

Preparing teachers who can improve student learning in mathematics – researching new qualifications
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Ms Smith is struggling. Her class of thirty seven- and eight-year-olds seems to be presenting greater challenges by the day. In the fifteen years that Ms Smith has been teaching, the job seems to have become harder. Her class is made up of children from fifteen different ethnic backgrounds. The majority are from Pacific nations, and although many were born in New Zealand, there are still twelve children for whom English is a second language. They all seem to have such varied backgrounds. There are a number of single-parent families, and children living in large extended-family groups in cramped conditions. Most of Ms Smith's class come from families who are surviving on welfare. They get sick a lot and some don't come to school very often.

In Ms Smith's class there are a couple of high-achieving students. They do as well as high-achieving students in more affluent schools. But the disparity within Mrs Smith's class is huge. There is a significant group of students who are well behind where they should be for their ages. This gap between successful and unsuccessful students is widening despite Ms Smith's best efforts - especially in literacy and numeracy.

Ms Smith has been part of a nationwide initiative aimed at improving student learning in mathematics. While it was very interesting at the time it has been quite hard to implement the suggested approaches with her particular class. Their needs just seem so disparate that it is hard to work out how to cater for them all – it is hard to keep them on task to start off with. Maths was not Ms Smith's strong subject at school and she finds that even with seven- and eight-year-olds she struggles to understand their reasoning sometimes. The school has moved on to a national literacy professional development contract, which is quite demanding, and Ms Smith is feeling increasingly stressed by the evident needs of her students and her apparent inability to meet them.

Ms Smith's fictional class typifies the issues that are driving research and practice in New Zealand initial teacher education. New Zealand has an increasingly diverse population, but this diversity is clustered in certain parts of the country. While we appear to have relatively high literacy and numeracy standards, our country's achievement profile is characterised by a long 'tail' of underachievers. Indigenous Maori students and students from neighbouring Pacific nations are over-represented in this achievement tail. Over the last seven years the New Zealand government has conducted its largest ever in-service professional development project in numeracy. As this project nears completion, with every school in the country having received in-school support, attention is turning to ways to promote and sustain change into the future. Initial teacher education is again coming under scrutiny as a key to developing effective teachers who can cater to the diverse needs of New Zealand's learners in ways which address the achievement tail and increase student success.

Initial teacher education in New Zealand has traditionally occurred in tertiary institutions known as Colleges of Education. In recent years central control of teacher education was loosened and a competitive market developed. Universities began to compete with Colleges to prepare teachers. In the last five years central Government has sought to regain some control over the quality of teacher education after the proliferation of providers was seen to produce very variable outcomes. One consequence has been the amalgamation of Colleges of Education with Universities. It is against this background of increasingly complex issues in classroom learning and the 'University-fication' of teacher education that we have begun to re-question the nature of effective teacher education. What are we trying to achieve during pre-service teacher education? Where can we have the greatest impact on teacher candidates? What are the key ideas, skills and attitudes that we can engender in teacher candidates which will enable them to improve student learning in their future classrooms? This very quickly becomes a debate as to whether teacher candidates need more general education theory, more curriculum-specific knowledge, improved personal knowledge in subject areas, more practical classroom experience, more critical attitudes to power relationships in schools and classrooms and so on. Initial teacher education seems all too brief and constrained to accomplish everything that teacher educators feel beginners need to know. In the process of amalgamating two institutions and creating new qualifications, these debates have taken on new urgency and meaning, with the opportunity to express what we believe about teaching and learning in both the structure and content of new programmes. This is the process that the amalgamated Faculty of Education at the University of Auckland has been engaged in for three years.

As a result of this process we have come to realise how little we know empirically about what is effective in preparing teachers for diverse classrooms, and how little we knew empirically about the outcomes of our programmes. Can our graduates teach mathematics to children in ways which reduced disparities and promoted success? Do we know which components of our programmes, and what type of learning opportunities, are most significant in promoting this? A research and inquiry project has arisen from these questions. Entitled 'Preparing Effective Teachers for All' (PETA), this project aims to gather a range of information about our teacher candidates, the quality of their experiences in teacher education, and the effectiveness of their teaching. Mathematics is one of the contexts for this research and the first one for which systematic data have been collected and analysed. In order to address the project aims we needed to conceptualise what we thought we were trying to develop in our teacher candidates.

We have begun by examining of the notions of content knowledge, pedagogical knowledge and pedagogical content knowledge. The competing calls for different types of courses within the new degree qualifications ('more content knowledge', 'more practical ideas and experiences, 'more theoretical background and reflection') need to be seen as part of the complex whole that is teaching. Intuitively we know that our interactions with children in classrooms are determined by an interdependent and fundamentally intertwined mixture of 'knowledges' and experiences. Knowledge of context, of the particular child, of learning in general, of the likely trajectory for learning in this particular situation, of the

subject matter or idea being discussed, of how we learned similar content, of our beliefs and understandings about the role of schooling and of teachers, of the history of the idea under discussion and of appropriate resources are just some of the factors that may cause us to intervene or to wait and observe, let alone select what we might say or do. These decisions are made quickly, and frequently, in the mathematics classroom. We want to identify where initial teacher education could, and should, have an influence, and how that influence might be nested within, and impact on, other factors which determine classroom practice.

Although elementary school teachers deal with what society might regard as 'everyday' knowledge, there is more to the task of teaching than imparting 'common sense' to children. Shulman (1986) coined the term 'pedagogical content knowledge' (PCK) to describe the understandings that are particular to the task of teaching. If PCK embodies the specialist knowledge that teachers require, then engendering PCK can be seen as the key task of teacher education. PCK is problematic, however. The term continues to feature prominently in discussions about teacher education but it is not clear that its meaning is understood in the same way by those who use it. Shulman's characterisation of the coming together of pedagogical knowledge and content knowledge as an 'amalgam' does embody the fundamentally intertwined nature of the way that these types of knowledge are held but it implies a static body of knowledge. It may be possible to hold PCK and yet not use it at the appropriate moment in the classroom. Being able to use PCK to act seems to be a crucial link in joining knowledge gained in initial teacher education with improved student outcomes. Shulman's division of knowledge into separate categories helps to identify the 'missing part' which distinguishes teacher knowledge from everyday knowledge – we can all add, but we can't all teach addition. However, it may oversimplify the inter-relationships between different types of knowing, especially as they are called upon in novel situations. The PETA project team have tried to conceptualise where initial teacher education could influence the development of effective teachers, we have theorised that teacher education candidates might arrive with some pedagogical knowledge and some content knowledge. These knowings would be added to, challenged and fused into PCK through the teacher education process. This view has brought to the fore the need for clarity about what PCK consists of and how we think it influences teacher practice. We are concerned with how we can see this type of knowledge as accessible 'in the moment' rather than static.

Mason and Spence (1999) develop the idea of 'knowing to act in the moment' as they discuss issues for students and teachers trying to call on what they know in new situations. Their discussion has led us to develop the following diagram to guide our research.

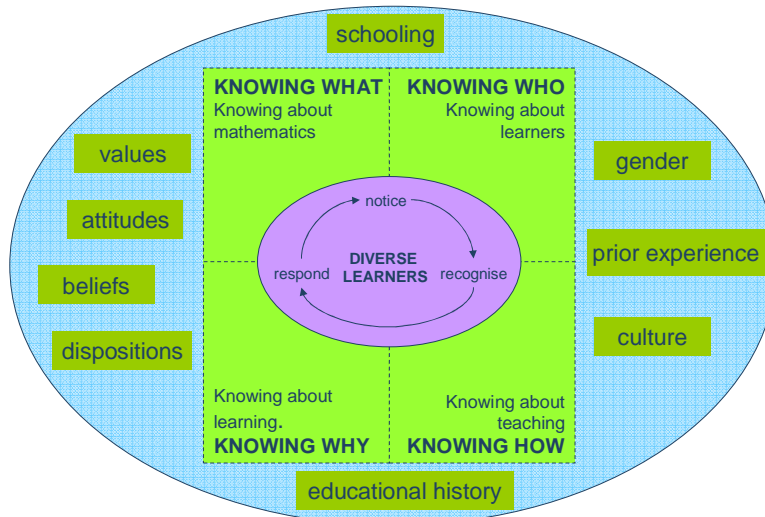


Figure 1: Teacher knowledge and teacher thinking

At the heart of the model, and our teacher education programmes, are improved outcomes for diverse learners in the classrooms of our graduates. Being able to act-in-the-moment in a way that promotes learning will lead to improved outcomes for learners. Mason and Spence (1999) describe knowing-to-act-in-the-moment as dependent on awareness and attention in the moment. We see links between this and Bell and Cowie's (1998) cycle of noticing what learners are doing, recognising the significance of their actions and responding appropriately. This therefore surrounds the learners as the mechanism by which the knowledges held by the teacher are enacted with children 'in-the-moment'.

The role of mathematics teacher education is to inform this cycle by helping teacher education candidates use and challenge their prior knowledge (in the outside circle) and to add to this new knowledge of the types shown in the green squares. The dotted lines suggest the permeability of these knowledges – they are intimately related to our own prior learning experiences and beliefs, as well as to each other. This attempts to represent the essentially personal nature of the knowledge teachers hold, and the ways in which they hold it. Teacher education involves an element of 're-storying' our experiences as learners and in relation to particular content. This is often a challenge for mathematics educators.

The model represents the outcomes for an ideal graduate, where these four types of understanding have come together to inform their interactions with children. Together they nest around the central task of noticing, recognising and responding to diverse learners – each being called on in different ways and in differing amounts. When formal teacher education begins, the knowledge in these areas may be scant, unrecognised or inaccessible. Teacher education performs the twin functions of identifying, delineating and

creating the necessary knowledges and bringing them closer together so they encapsulate the teacher-child interaction - the knowing-to-act in-the-moment. Knowledge of pedagogy and knowledge of content are not seen as dichotomous or exclusive, but rather as part of a whole complex of understandings and ideas that are brought to bear when we teach. In addition one could consider knowing-to-act-in-the-moment as an act of selection rather than knowledge in itself. Knowing-to-act-in-the-moment informs and is informed by the other types of knowledge which frame and constrain the choices teachers make.

The first phase of data analysis for the PETA project is complete. The data show that at entry to our one year diploma courses there is a significant positive relationship between teacher candidates' ability to solve problems using multiplicative strategies and proportional reasoning and their ability to notice significant aspects of a child's work and respond to it appropriately (Ell, Aitken, Grudnoff & Hill, 2007). The nature of the relationships between these types of knowledge and the strength of these relationships may change as the teacher education candidates progress through their course. Using the notion that what we are trying to educate is an ability to notice, recognise and respond to learners in ways that meet their needs and promote opportunities to learn, we will continue to examine the content and delivery of our courses in systematic ways.

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