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Teachers and Curriculum is an online peer-reviewed publication supported by Wilf Malcolm Institute of Educational Research (WMIER), Faculty of Education, The University of Waikato, Hamilton, New Zealand. It is directed towards a professional audience and focuses on contemporary issues and research relating to curriculum pedagogy and assessment.

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Notes for Contributors

Teachers and Curriculum welcomes

- innovative practice papers with a maximum of 3,500 words, plus an abstract or professional summary of 150 words, and up to five keywords;
- research informed papers with a maximum of 3,500 words, plus an abstract or professional summary of 150 words, and up to five keywords;
- thinkpieces with a maximum of 1500 words; and
- book or resource reviews with a maximum of 1000 words.

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Teachers and Curriculum provides an avenue for the publication of papers that

- raise important issues to do with the curriculum, pedagogy and assessment;
- reports on research in the areas of curriculum, pedagogy and assessment;
- provides examples of innovative curriculum, pedagogy and assessment practice; and

- review books and other resources that have a curriculum, pedagogy and assessment focus.

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Acknowledgement of Reviewers

Thank you to the reviewers for their contribution to the process and quality of this issue. Many thanks to those who also helped with a review but the paper did not make it to this issue.

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THE CHANGING LANDSCAPE OF ONE PRIMARY SCHOOL'S MATHEMATICS CURRICULUM

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Abstract

This paper describes a period of substantial changes in the mathematics curriculum of one primary school in Christchurch. Using retrospective analysis, we identified two important conceptual themes: equity of mathematical learning and opportunities for all students to learn to be a mathematician. Access to research about these themes prompted two organisational actions, the elimination of between class streaming and a concentrated professional learning focus on mathematics, that acted as catalysts for major changes. In the first year of these changes, there were significant gains in student assessment data, providing early and encouraging feedback for teachers. During subsequent years, further changes were implemented that illustrated how equity and opportunities to be a mathematician were enduring themes for resourcing and sustaining teachers' practices.

Keywords

Mathematics education; curriculum change; equity

Introduction

Long term and meaningful curriculum change in any class setting is complicated and takes time (Timperley, Wilson, Barrar, & Fung, 2007), and this complexity is magnified when curriculum change occurs across a whole school. While an s-shaped or sigmoid curve is a useful model to represent curriculum change over time, growth and consolidation phases might also be sequential or concurrent, illustrating that any change process "is complex, with the different aspects mutually informing and guiding each other" (Cowie, Hipkins, Keown, & Boyd, 2011, p. 2). System change in educational contexts can encompass larger systems of regional or national schooling, as well as mid-level networks, such as a cluster of neighbouring schools. While these larger systems exert different and often background influences on individual schools, the micro-systems of teachers and students in a single school setting, are the most closely interconnected and dynamic systems of change (Fullan, 2010; Hargreaves & Fullan, 2009). As an example of localised curriculum change, this paper describes our perspective of mathematics curriculum change at one primary school over a number of years. We highlight important features of the chronological sequence of changes in the school mathematics curriculum, and relate specific elements of the curriculum change to current research and debates within mathematics education.

Wendy is the Deputy Principal at a state contributing primary school in the southwest of Christchurch. During 2011 Wendy, while on study leave, completed a full year online masters course in mathematics education where Jane was one of the course lecturers. Due to the disruption of the February earthquake, the masters course began as an online course, followed by semi-regular meetings of a small group of primary teachers and primary mathematics advisors. The group of masters students read and discussed research and other writings about the learning and teaching of mathematics, and focussed on what was important for students. For this paper, the authors have drawn from our professional reflective notes, Wendy's assignment work, and our ongoing discussion notes to retrospectively describe and analyse important aspects of the curriculum change in Wendy's school.

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The work of Jo Boaler was an early focus of the course (Boaler, 2008, 2009), and turned out to be a critical resource for Wendy, who identified two conceptual themes. The first theme was *equity of mathematical learning*, meaning both *academic* equity (student achievement outcomes) and *relational* equity (the ways that student contributions are valued). And the second theme was *opportunities for all students to learn to be mathematicians*, that is, that all students participate in mathematical tasks that are worth solving (Boaler, 2008). These two conceptual themes will be discussed in later sections of this paper.

On the author's return to school later in 2011, mathematics became the focus of staff professional learning, and significant organisational changes were implemented within the school. Two of these organisational changes, prioritising professional resource (teacher time) and the elimination of streaming, were important and were catalysts, due to their impact on the mathematics curriculum in this school context. Processes of curriculum change are not necessarily constant but Wendy has found that returning to the overarching concepts of equity and opportunity for all to be mathematicians, ensured that the resources and staff levels of commitment were able to sustain ongoing cycles of curriculum design and change in practice. Evidence of changes in student achievement data and greater in-class student engagement, encouraged teachers to continue with the implemented changes. Finally, we propose that giving time and attending to important overarching concepts, while organisational structures change, can have surprising benefits that serve to support and sustain teachers' willingness to continue with enduring changes in curriculum and practice.

Commitment for change

Academic equity (related to student achievement) was an early focus when reading and discussing the work of Jo Boaler (2009) and other researchers. Firstly, classroom organising practices are never benign, and in particular, the research on streaming of students by mathematical ability is unequivocal and concerning. For many years, researchers have highlighted the effects of streaming on student learning opportunities (Wiliam & Bartholomew, 2004); students in the top streams experience academic success, at the expense of students in the low streams who do not. Further disparity arises when the top streams cover material more quickly compared to lower streams, creating a cumulative effect as the lower stream classes fall further behind (Boaler, 2009; Turner, 2007). Furthermore, there are usually disproportionate numbers of low-income and ethnic minority group students in lower stream classes (Wiliam & Bartholomew, 2004; Zevenbergen, 2003). Not only does ability grouping parallel social class and ethnic groupings, streaming by ability actually increases the achievement gap, acting as a sorting system for the next schooling transition, and possible future options. In the mathematics education course, we had discussed how streaming practices shaped opportunities for students to learn mathematics and provided different, and often unequal, mathematical experiences, which contributed to ongoing inequity of student academic achievement. Consequently, the research evidence about the effects of streaming in mathematics provided Wendy with a strong commitment to change the inequitable practice of streaming in the school.

In addition, research about the impact of ability grouping on teacher pedagogy was alarming. When teachers hold different expectations for differing ability groups of students, they can also value and respond differently to student contributions, with implications for relational equity (that is, contributions from all students are valued). Teachers make qualitatively different pedagogical decisions for and with, different ability groups, both in planning their mathematics programmes and during mathematics lessons. When teaching a low ability class, teachers tend to focus on basic skills, memorising facts, fragments of mathematics content, and managing student behaviour. In contrast, when teaching high-ability groups, teachers include investigative activities with mathematical challenge, higher-level questioning, and more collaborative and shared opportunities for making meaning (Boaler, 2008; Wiliam & Bartholomew, 2004). When applied to a primary school context, student grouping decisions influence teacher decisions around expectations of who can and will succeed, clearly channelling learners towards opportunities to either engage in genuine and challenging problem solving tasks (Boaler, 2009), or towards completing procedural tasks that require lower-level demand (Smith & Stein, 2011). Staff came to understand this distinction where classroom tasks that convey different expectations of mathematical learning, shape student contributions in different ways.

Introducing the notion of 'opportunities to learn to be a mathematician' opened a door for teachers to consider the school mathematical worlds of their students, worlds that could be experientially different for different groups of students (Nuthall, 2007). For Wendy, this became the second commitment for change; that each and every student has the opportunity to learn to be a mathematician. She was committed to the view that mathematicians pose questions for exploration, use a range of representations to assist with problem solving, collaborate with others, and use precise language and symbols for communicating their findings and ideas (Boaler, 2009). In addition, being a mathematician is about exploring activities with an unknown solution process or the answer.

Two catalysts for curriculum change

Since 2005, the school had operated a streaming system known as 'interchange' for mathematics in the Year 3 to Year 6 classes. Students were allocated to a particular ability group, based on assessment data from the previous year, and mathematics was timetabled at the same time each day for two parallel interchanges (one for Years 3 and 4 students and the other for Years 5 and 6) so that students could move to their streamed classes at the same time. Interchange is still a relatively common feature of primary school mathematics programmes. The original rationale for interchange at the school was the belief that ability grouping would optimise learning for all students by reducing the within-class range of mathematics ability, therefore allowing teachers to target the mathematics content at a more appropriate level for student learning needs. At the beginning of 2012, Wendy led staff meeting discussions on research about ability grouping and how grouping decisions could lead to inequitable opportunities for students, thereby inhibiting the mathematical growth of some. This touched a chord with staff. In the school, teachers were concerned about the school data that showed a considerable discrepancy between the achievement of Māori students when compared with their school-wide cohort groups in mathematics. Based on research and discussions, staff were keen to address this issue and agreed with the decision to eliminate the practice of between class streaming. This decision was the first catalyst for significant curriculum change in mathematics.

While all teachers were in agreement with the decision to stop streaming for maths, some were anxious about meeting the needs of all their students in a heterogeneous class setting. In response, the school leadership team prioritised mathematics as the sole professional learning focus for 2012. This was a major commitment in a primary school where there are often multiple professional developments occurring simultaneously. A consequence of this decision was that resources of time and professional learning were dedicated to supporting the staff to plan and implement a more equitable mathematics programme. We have identified this commitment to professional learning by both the teachers and school management as the second catalyst for curriculum change.

Sharing, supporting and sustaining

The two catalysts described above were crucial in supporting changes to existing school practices but were only one part of the school's story of mathematics curriculum change. In this section, we outline some of the features of teachers' work that were also important.

During a time of curriculum change, teachers need to be able to keep some aspects of their practice and programmes the same. Although teachers were now teaching mathematics within their own heterogeneous class, many continued to predominantly group by achievement for direct teaching of the different groups—a practice that had been in place for a number of years and was influenced by the early professional development of the Numeracy Development Project Ministry of Education, 2006). As part of the school's professional learning, and in response to the discrepancy of achievement for our Māori students, teachers at all levels identified a small target group of three students, prioritising Māori students who were not achieving at National Standard expectation. Throughout the year, the teachers presented assessment data and a narrative of each student's learning to their teaching team and collaboratively discussed other ways of enhancing mathematical outcomes. Teachers' attention to the mathematical learning of specific students was important for igniting professional dialogue and reflection around teaching approaches. In addition, the sharing of each student's narrative created a communal sense of responsibility for the learning of all students.

As well as professional learning sessions for the whole staff and for teaching teams, during 2012 there were a number of specific activities that were introduced and sustained. Teachers read and discussed professional literature, such as Boaler (2006) and Chapin and O'Connor (2007). An important thread of the teacher conversations related to the earlier themes that we have identified: the importance of opportunities to learn to be a mathematician and academic (achievement outcomes) and relational equity, where all students have the opportunity to have their contributions heard, valued and accepted as worthy (Boaler, 2008). It was important that teachers attended to both concepts of equity, where academic and relational equity were useful lenses for examining existing practices. To realise relational equity, both teachers and students needed to recognise that everyone can "add value" within the mathematics classroom. In many classrooms students have unequal status in the eyes of their teachers and amongst their peers (Boaler, 2008; Gresalfi, 2009), and consequently their opportunities to explicitly participate, and therefore to succeed, are inequitable. "One of the consistent findings from international comparisons of attainment in mathematics is that 'opportunity to learn' is a good predictor of pupil outcomes" (Askew, 2001, p. 110). Consequently, deliberate teacher actions were required to actively promote and sustain relational equity.

Within their professional learning meetings, teachers read and discussed the concepts of equity and student participation, and decided to introduce some specific practices into their mathematics programmes. These practices were based around increasing the opportunities for students to engage in productive maths talk with each other and in the more public sphere of class interactions (Stein, Engle, Smith, & Hughes, 2008).

The school mathematics achievement results at the end of 2012 amazed the staff. The overall school-wide achievement of students meeting or exceeding National Standard expectations had lifted from 81 percent in 2011 to 94 percent in 2012, and Māori students were achieving at the same rate as their school-wide cohort. This was particularly significant for Māori students, because only 64 percent had been achieving at or above National Standard in 2011. There was a general consensus among the staff that the biggest impact on students' learning had been the move to heterogeneous groupings where students remained in their own classrooms with their own teacher and peer group. The evidence of the data was important feedback for teachers, demonstrating that a major change to their mathematics programmes had resulted in a substantial improvement in a relatively short time span of one school year. Teachers could see that their efforts made a difference and their additional work and risks were worth it for the students in their classes.

The next three years

In 2013, teachers continued to the implement the mathematics curriculum changes, and one Year 5 and 6 class trialled a problem solving approach with flexible heterogeneous groupings. This approach also relied on developing productive mathematics dialogue, using talk moves among peers and with the teacher in class discussion (Chapin, O'Connor, & Anderson, 2009). The trial extended over Terms 2 and 3 with Progress and Achievement Test (PAT) (Neill, 2015) data collected at the beginning and end of the trial, and compared with a similar class that had not been involved in the problem solving, heterogeneous grouping approach. While 17 percent in the usual numeracy approach class achieved two or more stanine shifts over the trial period, 41 percent of the trial problem solving class moved two or more stanines during that period. Student voice was also gathered through interviews with their teacher. The students said that they enjoyed maths, they loved learning how to 'maths argue a point', and that they were more confident in sharing their thinking. As one Year 6 boy said, "My favourite thing at school is problem solving because you get time to think. I hope they do problem solving at intermediate (school) next year".

In 2014, the Year 5 and Year 6 teacher team (5 classes) embraced the idea of providing a programme that provided opportunity for all children to engage in realistic mathematical problems. This problem solving approach, with flexible heterogeneous groupings, resulted in notable shifts in mathematics achievement data. The PAT scaled score (PAT mathematics), which applies the same scale across the learning area regardless of the year group of the student, is useful for tracking student progress over time. At the end of 2014, 31.5 percent of the Year 5 student PAT mathematics results and 48.5 percent of the Year 6 student PAT mathematics results indicated shifts that were equivalent to two years or greater progress. The data was supported by high levels of student engagement, demonstrated by their enthusiasm for maths. At parent interviews, students were excited to share their maths with their parents, and talked to them about their ideas. In Term 3, when Year 5 and Year 6 students were interviewed by ERO (Education Review Office) staff, they ranked maths as their second favourite subject, after Physical Education.

The in-school evidence suggests that providing opportunities for all students to be involved in realistic mathematical activity, with mathematical reasoning at the centre, was successful in raising student outcomes. Based on this, mathematical problem solving using productive mathematical talk was extended across other teaching teams (Year 1 to Year 4) who are currently trialling a problem solving approach. These teachers are similarly seeing the benefits of equity practices where heterogeneous groups share their thinking through productive maths talk, and consequently the students are supporting, challenging and learning from each other. As one student said, "I like working in groups because I can learn from others and they can learn from me". This statement is poignant because this student had not previously experienced success nor valued herself as a mathematician. Her shift in thinking came about because she experienced success with challenging tasks, alongside her peers, and she knew her mathematical contributions were valued within the mathematics classroom. With assessment data continuing to show learning gains and with noticeable shifts in student engagement, teachers continue to be committed to adapting their mathematics programmes to ensure equity, both academic and relational, for each and every student.

Conclusions

In retrospectively examining the process of localised change in one primary school's mathematics curriculum, we have identified a number of aspects that were important in supporting, sustaining and enhancing the ongoing changes in teacher practice and student learning. We named two of these as conceptual themes and identified two catalysts, as well as additional aspects that we recognised as important for teachers and students. In this concluding section we discuss how these are interconnected, and might be related to the notion of a sigmoid curve (Hipkins & Cowie, 2016) as a model of change in educational settings.

The two conceptual themes of equity and opportunity for every student to be a mathematician were important at the early stage of examining existing practices such as streaming and expectations of student competence in mathematics. Once streaming was abandoned and classes became heterogeneous, teachers continued to be committed to these themes. Supported by the school leadership, teachers worked together to implement further practices, such as a focus on tasks worth solving, and providing scaffolds to ensure that maths talk was productive. Teachers found that the two aspects of equity, academic and relational, were strongly interlinked because when student contributions are encouraged, supported and valued, their mathematics learning is enhanced with associated improvements in their academic achievement. Additionally, it became clear that it was impossible to achieve equity (relational and academic) without a significant shift in teachers' and students' perspectives about who can be successful at mathematics, that is, everyone can. In 2013, when asked who can be good at maths, students said, "people can be good at maths in different ways" and "all that really matters is you try your hardest". Assigning mathematical competence for all students, and altering how teachers and students thought and talked about mathematics, resulted in greater academic equity.

The two significant organisational actions identified as *catalysts* occurred during 2012 and were interconnected. One catalyst was the permanent whole school organisational change away from streaming to heterogeneous mathematics classes, which was supported by the second catalyst, intensive mathematics professional learning for the entire year. A concentration on mathematics prioritised and protected resources of staff time and attention, as well as providing opportunities for different groups of teachers to make autonomous decisions about their practice. As part of their professional learning, the teachers were challenged by research evidence around effective pedagogy in mathematics. The research literature also provided resources of ideas and practices that could be adopted or adapted to teachers' own class contexts, illustrating that a professional learning environment can be resourced both within and from outside their school professional community. The first year of trialling heterogeneous maths classes corresponded to an upswing in a sigmoid curve because the pace of change was rapid within the one school year, and there were early and substantial beneficial outcomes for both mathematics achievement and student engagement. This relatively quick feedback of an improvement in mathematics results were "the fruits of change" (Cowie, et al., 2011, p. 5) and as Fullan (2010) has noted, these served to be motivating and sustaining for teachers and school leaders. An important factor therefore in sustaining and enhancing the curriculum changes was that observable outcomes were clearly evident in student achievement data and student engagement. We contend that it is crucial that teachers know that what they are doing is making a difference for their students to ensure that teachers remained committed to the changed practices.

The second year of heterogeneous classes was a consolidation phase that involved "filling in gaps, (and) reworking areas where new horizons have opened up" (Cowie et al., 2011, p. 7). It was a plateau phase that often follows a time of intensive highly concentrated change. During this particular year however, one teacher continued to substantially change her mathematics programme. Not only did she deliberately organise students in heterogeneous groups for mathematics, she also trialled a problem solving approach alongside strategies for more productive mathematics dialogue. We claim that this classroom trial constituted a new thread, drawn from the horizontal plateau of the ongoing school change, and rising in an upward curve. This new change continued with a focus on the two conceptual themes and adapted and extended these into a different localised classroom curriculum. Importantly, this teacher was strongly connected with the Year 5-6 teaching team, and her class programme and assessment data were openly shared as a topic of discussion among the teachers. The students' views were also crucial for convincing the teaching team to embark on a problem solving approach in the following year of 2014, initiating a further sigmoid curve of substantial change for a whole cohort of students.

While sigmoid curves might be useful models, there may be other ways of understanding complex curricular systems across multiple classes and year levels in one school. Within a group of teachers, in any school, there are similarities and differences in practices and in responses to new situations. So, it seems reasonable to look for smaller or more localised changes that might become new threads, reaching from a sigmoid curve but modelling a new beginning of professional learning for teachers. When teachers themselves select conceptual themes or professional purposes as guiding principles, they importantly generate a shared language and vision (Cowie et al., 2011). The teachers in this school enjoyed talking and planning together for better outcomes for their students, and, in the process, have constructed localised meanings that may alter or become more deeply understood over time. Similarly, when assessment of individual student learning becomes more than achievement data and instead rich learning narratives shared with others, then these are not simply pedagogical resources for teachers but are also a source of collective pride in students' learning achievements. These narratives are illustrations of what Fullan (2010), has called the moral purpose of teaching and are important features for sustaining longer-term and enduring changes in practice that continue to evolve over different years, and with different staff and students. The last word goes to a year-6 mathematician, who prior to the heterogeneous class problem-solving approach had always been allocated to the lowest ability group. When asked if anyone can be good at maths, the response was, "Yeah. It's not all about smartness. It's just not giving up. You just use what you do know, and then if you keep on trying, you'll eventually get there."

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