevere when problems are more challenging".

> [There was] a desire to improve and add learning intention stickers to their progress and achievement charts [and] a willingness to stay focussed until they had mastered a concept and consistently do their home tasks with positive parent support. (Teacher)

The benefits and importance of home and whänau involvement in students' learning were affirmed. This resonates with ideas from evaluations of home-school partnerships in numeracy (Fisher & Neill, 2008). One school had home learning packs designed to involve the parents and to reinforce learning through games. Teachers had observed that low attendance at the intervention sessions was often related to low achievement, and the home maybe able to help ensure students attend consistently.

> Parents were invited to sit in on intervention sessions and the children took home activities/games to do with parents. Parents were pleased to be involved and were delighted that their children were getting the opportunity for extra help (Facilitator).

Views on potential reasons for no shifts in achievement

Some students made no shift in achievement, and there were relatively few comments by teachers or facilitators about aspects of the intervention that may have been related to this. Several teachers questioned the emphasis on memory games and basic facts, and one would have spent more time on subtraction. The issues of the time or the pace of the teaching required to effect change and the need for reinforcement of knowledge aspects were mentioned by others. Some teachers would have liked a longer period of intervention, though other teachers considered the time period should not be extended. Pressure from the wider school programme was sometimes seen as reducing the impact of the intervention. ALiM requires time and resources.

Some comments were made about characteristics of children that related to them making no gains in achievement. The most commonly mentioned were lower attendance or issues around attention, dis-engagement or behaviour. Some students were reported as showing lower confidence or negative attitudes towards maths or school in general. Several mentions were made of students still struggling with retention of the learning from the interventions. For some others it was specific or overall learning difficulties, or various issues in students' lives.

Aspects of the intervention correlating with growth in achievement

The survey responses from teachers and facilitators gave an extensive set of variables that could potentially influence student achievement positively. A search was made of these variables for aspects of the intervention that may have a positive effect. We compared a small selection of schools that achieved significant positive shifts in their PAT:Mathematics results[10] with another group that had made neutral or negative shifts.

We then looked at the difference between these two 'sets' of interventions to identify factors that were evident in interventions with strong positive shifts but not with schools with neutral or negative shifts (and vice versa). However we also looked for any commonalities which would indicate that these factors were not likely to be contributing to the difference. These factors have been described elsewhere in this paper and the commonalities were in keeping with the range of all interventions.

The number of these interventions and the number of students in each are small, and the number of possible contributing factors is immense and very complex. Accordingly these results are exploratory and seek to offer possible ideas for further exploration.

Mathematical concepts and instructional focus

The set of interventions that had marked positive shifts focused on language and memory and more on teacher and student reflection. Schools with the big shifts typically looked at patterns, decimals, multiplication and division. These concepts all relate to working with older students in the positive shift set, and it may be that age is the factor rather than the mathematical concepts targeted.

[10] We decided to use PAT:Mathematics results for reliability and validity reasons; they are an independent assessment of the student achievement and do not rely upon teacher interpretation and moderation, and they are not closely related to the type of questions used in the intervention.

Student attitude and self-concept

Teachers in the schools with the big positive shift were far more likely to comment that students were engaged and beginning to develop a sense of their identity as learners, and confidence and belief in themselves. Teachers involved in these interventions used words like *excited*, *engaged* and *focused* to describe students. Conversely, in the neutral or negative shift interventions, teachers described students' lack of self-belief or confidence, behaviour issues, and poor attendance (although one positive-shifting intervention identified that they had attendance issues with high achieving students). In one intervention that had a negative shift the teacher described a student that became "disheartened" not being able to compete in the group.

Connections between intervention and classroom programmes

Another notable difference was how teachers described the connections between the intervention group and the classroom teacher. Teachers from the interventions that had neutral or negative shifts indicated the need for better communication and continuity between the intervention and classroom mathematics teacher.

Student attitudes

Students were given a survey before the intervention and again after it. The survey included questions on: resources they have at home; attitudes to school in general; attitudes towards mathematics; aspects of their mathematics lessons; and aspects about their lessons and learning in general, including aspects of key competencies.

A statistical analysis[11] showed that the questions grouped into four main sets of the questions (referred to as "factors") each of which relates to a similar underlying construct. The first of these related to aspects of their classroom-based learning in general, including their mathematics lessons; the second, to their positivity towards mathematics; the third, to their positivity towards school; and the fourth, to their negativity towards mathematics. While the second and fourth dimensions were separate entities from a statistical perspective, from an interpretive viewpoint they are opposite sides of the one coin.

Pre-intervention attitudes

The baseline attitudes showed that boys were somewhat more positive towards mathematics than girls (chi-squared = 9.68, 3 d.f., $p=0.022$), and somewhat less negative than girls (though the latter comparison did not reach statistical significance). Another significant effect was that students' general enjoyment of school diminished the longer they had been at school, and was lowest in Years 7 and Year 8. This is consistent with research findings that show a decreasing trend in engagement levels with maturation (Dingle & Boyd, 2009). Students' general enjoyment of school

[11] A factor analysis was performed. This involved an initial principal component analysis, and then a varimax rotation to arrive at the final four factors.

tends to be higher as the number of resources that are available to them at home increases. This is consistent with findings from the Competent Learners study (Wylie, Hogden, Hipkins, & Vaughan, 2008). There was no relationship between attitudes and student ethnicity.

Changes in attitude

The attitudes questionnaire was repeated by students after the intervention. Significant changes were seen in two of the four attitudinal factors identified, while little change was seen for the other two. Students' responses showed that their overall enjoyment of maths had increased over the intervention (Factor 2), and that they were less likely to express negative attitudes towards maths (Factor 4). The shift away from negative perceptions was more marked than the shift towards positive perceptions. The summary of the changes for the students who responded both pre- and post-intervention are shown in Table 4. Factors 2 and 4 showed a significant shift, as substantially more students showed more positive attitudes than more negative ones. For the other two factors—aspects of the student's learning (Factor 1) and their positivity towards school (Factor 3), the few positive (upwards) and negative (downwards) movements were approximately in balance, especially for Factor 3.

Table 4 **Changes in attitudinal rating by students**

Factor	Up more than 1	Up by 1	Same	Down by 1	Down more than 1	TOTAL
1. Classroom learning / key competencies	21	40	67	29	20	**177**
2. Likes maths**	25	40	102	24	10	**201**
3. Likes school	19	39	75	43	23	**199**
4. Dislikes maths***	29	55	82	24	11	**201**

**Significant at 1% level (based on assumptions of symmetry of movements up and down)

***Significant at 0.1% level (based on assumptions of symmetry of movements up and down)

By far the biggest shift in individual questions about attitudes was that far fewer students reported that "Mathematics confused them". Smaller changes towards a more positive outlook towards mathematics were seen in virtually all of the related sub-scales. Student ethnicity or gender showed no significant relationship with changes in attitudes.

Teacher and facilitator views on changes in students' attitude

Most teachers thought that student attitudes had improved, with 32 of the 35 who gave an opinion reporting a big or some positive shift. The facilitators concurred that student attitudes had improved, with all 24 who responded reporting a big shift or some shift (see Table D2 in Appendix D). There were numbers of comments, however, that indicated that not all students had made a positive shift, and that for a few their attitudes had declined.

Generally teachers and facilitators described evidence of students becoming more positive, rather than identifying *reasons* for the improved attitudes. The most common words teachers used to describe students attitude were *confidence; enjoyment; focused, engaged, or on task; interested; involved; motivated; positive attitudes; risk taking; success; and improved understanding*. Facilitators emphasised the active involvement of the students more heavily than teachers.

> [Students] were a lot more talkative and involved in discussions [and] keen to participate in anything. (Facilitator)

> More confidence in their maths ability, eager to learn, enthusiastic, engaged, willing to take risks, encouraging each other. (Teacher)

> [Students were] engaged and focused in all sessions, attended all sessions, confident to contribute to group discussions, wanted to learn new concepts. (Facilitator)

Views of potential reasons for attitudes improving

Teachers and facilitators identified a diverse range of features they considered affected attitudes positively. Many of these are the same as those perceived as leading to positive achievement.

The most common reason given for upwards shifts in student attitudes was the positive, encouraging, caring relationships between teacher and students, and between students. Small groups, plus working in pairs, fostered these relational aspects.

> A very caring teacher who has excellent relationships with the students. (Facilitator)

Acknowledging student voice and student needs, and letting students know they are valued were also seen as a way to improve attitudes. Knowing what is expected of them, and ownership of the learning process were also mentioned.

The use of small groups was often mentioned. This was because there was an environment where students could take risks, be more involved in discussions and group work, and be free from the negative preconceptions of others toward them.

Teacher attitudes to mathematics itself, and the ability to make it "do-able" were also seen as important, as was teachers' pedagogical content knowledge.

> Teacher's positive and enthusiastic attitude to maths [is important]. (Facilitator)

> [The] ability and inclination to see mathematics as sensible, do-able and worthwhile is important. (Facilitators—several used this phrase)

Another major influence on student attitude reported by teachers and facilitators was the support and interest from the students' homes, and the active involvement of parents and caregivers.

Many schools also reported that their current school-wide emphasis on mathematics was influencing student attitudes, as was students seeing the relevance of mathematics. This "coherence" (Newmann et. al., 2001) within schools was also seen as having a positive influence on student achievement.

Students experiencing success in mathematics was seen as closely linked to improved confidence and overall attitudes towards mathematics. About a quarter of teachers mentioned that celebrating this success in tangible ways was important. High teacher expectations were also seen as a way to improve success and thence attitudes. This creates an interesting cycle, with good attitudes, especially confidence, leading to success, and success to good attitudes and higher confidence. From this it follows that high expectations lead to success and this flows on to improved attitudes.

Views of potential reasons for attitudes not improving

Very few comments were made by teachers or facilitators about possible reasons why some students continued to have negative attitudes towards mathematics. The most common reasons given were a lack of confidence, poor self-esteem, low involvement, risk aversion, off-task behaviour, and students becoming discouraged at their lack of progress. Some students did not like missing out on regular classroom time and some resented this. The time of day of the intervention was mentioned by one who said that afternoons were not a good time. Another said they would emphasise group work more strongly.

Sustainability of achievement gains

Teachers and facilitators were asked their opinions about students' sustaining their learning. On the whole they were optimistic about students retaining the learning benefits of the intervention, given a range of conditions. Some stated that it is likely that some students will sustain their learning and not others, and very few indicated that they didn't think the learning would be sustained.

Four responses from teachers indicated they had further evidence of short-term retention of gains in achievement. One intervention teacher noted student sustaining their learning in class:

> Discussion with the class teacher and assessment done (5 weeks after intervention) has indicated gains have been sustained and the children who moved up a stage are working very, very comfortably in that area. (Teacher)

The most common reason for respondents believing that learning gains were sustainable was the positive change in students' self-belief and attitude toward developing their identity as learners. The next most common reason was that attention had been given to specific key areas of mathematics that had acted as barriers and that students had moved past these barriers through developing their understanding. The areas that were mainly cited were developing their basic facts knowledge, and understanding of place value.

Conditions needed to sustain learning

Many facilitators considered continued planning, monitoring, or school leadership commitment to the intervention group, and, to some degree, whole school involvement as important to sustain the learning gains. Teachers and facilitators also noted the importance of either involving the classroom teacher during the intervention or maintaining ongoing communication to support the classroom teacher to build on the learning from the intervention. They identified many post-intervention actions that classroom teachers could take to assist students to maintain their gains. These included: making connections to previous learning; revisiting learning; authentic, relevant real life learning; practice; and using equipment to support understanding. Many of these components are fundamental aspects of effective teaching (Askew, Rhodes, Brown, Wiliam, & Johnson, 1999; Alton-Lee, 2003; Anthony & Walshaw, 2007).

One teacher noted the importance of student confidence and continuing to build on their learning:

> For most of the group, yes. For the less confident one or two, I feel the learning may not be maintained without the regular structure and knowledge focus. The children felt their class maths was harder than the focus group work, and it is much harder to closely monitor learning gaps in a whole class. (Teacher)

In a number of these interventions the intervention teacher was the classroom teacher and this may well support this continuity. Some of the other conditions for sustaining the learning that respondents gave were the need for ongoing professional development and informing or involving parents, and teacher belief and buy in.

These findings are consistent with the findings from an evaluation of Reading Recovery (McDowall et. al., 2005).

Discussion

Given the success of the intervention at achieving significant gains in student achievement, it would be worthwhile to investigate further a number of questions:

- Will the gains be able to be replicated in a larger group of schools, and be rolled out successfully to all schools? This has significant resource implications.
- Will the gains these students have made be sustained over the medium to long term? This will require follow-up research of the students in this intervention as well as future interventions.
- To what extent were the gains in student understanding in this intervention influenced by having additional numeracy time on top of normal classroom mathematics?

Even though some potential factors influencing the growth in achievement are identified, further exploration needs to continue. The schools' reflective journals may well provide further insight.

There is some difference of opinion as to whether the schools should withdraw the students or keep them in class; or whether the home-room teacher should take the intervention or trained intervention specialists.

In this exploratory evaluation, the gains in Numeracy stages diminished the further up the Framework the student started from. This is consistent with where the stages are located on the National Standards poster.

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Appendix A: **Profiles of the sample and the interventions**

Table A1 **Main Number Framework stages targeted by each school**

Number framework stage	Schools (%)
Stage 0 – Emergent	1 (3%)
Stage 1 – One-to-one counting	2 (5%)
Stage 2 – Counting from one on materials	7 (19%)
Stage 3 – Counting from one by imaging	17 (46%)
Stage 4 – Advanced counting	30 (81%)
Stage 5 – Early additive part-whole	27 (73%)
Stage 6 – Advanced additive (early multiplicative part-whole)	12 (32%)
Stage 7 – Advanced multiplicative (early proportional part-whole)	1 (23%)
TOTAL	**37**

Percentages sum to over 100% as respondents could be working across several stages.

Table A2 **Year level of students**

Year level	Students (%)
Year 3	5 (2%)
Year 4	67 (24%)
Year 5	78 (28%)
Year 6	65 (24%)
Year 7	37 (13%)
Year 8	24 (9%)
TOTAL	**276 (100%)**

Table A3 **Main mathematics concepts focused on by schools**

Mathematics concept	Schools (%)
Place value	30 (81%)
Basic facts	30 (81%)
Subtraction	24 (65%)
Addition	23 (62%)
Patterns	20 (54%)
Multiplication	11 (30%)
Fractions	9 (24%)
Division	8 (22%)
Decimals	6 (16%)
Other	8 (22%)
TOTAL	**37**

Percentages sum to over 100% as respondents could be working across several mathematical concepts.

Table A4 **Instructional foci of the intervention by schools**

Focus	Schools (%)
Mathematical language	26 (70%)
Memory	24 (65%)
Visualisation	23 (62%)
Attitude/affective domain	21 (57%)
Problem solving	18 (49%)
Constructing equipment	15 (41%)
Student voice	14 (38%)
Teacher knowledge	13 (35%)
Working with teachers	12 (32%)
Home-school partnerships	12 (32%)
Reflection	12 (32%)
Recording	7 (19%)
Reflective journaling	6 (16%)
TOTAL	**37**

Percentages sum to over 100% as respondents could have multiple foci.

Appendix B: **Shifts in the Number Framework domains**

Table B1 **Shifts in addition stages over the intervention**

Pre-Study Stage	**Post- Study Stage**						**Average growth (stages)**	**TOTAL**
	2	**3**	**4**	**5**	**6**	**7**		
1	1	0	2	0	0	0	2.3	**3**
2	1	3	19	0	0	0	1.8	**23**
3	0	0	8	2	1	0	1.4	**11**
4	0	0	34	72	5	1	0.8	**112**
5	0	0	4	52	18	1	0.2	**75**

Table B2 **Shifts in multiplication stages over the intervention**

Pre-Study Stage	**Post - Study Stage**					**Average growth (stages)**	**TOTAL**
	2–3	**4**	**5**	**6**	**7**		
2–3	2	9	5	0	0	1.6	**16**
4	1	37	67	15	1	0.8	**121**
5	0	2	22	11	1	0.3	**36**
6	0	0	0	4	2	0.3	**6**

Table B3 **Shifts in proportional stages over the intervention**

Pre-Study Stage	**Post - Study Stage**				**Average growth (stages)**	**TOTAL**
	2–4	**5**	**6**	**7**		
1	9	8	1	0	3.1	**18**
2–4	38	47	14	0	1.4	**99**
5	0	21	10	1	0.4	**32**
6	0	0	2	1	0.3	**3**

Table B4 **Shifts in FNWS stages over the intervention**

Pre-Study Stage			Post -	Study	Stage		Average growth (stages)	TOTAL
	1	**2**	**3**	**4**	**5**	**6**		
1	0	0	0	0	0	0	-	**0**
2	0	3	9	4	0	0	2.1	**16**
3	0	0	1	4	1	0	1.0	**6**
4	0	0	0	24	30	1	0.6	**55**
5	0	0	0	2	97	27	0.2	**126**
6	0	0	0	0	6	8	-0.4	**14**

Table B5 **Shifts in BNWS stages over the intervention**

Pre-Study Stage			Post -	Study	Stage		Average growth (stages)	TOTAL
	1	**2**	**3**	**4**	**5**	**6**		
1	1	1	4	1	0	0	1.7	**7**
2	0	2	6	8	0	0	1.4	**16**
3	0	0	2	1	2	0	1.0	**5**
4	0	0	2	24	42	1	0.6	**69**
5	0	0	0	3	88	26	0.2	**117**
6	0	0	0	0	0	3	0.0	**3**

Table B6 **Shifts in Fractions stages over the intervention**

Pre-Study Stage		Post -	Study	Stage		Average growth (stages)	TOTAL
	2–3	**4**	**5**	**6**	**7**		
2–3	6	14	17	1	0	1.8	**38**
4	0	19	44	7	0	0.8	**70**
5	0	0	23	16	5	0.6	**44**

Table B7 **Shifts in Place value stages over the intervention**

Pre-Study Stage			Post -	Study	Stage		Average growth (stages)	TOTAL
	2	**3**	**4**	**5**	**6**	**7**		
0–1	4	0	11	2	0	0	3.1	**17**
2	10	0	13	0	0	0	1.1	**23**
3	0	0	12	2	0	0	1.1	**14**
4	0	0	56	56	17	4	0.8	**133**
5	0	0	3	12	7	3	0.4	**25**
6	0	0	0	0	2	0	0.0	**2**

Table B8 **Shifts in Basic Facts stages over the intervention**

Pre-Study Stage				Post -	Study	Stage		Average growth (stages)	TOTAL
	0–1	**2**	**3**	**4**	**5**	**6**	**7**		
0–1	5	10	5	6	0	0	0	2.1	**26**
2	0	3	3	15	1	0	0	2.6	**22**
3	0	0	1	14	9	0	0	1.3	**24**
4	0	0	0	30	53	14	1	0.9	**98**
5	0	0	0	3	23	17	2	0.4	**45**
6	0	0	0	2	2	4	0	-0.8	**8**

Appendix C: **Shifts in PAT:Mathematics scores**

Table C1 **Growth in patm scores by year level of students**

Year level	Number of students	Mean growth of students (patm units)	Yearly growth in Norms* (patm units–2009)	Percentage of yearly growth
4	55	6.85	7.7	89%
5	44	2.63	6.2	42%
6	56	3.64	4.5	81%
7	35	4.57	5.4	85%
8	23	5.94	5.6	107%
TOTAL	**213**	**4.66**	**5.9****	**79%**

* The difference between successive yearly norms (Darr et.al., 2009, p.30)

** Average growth per year.

Appendix D: Reported shifts in achievement and attitudes

Table D1 **Teacher and facilitator reported shifts in student achievement**

Amount of shift	Teacher views	Facilitator views
Big positive shift	18 (49%)	13 (43%)
Some positive shift	18 (49%)	14 (47%)
Little positive shift	1 (3%)	2 (7%)
No shift or negative shift	0 (0%)	0 (0%)
Don’t know	0 (0%)	1 (3%)
TOTAL	**37**	**30**

Table D2 **Teacher and facilitator reported shifts in student attitude**

Amount of shift	Teacher views	Facilitator views
Big positive shift	19 (51%)	16 (53%)
Some positive shift	13 (35%)	8 (27%)
Little positive shift	3 (8%)	0 (7%)
No shift or negative shift	0 (0%)	0 (0%)
Don’t know	2 (5%)	6 (20%)
TOTAL	**37**	**30**

