Findings From the Secondary Numeracy Project 2008

Foreword

The Secondary Numeracy Project (SNP) was introduced in 2005 with the aim of helping students develop a deeper understanding of mathematics. This compendium is a collection of papers based on research and evaluation undertaken during the fourth year of the SNP.

As has been the practice in previous years, many researchers have continued to work on themes explored in earlier studies. These include: a fourth year of analysis on attainment data for students in years 9 and 10; results of the further development of a written assessment tool to reliably determine numeracy strategy stages; a further investigation into students' algebraic thinking; the effect of SNP on mathematics teaching practice at senior secondary school level; research into facilitator practices that support effective implementation of teaching and learning in the wharekura Te Poutama Tau project; and a review of the impact of CAS calculators on the learning and understanding of students involved in the CAS Pilot Project.

This compendium shows the benefits of long-term investment by the Ministry of Education in the development of mathematics learning communities. SNP continues to have a positive impact both on student achievement and teacher pedagogy, and there is continuing growth in professional understanding of student learning. Patience is needed for the SNP to show sustained gains.

Student Performance and Progress

Andrew Tagg and Gill Thomas undertake a fourth year of analysis on student data in "Performance of SNP Students on the Number Framework". It is now possible to measure trends in the data from 2005 through to 2008.

A notable difference in the population of students in the SNP occurred in 2008, with a greater proportion of students coming from low-decile schools (36%), compared with a 12% maximum from this sector of schools in previous years. This factor has had an impact on the initial profile of student attainment on entry to year 9, with a smaller percentage of students initially identified as operating in the top two stages of the multiplicative (19% compared with 25% in 2007) and proportional domains (28% compared with 37% in 2007) than in all previous years. Despite this weaker starting position, the 2008 cohort demonstrated similar improvement by the end of year 9 to that in previous years.

The impact of other demographic factors is consistent with previous years: New Zealand European students performed better as a group than Māori or Pasifika students, students from high-decile schools performed better than students from middle- or low-decile schools, and male students attained higher mean stages than female students.

By analysing school data for successive year 9 cohorts, Tagg and Thomas have been able to demonstrate sustained student achievement in numeracy for year 9 students in schools in the second year of the SNP. At the end of 2008, schools that had entered the project in 2007 were able to gather student achievement data for their year 9 students. This was compared with the school's year 9 data for 2007 and any trends noted. While acknowledging that these are two different cohorts of students, the comparisons indicate that the level of student performance in year 9 has been maintained for a second year.

Previous evaluations by Tagg and Thomas have revealed little movement in student attainment during year 10. Of particular concern are those students operating at or below stage 5 on the Number Framework. Tagg and Thomas note: "A comparison of the percentages of students remaining below stage 5 shows that those students rated as 'at risk' at the end of year 9 do not make progress during year 10, with at least as many still in the bottom stages at the end of year 10." These students will by now have effectively disengaged from learning mathematics and appear to have done so for at least a year, if not longer. Some appropriate targeted assistance may be in order.

Written and Oral Assessments of Secondary Students' Number Strategies: Ongoing Development of a Written Assessment Tool

In their 2008 evaluation of a written assessment for use in secondary schools, Gregor Lomas and Peter Hughes continue their work from last year in designing a pen-and-paper assessment tool that can determine a student's numeracy strategy stage as reliably as the oral strategy interview.

Building on what they learned during the first stage of the development of this tool in 2007, Lomas and Hughes repositioned some items, organised each section into strategy and knowledge items, and standardised the number of strategy items in each section. This revised written strategy stage assessment tool (WSSAT) was trialled in the middle of 2008, modified again, and then piloted with two schools at the end of 2008. As with the 2007 model, WSSAT displayed a high level of internal consistency, although some variation existed for stages 7 and 8. It also aligned well with information used for banding students into classes. A comparison with data from the oral assessment was perhaps less conclusive but was more stable than a similar comparison in 2007. There was a strong match between the oral and WSSAT for stage 8 assessments. For lower stages, the data for individual students either matched with both assessments or differed by one stage, with the pen-and-paper assessment rating the student at the higher stage. The researchers point out that this is comparable to the result presented by Thomas and Tagg (2006), who noted that secondary teachers had a tendency to assess student performance "at lower levels based on the teacher's perception of students' needs rather than actual performance on some numeracy assessment tool". On this basis, Lomas and Hughes conclude that they have now developed a significantly improved tool that determines student strategy stages with a reasonable degree of accuracy.

Students' Knowledge and Strategies for Solving Equations

Chris Linsell continues the investigation into students' algebraic thinking that he commenced in 2007. The diagnostic tool developed in 2007 was again used, this time with a further 621 year 7-10 students. The tool identifies strategies that students use to solve linear equations.

In Linsell's 2007 research, the diagnostic tool was able to uncover a range of strategies that students employed to solve linear equations. While some of the strategies were clearly more sophisticated than others, no definitive hierarchy amongst the strategies was suggested. This new research now proposes such a hierarchy. The proposed increasing order of sophistication of strategies used by students is: guess and check; using known basic facts and/or counting techniques; using inverse operations; working backwards, then using guess and check; working backwards, then using known facts; working backwards; and transformations (equation as an object). Linsell suggests that the grouping of students for instruction according to their most sophisticated strategy, as happens in numeracy teaching, is likely to be of benefit for teaching students to solve equations.

The relationship between a student's prerequisite knowledge and skills and the most sophisticated strategy employed to solve equations was investigated further in this research. Students rated at

the early strategy stages on the Number Framework employed only primitive solution strategies. As students' understanding of basic facts improved, so did their use of more sophisticated solution strategies. A similar picture emerged for understanding of arithmetic structure, inverse operations, acceptance of a lack of closure, and understanding of equivalence.

It was of interest in the 2007 study that students tended to be able to employ their most sophisticated strategy in both a formal symbolic question and an equivalent question that was described in a context using words or diagrams. This finding is replicated this year. Linsell concludes that this lends weight to a teaching model for the solution of equations comparable with that used for developing an understanding of number: start with a concrete representation of a problem before expecting a visualisation that can then lead to operating on abstract symbolic structures.

Senior Secondary Numeracy Practices in Successful Schools

Roger Harvey and Robin Averill explore the effect of SNP on mathematics teaching practice at senior secondary school level. Questionnaires and semi-structured interviews were used to collect the evidence from six regional professional development facilitators and from mathematics teachers at four low-to-middle-decile schools with effective numeracy practices.

Teaching strategies that were adopted and used by successful numeracy schools in year 11 include: greater emphasis on key ideas; sharing learning intentions at the start of a lesson; an increased focus on student thinking and students explaining their thinking; an increased focus on assessing and developing students' mathematical understanding; and an increased use of real-world contexts.

SNP also appears to be contributing to the development of cohesive mathematics teams, an essential ingredient in a school to ensure continued development and transformation of teacher practice. Ongoing departmental practices fostered through SNP included: giving increased emphasis to professional discussions based around student learning and understanding; carrying out activities for the purpose of discussing the results with colleagues; altering assessment practices; sharing resources; and developing teaching schemes.

The professional conversations between teachers were reported as being richer as a consequence of SNP. It appears that the benefits of the SNP professional development do extend beyond the target classes of years 9 and 10.

Fostering the Growth of Teacher Networks within Professional Development: Kaiako Wharekura Working in Pāngarau

Pania Te Maro, Robin Averill, and Joanna Higgins, joined this year by Brian Tweed, followed up on their evaluative research in 2007, which examined the impact of a pilot project of professional development and support in the wharekura Te Poutama Tau (the Māori-medium version of the SNP) and pāngarau (mathematics) for nine teachers working in wharekura in the Hawke's Bay, Taranaki, Waikato, Wellington, and Whanganui regions. A further cluster of 10 teachers was added to this group in 2008. The 2008 evaluation examined facilitator practices that fostered kaiako (teacher) networks in order to support effective implementation of teaching and learning based on Te Poutama Tau.

New elements were introduced into the modes of delivery of the professional development: a wiki as a store of resources; WiziQ, an Internet-based networking function that replaced video-conferencing; videoing of kaiako working with their classes; and discussions with tumuaki (principals). In addition, the hui were restructured to give kaiako more responsibility for determining their content. Kaiako rated the hui as the most effective mode of delivery, followed by face-to-face visits that also

incorporated the use of video. Internet delivery using WiziQ and wiki was deemed the least effective mode, with access to and familiarity with the medium acting as significant inhibitors.

The researchers have continued their exploration of essential characteristics for effective facilitation. Of particular note are the notions of ngāwiritanga and whanaungatanga. Ngāwiritanga captures the idea that a facilitator needs to be flexible, supple, accommodating, non-judgmental, and caring. Such a facilitator "is so knowledgeable about their subject that they are able to give control over to the kaiako, knowing when to participate and when to step back". Whanaungatanga is about facilitating change by engaging as part of a community to foster authentic relationships rather than by acting as a disengaged external expert. Such a relationship could be the foundation for some form of long-term professional development support.

Student Learning and Understanding in the CAS Pilot Project

Alex Neill and Teresa Maguire investigate the progress being made by some of the students from 22 schools involved in the CAS Pilot Programme. Using PAT:Mathematics tests as a measure of mathematical understanding, the researchers collected achievement data to make comparisons between students involved in the pilot and students in a control group, from the same schools, who were not involved.

The data reveals an inconclusive picture. The average score for students in the 2006 year 9 control group was significantly better than the year 9 CAS students and marginally below the 2007 year 9 CAS students, although all groups progressed at near to the expected achievement growth rate in both years. For students in year 10, neither group performed at the expected growth rate, with the control group showing no growth while the CAS group made a small increase that was not statistically significant.

At the end of the two years, no significant difference in performance was detected between the two groups. Qualitative data collected during the research indicated that teachers overall held a neutral position on the impact of CAS on student understanding. On the other hand, many students taking part in this evaluation thought they had made some gains in their mathematical understanding, especially in algebra, with relatively few reporting lower levels of understanding.

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