Curriculum Intent, Teacher Professional Development and Student Learning in Numeracy

Vince Geiger, Merrilyn Goos, and Shelley Dole

Abstract Numeracy, or mathematical literacy as it is also known, is a major educational goal internationally, and as such, is addressed in the curriculum documents of educational jurisdictions and in national and international testing regimes. This chapter reports on an aspect of a research study which investigated the interrelationship between curriculum intent, teacher professional learning and action, and students' perspectives on their own learning in a 12 month long research and development project. Specifically, this chapter examines the impact upon student learning as a teacher attempted to implement the numeracy requirements of a state based curriculum in an educational jurisdiction within Australia. These attempts were structured through a rich model of numeracy and supported through regular interaction with the project researchers in a collaborative partnership aimed at improving student learning outcomes in alignment with state curriculum objectives. An emergent aspect of the project is the importance of a clear model of numeracy, which outlines essential elements, to changes in a teacher's numeracy practice. These changes in practice led to positive student views on their mathematics learning and to greater connectedness of this learning within and outside of mathematics itself.

Keywords Numeracy across the curriculum · Mathematical literacy · Applications of mathematics · Teacher professional development · Student perceptions of numeracy

Introduction

Numeracy, or mathematical literacy as it is also known, is a major educational goal internationally, and as such, is addressed in the curriculum documents of educational

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jurisdictions and in national and international testing regimes. Numeracy is increasingly seen as fundamental to developing students' capacities to use mathematics to function as informed and reflective citizens, to contribute to society through paid work, and in other aspects of community life (Steen 2001). This aspect of mathematics education has been recognised internationally through the OECD's *Program for International Student Assessment* (PISA). According to PISA's definition mathematical literacy is:

> an individual's capacity to identify and understand the role mathematics plays in the world, to make well-founded judgments, and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. (OECD 2004, p. 15)

This chapter reports on an aspect of a research study which investigated the interrelationship between curriculum intent, teacher professional learning and action, and student learning, in a 12 month long research and development project. A focus of this project was on enabling the numeracy dimensions of school subjects across the curriculum. The purpose of this chapter is to examine the impact upon student learning of a teacher's attempts to implement the numeracy requirements of a state based curriculum in an educational jurisdiction within Australia. These attempts were structured through a rich model of numeracy and supported through regular interaction with the project researchers in a collaborative partnership aimed at improving student learning outcomes in alignment with state curriculum objectives.

The chapter is structured in five sections. First, the curriculum context in which the study was situated is described. Second, the theoretical framework which guided our approach to supporting teachers in the development of rich numeracy focused learning experiences is outlined. Third, we summarise the methodological approach we employed when working with students and teachers. Fourth, we present vignettes based on observations of teacher designed classroom activities as well as students' views of their own numeracy development in order to illustrate the nature of students' experiences of numeracy learning. Finally, we discuss the challenges of moving from the intended learning objectives of a curriculum document to the enactment of these objectives in teaching and learning practice.

Curriculum Context

In Australia, numeracy is an educational priority, with the national numeracy strategy being part of government policy since 1997. The launch of the national numeracy strategy was encapsulated in the following statement:

> . . .that every child leaving primary school should be numerate, and be able to read, write and spell at an appropriate level. (MCEETYA 1997, p. ix)

This statement resulted in vigorous debate in relation to defining numeracy. After continual discussion, consideration and revision of proposed definitions, educators and policy makers in Australia have embraced a broad interpretation of numeracy

similar to the OECD definition of mathematical literacy: "To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life." (AAMT 1997, p. 15). A further outcome of the discussion around a succinct definition that captured the essence of numeracy, and particularly a definition that was broader than facility with basic number and calculation skills, was agreement that mathematics is necessary but not sufficient for numeracy, and that all teachers are teachers of numeracy.

The cross-curriculum and contextual notion of numeracy as an Australian educational goal has further been validated and reiterated by a review of numeracy education undertaken by the Australian government (Human Capital Working Group, Council of Australian Governments 2008), recommending:

> That all systems and schools recognise that, while mathematics can be taught in the context of mathematics lessons, the development of numeracy requires experience in the use of mathematics beyond the mathematics classroom, and hence requires an across the curriculum commitment. (p. 7)

Australia is now moving to implementation of a new national curriculum, and numeracy continues to be a government educational priority. Within the national curriculum numeracy has been included as a General Capability in all subjects. In the case of the Mathematics curriculum documents (Version 3.0), numeracy, in all subjects, is described in the following way.

> Students become numerate as they develop the knowledge and skills to use mathematics confidently across all learning areas at school and in their lives more broadly. Numeracy involves students in recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully.
>
> (Australian Curriculum, Assessment and Reporting Authority 2012a, p. 11)

There is also a specific numeracy statement within each subject. For example, in the Australian National Curriculum: History, it is stated that:

> Students develop numeracy capability as they learn to organise and interpret historical events and developments. Students learn to analyse numerical data to make meaning of the past, for example to understand cause and effect, and continuity and change. Students learn to use scaled timelines, including those involving negative and positive numbers, as well as calendars and dates to recall information on topics of historical significance and to illustrate the passing of time.
>
> (Australian Curriculum, Assessment and Reporting Authority 2012b, p. 10)

Hence, numeracy, from the perspective of the national government, is considered to be a vital element in all students' education across all subjects within schools.

In Australia, however, the responsibility for curriculum development and implementation lies within the individual states of the federation. This means that states have the authority to implement curriculum with a flexibility that allows them to cater for the circumstances of schools and students within their jurisdictions. Nonetheless, numeracy remains a priority for all Australian states and territories. In the specific case of the educational jurisdiction that forms the background for the research study reported here, numeracy was viewed as a critical element within all

school subjects. Curriculum documents in this state, known as the *Curriculum Standards and Accountability Framework*, include a specific statement on numeracy in relation to each subject. For example, within the Society and Environment subject area numeracy is described through the following statement.

> Learners develop and use operational skills in **numeracy** to understand, analyse, critically respond to and use mathematics in different contexts. These understandings relate to measurement, spatial sense, patterns and algebra and data and number. This learning is evident in society and environment when, for example, students use and understand the concept of time, when they use spatial patterns, locations and pathways in the form of maps, and they gather and analyse data for social decision-making.
>
> (Department of Education and Children's Services 2005, p. 294)

Numeracy is also seen as an important goal for students in Mathematics.

> Learners develop and use operational skills in **numeracy** to understand, analyse, critically respond to and use mathematics in different contexts. Students' learning in mathematics enables students to explore the relationships between different mathematical ideas and apply mathematical understandings to their learning in all curriculum areas.
>
> (Department of Education and Children's Services 2005, p. 219)

Even with the support of educational policy makers and curriculum authorities, it has proven difficult to implement effective numeracy practice in Australian schools. Attempts to introduce numeracy practices into schools have sometimes been characterized by a utilitarian approaches that have emphasized basic skills over the capacity to engage higher order thinking. This is in contrast to the growing complexity of the mathematical demand of work in many industries (Hoyles et al. 2002; Straesser 2007). Further, numeracy has often been interpreted as being almost exclusively associated with number, excluding other areas of mathematics, such as geometry and algebra, which can also contribute to an individual's capability to use mathematics to solve problems in contexts outside of mathematics itself. Until recently, few proponents of numeracy practice have acknowledge the important role physical, representational and digital tools play in using mathematics in the outside of school world despite the importance of these tools in working with mathematical ideas and concepts in industry and in life away from the workplace (e.g., see Zevenbergen 2004). Thus, while the view of numeracy as a capability every student should possess is endorsed by educational policy makers and curriculum authorities the implementation of approaches to teaching and learning that foster the numeracy development of students has been problematic. The challenge, therefore, is to find ways to enact the intent of numeracy statements and objectives within curriculum documents into mainstream classroom teaching and learning practice.

Theoretical Framework

While previous definitions capture the broad thrust of the concept of numeracy, they lack the detail necessary for teachers to implement numeracy based approaches in

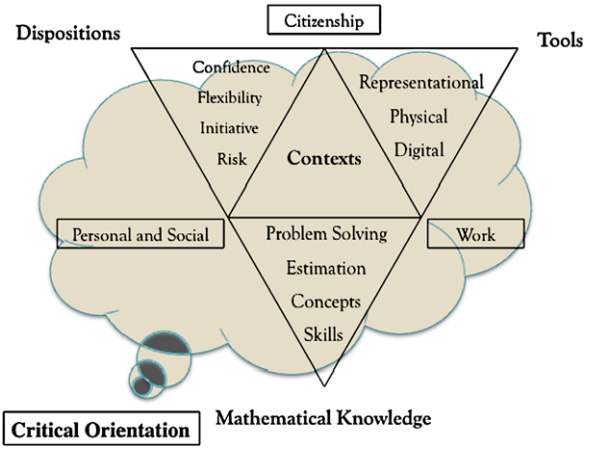

Fig. 1 A model for numeracy in the 21st century (Goos 2007)

practice. In short, current definitions of numeracy do not appear to convey what is needed to transform what is intended within curriculum documents into what is enacted in school classrooms. More recently, however, Goos (2007) has proposed a model of numeracy (Fig. 1) which encompasses four essential elements: attention to real-life *contexts*, the deployment of *mathematical knowledge*, the use of physical and digital *tools*, and consideration of students' *dispositions* towards the use of mathematics. These elements are embedded in a *critical orientation* to the use of mathematical skills and concepts that emphasises, for example, the capacity to evaluate quantitative, spatial or probabilistic information used to support claims made in the media or other contexts. While the model was intended to be readily accessible to teachers as an instrument for planning and reflection, its development was also informed by relevant research, as outlined below.

At the centre of the concept of numeracy is the key dimension of *context*. According to Steen (2001), numeracy is about the use of mathematics to act in and on the world. Typically, when mathematics is used in a context it is applied in a way different from how it is traditionally taught in school (Noss et al. 2000; Straesser 2007) and so to learn to be numerate individuals must be exposed to using mathematics in a range of contexts (Steen 2001).

Appropriate mathematical knowledge is required to act on problems within a given context. In a numeracy context, mathematical knowledge includes not only concepts and skills, but also higher order thinking—such as problem solving strategies and the ability to make sensible estimations (Zevenbergen 2004). How to interpret a problem outside of mathematics in a mathematical way, and then how to choose which mathematical knowledge needs to be selected to engage with the mathematised problems is a challenge that lies at the intersection of *contexts* and *mathematical knowledge*.

The desire and confidence to apply mathematics in real world contexts is related to the *disposition* of an individual in relation the use of mathematics. The importance of developing positive attitudes towards mathematics is emphasised in national and international curriculum documents (e.g., Australian Curriculum, Assessment and

Reporting Authority 2012a; OECD 2004). Further, Gresalfi and Cobb (2006) argue that it is not sufficient to focus on the mathematical skills and capacities we want students to learn alone, but that teaching must take place with students' dispositions in mind if students are to develop an affinity with a discipline. This affinity is vital for students to be disposed to making use of mathematics in their current lived in worlds and in their future lives (Boaler and Greeno 2000). These dispositions include not just confidence with mathematics but a willingness to think flexibly, to show initiative, and to take risks.

An increasing number of studies identify tools as mediators of meaning making, reasoning and action in relation to mathematical learning (e.g., Pea 2004; Verillon and Rabardel 1995). In school and workplace contexts, tools may be representational (symbol systems, graphs, maps, diagrams, drawings, tables, ready reckoners) and physical (models, measuring instruments), but increasingly tools are digital (e.g., Artigue 2002; Goos et al. 2003).

The elements of the Goos (2007) model are embedded in a critical orientation of the use of mathematical skills and concepts which emphasises the evaluative and judgemental aspects of numeracy practice. We view this critical orientation as a vital capacity for informed and participatory citizenship and for exercising effective and socially conscious decision making in an individual's personal life. Ernest (2002) views social empowerment as an important reason for teaching mathematics. This social empowerment can range from the purely utilitarian skills associated with the mathematics that is needed to function, in the simplest sense, in work and society through to the critical skills that enable individuals to: make decisions and judgements; add support to arguments; or challenge an argument or position. This position is also consistent with that of Frankenstein (2001) and Jablonka (2003) who argue for the need to recognise how mathematical information and practices can be used to persuade, manipulate, disadvantage or shape opinions about social or political issues.

The elements of the model and the critical orientation within which these elements interact are summarised in Table 1.

Table 1 Descriptions of the elements and critical orientation of the numeracy model

Mathematical knowledge	Mathematical concepts and skills; problem solving strategies; estimation capacities.
Contexts	Capacity to use mathematical knowledge in a range of contexts, both within schools and beyond school settings
Dispositions	Confidence and willingness to use mathematical approaches to engage with life-related tasks; preparedness to make flexible and adaptive use of mathematical knowledge.
Tools	Use of material (models, measuring instruments), representational (symbol systems, graphs, maps, diagrams, drawings, tables, ready reckoners) and digital (computers, software, calculators, internet) tools to mediate and shape thinking
Critical orientation	Use of mathematical information to: make decisions and judgements; add support to arguments; challenge an argument or position.

This model has been used as a framework to audit school curricula (Goos et al. 2010) and for analysis of teachers' attempts to design for the teaching of numeracy across the curriculum (Goos et al. 2011). The numeracy model was also used to promote teacher professional learning and, in particular, to assist teachers to reflect upon their own practice. In this chapter the numeracy model will be used to evaluate one teacher's attempts to enhance her numeracy teaching practice by developing richer classroom learning experiences and to analyse her students' perceptions of their own numeracy learning as a result of their teacher's attempts to change her practice.

Research Design

Twenty teachers were recruited from ten demographically diverse schools on the basis of their interest in cross-curricular numeracy education. They came from four primary schools (Kindergarten-Grade 7), one secondary school (Grades 8–12), four smaller schools in rural areas (Grades 1–12), and one school that combined middle and secondary grades (Grades 6–12). The focus on teaching numeracy across the curriculum meant that it was important to include teachers with varying subject area specialisations. Thus, participants included generalist primary school teachers as well as secondary teachers qualified to teach particular subject areas (mathematics, English, science, social education, health and physical education).

The research design was consistent with an action research model with the Loucks-Horsley et al. (2003) framework for professional development underpinning the development aspect of the project. Consistent with this framework, project meetings were followed up with school visits, enabling the research team to provide on-going support to teachers in their efforts to change their numeracy practices, whilst simultaneously providing the means to gather data on the process. Two full action-research cycles were implemented, providing teachers with the opportunity to set new goals and re-plan after the first cycle.

At the first project meeting, teachers came together with researchers and Department personnel to explore the ideas embedded in the numeracy model, to discuss the potential to teach numeracy within the constraints and affordances of the statewide curriculum framework, and to work through investigations that allowed for the elaboration and clarification of the ideas embedded in the model. In order to stimulate discussion about numeracy demands that existed within the curriculum, teachers were also presented with a numeracy audit of the curriculum framework. The audit was completed by examining the relevant Curriculum Scope and Standards statements within the *Curriculum Standards and Accountability Framework*. Numeracy demands of each subject were evaluated by reference to the elements of the numeracy model in Fig. 1: mathematical knowledge, contexts, dispositions, tools, and critical orientation. The results of the audit indicated that numeracy demands existed within each subject area in alignment with the dimensions of the Goos numeracy model (further detail can be found in Goos et al. 2010). After discussing the

demands and opportunities provided by the curriculum framework within the whole group, teachers worked in small groups to adapt presented tasks or to develop new activities they might trial in their own classrooms.

After this initial meeting, teachers were asked to introduce the activities they had begun to develop at the first meeting and/or other activities into their own classroom. After a number of months, teachers were brought together again for a second whole project meeting to present examples of activities they had trialled and to engage in further curriculum planning while being supported by teachers from other schools. During this meeting, the researchers provided input on the way elements of the numeracy model were evident in each of the activities presented. The researchers also provided additional input on the role of critical orientation within the numeracy model as this was an area that was noticeably underdeveloped during the first round of school visits and an aspect that teachers had asked for further advice in particular.

The project concluded with another cycle of trialling activities, visits from the research team and a final presentation to the entire project group.

Between each of the whole project meetings, the researchers visited schools to provide further input and support, and to collect data for the purpose of evaluating the success of the trialled activities from the perspective of students and their teachers. Across the project data were collected via field notes of classroom observations, records of semi-structured interviews with teachers and students, and artefacts such as student work samples and computer files. The data used in this chapter are drawn from one teacher and her class of Grade 8 students (12–13 years of age), which represents a case study from within the larger project. The teacher was selected because her progress through the course of the project revealed a developing capacity to interpret the numeracy demands and opportunities of the *Curriculum Standards and Accountability Framework* in a way that allowed her to create tasks of increasing richness for her students. Her case was also chosen for this chapter because her field of expertise lay outside of mathematics teaching, that is, health and physical education, which demonstrates the across the curriculum possibilities that exist for numeracy learning and teaching practice. The student participants who were interviewed as part of the data collection process where nominated by their teacher as individuals she perceived to have the capacity to articulate their thoughts on classroom activities the teacher had designed for their numeracy learning in a clear, open and honest fashion. As a group, these students' history of mathematic achievement was varied. Interviews lasted approximately 30 minutes and were conducted away from the classroom without the presence of the teacher.

The Development of a Student Oriented Numeracy Practice

In this section one teacher's attempt to design student learning experiences that satisfied the requirements of the *Curriculum Standards and Accountability Framework* within the subject area, Health and Physical Education (HPE), while also meeting the numeracy demands of this framework, is outlined and illustrated. This teacher,

Clare, had volunteered for the project for two reasons. Firstly, she was initially trained as a Health and Physical Education teacher but over time had found she preferred to work with students in the middle school (Grades 6 to 9) where she was required to teach across the curriculum. As a result, she found herself teaching in a subject where she had received no pre-service training and in which she felt less confident. Her engagement with the project was, in part, an attempt to improve her content and pedagogical knowledge in an area she perceived to be a weakness—mathematics teaching. Secondly, she had begun to believe that her approach to teaching, in general, was too direct, and she saw the project as a way of engaging with more inquiry based approaches to teaching and learning.

First School Visit

Clare had worked hard to improve her classroom numeracy practice from the onset of the project but had been disappointed with her initial efforts with a Grade 8 class (12–13 years of age). In the first lesson we observed, Clare attempted to develop students' understanding of the addition and subtraction of directed numbers. She demonstrated the method via a number line drawn on the blackboard, which was also illustrated on a handout distributed to students. Students were to stand on the first number listed and face in the positive direction if the operation was to be addition or the negative direction if the operation was to be subtraction. They were then to walk the number of steps indicated by the second number, walking forward if this number was positive and backwards if it was negative. The number at which they arrived via this process was the answer to the problem. The handout provided a systematically developed list of problems involving adding and subtracting positive and negative numbers, including a "long walk" with seven operations in succession. Two questions then required students to describe any patterns they observed in their walks and to explain some of the rules they discovered while adding and subtracting.

After an initial ten minutes of teacher instruction, students moved outside to complete the activity. One drew a chalked number line and gave instructions to another as this student "walked" a couple of problems. After 30 minutes of outdoor activity the class moved inside and Clare asked students what they had been thinking and feeling during the activity. How did they know if they were on the right track? Students seemed willing to say they were confused; others simply said that the activity was fun. Clare explained to them that they had been using a model that would help them understand the thinking they would be doing in the next few lessons on adding and subtracting directed numbers. She drew their attention to the questions about patterns and rules, and asked them to try a list of additional exercises for homework. She then modelled the number line representations of:

$$-3 + +2 = -1$$
$$-3 + -2 = -5$$
$$-3 - +2 = -5$$
$$-3 - -2 = -1$$

and asked if anyone could describe something about what they saw, reiterating that this was to be done for homework.

Reflecting on this lesson through the lens of the numeracy model, *mathematical knowledge* had a clear focus in the addition and subtraction of directed numbers. At the start of the lesson Clare elicited some of the real life *contexts* in which directed numbers appeared, however, the *context* she used to demonstrate these operations, the chalk number line outside the of classroom, could not be considered to be related to a real-life use of directed numbers. A *representational tool*, the number lines drawn on the blackboard and on the ground, was used to help students discover patterns and explain rules concerning these operations on directed numbers, although Clare did not elicit and evaluate students' ideas during the lesson. Clare attempted to ascertain students' *dispositions* towards mathematics and the learning activity by asking them how they felt about the lesson but students' responses were varied from finding the lesson fun to experiencing confusion in relation to what they were meant to learn. Despite Clare's efforts to design an engaging and thought provoking lesson for her students, there was no opportunity to develop a *critical orientation* to this subject matter.

Clare was disappointed with the lesson and admitted she was struggling, in particular, with critical orientation. She felt there was no scope in the lesson for developing a critical orientation to the subject matter.

After some reflection, Clare decided the only way to improve her practice was to take a very different approach from how she had taught in the past.

> After much reflection I decided to do some things differently… One of the goals I set myself was to take a more exploratory and investigative approach, particularly in dealing with teaching aspects of numeracy across all learning areas.
>
> (Peters et al. 2012, p. 24)

Between School Visits

Clare's first step on the new pathway she had set herself took place between the school visits by the project researchers. In this activity, students in HPE were to investigate media coverage of sports. Clare implemented this activity in preparation for a report at the second teachers' meeting. Her students collected sports reports from a local newspaper each day for a week and then measured and calculated the area of the space devoted to both female and male sports. Clare reported that students found that equal representation was not given to female and male sports in the media and that an interesting discussion had followed. Clare was much happier with the outcome of this lesson as she felt she had begun to address numeracy in HPE and that it seemed to create a deeper student understanding of the concepts and processes covered.

Second School Visit

During our second visit to the school, near the end of the project, Clare had prepared an activity within Health and Physical Education where students investigated the level of their physical activity through the use of a pedometer that they wore during the day for one week. Students entered the number of paces they had walked or run every day into a shared Excel spreadsheet. They were then asked to analyse their own data using Excel and to compare their results with those of other students (see Fig. 2).

Students also had to convert their total daily and total weekly paces into kilometres to gain a sense of how far they typically walked in a day or a week. The task was also designed to help students realize that the distance they walked was not determined by the number of paces alone, as an individual's pace length was also a factor. In order to bring about this conversion, students were required to design a process for determining the length of their own pace. This involved marking out a distance of 100 metres and counting the number of paces they each took to walk this distance. After demonstrating the procedure for obtaining the length of her pace and then converting paces in a day to kilometres from her own personal data, the teacher asked students to complete conversions of their own pace totals to kilometres. She also suggested that students compare their kilometric distances with each other and discuss why they were different.

Clare finished the lesson by indicating the next session would include an investigation of the number of paces Usain Bolt takes during a 100 metre sprint.

This activity provided Clare with the opportunity to promote the elements of numeracy described in the *Curriculum Standards and Accountability Framework* and

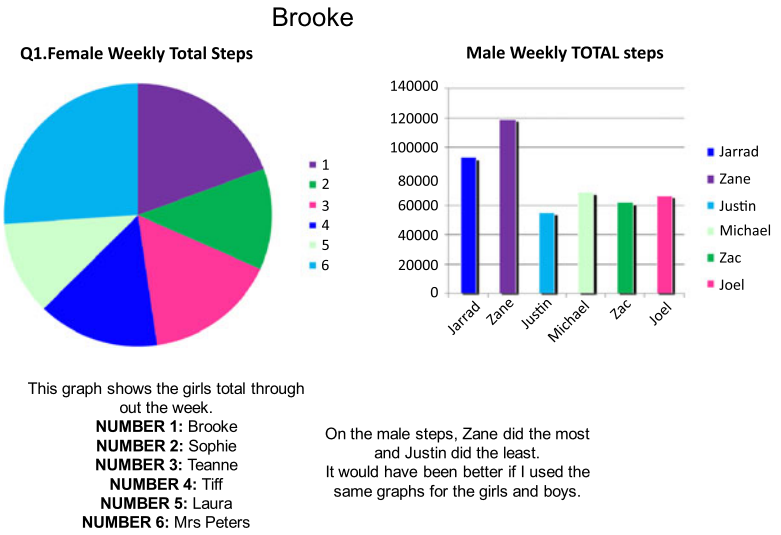

Fig. 2 A comparison of male's and female's weekly total steps

made explicit in the numeracy model employed to guide her practice. In this activity, the elements of numeracy were situated in an authentic *context* (their level of physical activity) in which students were challenged to use a range of *mathematical knowledge* (measurement, conversion of units, representation of data) and to make use of physical (measuring tapes, trundle wheels), digital (pedometers, spreadsheets), and representational *tools* (graphical representations). She encouraged the development of positive *dispositions* in students towards the use of mathematics by designing a task students were personally interested in (their own activity levels). This lesson also incorporated aspects of a *critical orientation* as students made judgments about the reasonableness of results and posed their own questions about meaning that lay within the collected data. Clare indicated that making the desired changes to her practice necessitated a change in teaching practice towards a less directive and more inquiry-oriented approach, a "letting go" process that she found difficult but more effective for enriching students' mathematical knowledge and promoting a critical orientation to evaluating information and answers.

It can be seen though this sequence of events that Clare had attempted to enact the numeracy aspect of the *Curriculum Standards and Accountability Framework* in a rich and engaging way for students. From Clare's perspective, she had been successful in her aim to improve students' dispositions towards mathematics learning that in turn resulted in positive outcomes for her students in all aspects of numeracy. She believed these improvements were due to the changes she had made to her teaching practice. But teachers' perspectives on the benefits to student learning as a result of changes in teaching practice are only one part of the story of realising the intent of a curriculum in practice. In the next section, students' perspectives on the changes they experienced though the year, as part of the project, are presented.

Students' Perspectives on Their Learning Experiences

Students were interviewed in small groups of five during each of the school visits. They were asked to reflect upon the numeracy lessons they had recently experienced and to express their feelings about mathematics or using mathematics in various activities.

First School Visit

During the first visit to the school, we interviewed four students immediately after Clare's lesson on directed numbers. Attitudes towards mathematics varied in this group with some saying it was at the "top" of their favourite subjects and others saying it was at the "bottom".

When asked about the lesson they had just experienced on directed numbers, students were able to explain they were learning how to add and subtract positive

and negative numbers. They thought the activity was helpful because it was "step by step" and they could "do it", by which they meant engage with the ideas and concepts through a physical activity. Students' responses varied in relation to what they had learnt from the lesson. One student could not recall if her group came up with any rules about the addition or subtraction of directed numbers based on the activity. Another student, however, recounted that he had worked out that you go "up the number line" if adding positive numbers or subtracting negative numbers and "down the number line" if adding negative numbers or subtracting positive numbers. It would appear that their learning in relation to mathematical knowledge ranged from improved understanding and confidence to that of only limited observations on the key features of the lesson.

Students were also asked about the nature of the activity, not just its content, and how they felt about learning mathematics. Students indicated that they had occasionally gone outside for mathematics lessons, for example, to find shapes nominated by the teacher (rectangles or triangles), or to measure the perimeter of the basketball court. They offered the opinion that these "outside" activities helped them understand mathematics better than when they worked on mathematics in their exercise books while sitting at a desk in the classroom. This was because they felt they "really didn't pay attention to what they were doing" when working in this fashion. While the students were positive about their teacher, they did not express any excitement about their mathematics learning nor indicate that mathematics was being connected to contexts that were interesting to them or relevant to their current or future lives, other than through occasional "outside" activities. It would appear from these comments that the students believed the use of *contexts* was advantageous to their learning but that this approach had been infrequently adopted by their teacher. Further, students' positive attitudes to learning mathematics in ways that varied from traditional classroom bound approaches and their lack of enthusiasm for mathematics taught in this way implies that their *dispositions* towards mathematics and to learning mathematics is influenced by the *context* in which it is presented. During this interview, students made no mention of the use of *tools*, either representational or digital, when learning mathematics.

Second School Visit

During the second school visit we observed a HPE lesson in which students were analysing the data they had collected using pedometers by the use of Excel spreadsheets. Four students were interviewed as a group directly after the lesson. During this discussion students were clear about how they were meant to conduct the activity, what they were meant to investigate, and what they found.

Researcher 1: *We saw you earlier today—and you were wearing pedometers! What was going on there? What was that all about?*

Student 1: *We were measuring how many steps we took over a period of one week. From, in effect, Saturday to Friday—measuring how many steps we took.*

Researcher 2: *So, did you have to wear the pedometers the whole time?*
Student 1: *Yeah, pretty much.*
Student 2: *And we were told that when we measured our steps it had to be at around the same time everyday. So that you've got an even amount of steps every week day.*
Researcher 2: *So weren't wearing it all day then?*
Student 2: *Yeah you wore it most of the day.*
Student 1: *Whenever we walked.*
Researcher 2: *So you didn't have to wear it while sitting on the couch then?*
Students: *Laugh.*

As part of the discussion, students indicated they were enthusiastic about the opportunity to use digital *tools*. They made use of an Excel spreadsheet to graph different representations of the data and then used these graphs (*representational tools*) to draw conclusions about their own and other class members' level of physical activity (*critical orientation*).

Researcher 1: *So, it was interesting seeing that table* (*referring to the Excel spreadsheet*) *and one thing that stood out for me was first, if you look at the totals, there are differences between all of you. But did you notice when you were looking at that on different days of the week each of you were walking different numbers of steps?*
Student 2: *Yeah, Sunday was smallest.*
Researcher 1: *I noticed!*
Student 2: *I was going to say that Thursday and Saturday probably would have been the biggest too, 'cause that's when we play sport.*
Student 3: *We did some graphs on the computer too showing two days and I did Saturday and Sunday on a line graph . . .and there was a major difference! Saturday was like this* (*gesturing to show a large number of steps*) *and Sunday was like this* (*gesturing to show a small number of steps*).
Researcher 1: *OK. So when you did this on the computers, you used Excel did you?*
Students: *Yeah* (together).
Researcher 1: *Had you ever used Excel before?*
Student 1: *Yes—last year we learnt the basics of it.*
Student 2: *Except this is the new version and not many of us knew how to use it except for me.*
Student 1: *I think we are getting the hang of it. There haven't been too many complaining about how hard it is, but it is very complicated.*
Researcher 1: *So some of you already knew how to use it and others of you didn't—so how did that work in the classroom when some people knew what to do and others didn't?*
Student 1: *Well some of us are a bit better with it—like we understand it a lot quicker, so just got help from them.*

Interestingly, and even surprisingly, students were comfortable with having a higher skill level in relation to this type of technology than their teacher and their peers, and

were happy to accept the responsibility of providing assistance, where necessary, to their teacher and other class members. This is an indication of both the confidence students had developed with respect to the use of digital *tools* and their willingness to take the lead in assisting all members of the class, their teacher included, in moving forward with their mathematics learning (*dispositions*). It also demonstrates the teachers' new preparedness to take risks by including skill elements in an activity she herself was yet to master and to give over some degree of control to the students in order that they had opportunity to feel responsible for their own and others' learning (*dispositions*).

Student 2: *And I was trying to help Mrs Clarke as well, so then she knew how to use it to help others*.
Researcher 1: *That is an interesting thing. Most people think that teachers know all of this stuff and they are meant to help students*.
Student 2: *Well, she admitted she didn't know how to use it*.
Researcher 1: *Is that OK, for a teacher to be learning stuff?*
Student 2: *Yeah* (all students).

Students were conscious of the potential for the use of digital *tools* in other subject areas and in different real-life *contexts*. They were also aware that their teacher was deliberately attempting to provide greater focus on mathematical ideas, skills, and processes, in other school subjects (*contexts*). To illustrate this awareness they recalled a number of instances where mathematics was particularly relevant to their learning in other subject areas.

Researcher 3: *So do you think it is a program you could use in other subject areas?*
Student 1: *Definitely!*
Researcher 3: *Like what?*
Student 1: *Like we had to do in Science recently, a prac, and it required amounts, graphs and percentages. I haven't done it yet but I'm going to get the percentages and use them on Excel and make a graph out of it*.
Researcher 3: *And that will be OK with your teacher?*
Student 1: *Yeah. The idea is to create a graph and on the computer is fine. And it is easier than trying to draw up one*.
Researcher 1: *So that subject we saw today was PE?*
Students: *HPE!* (together).
Student 1: *But with a bit of maths integrated*.
Researcher 1: *Yeah*.

The students were very aware of the teacher's purpose in relation to the "mathematics" in other subject areas (*contexts*).

Student 1: *That's what out teacher, Mrs Clarke, is trying to do. Trying to get more maths stuff in other subjects*.
Researcher 1: *Do you think that it is working? Can you see how maths is being integrated into other subjects?*
Students: *Yeah* (together).

Student 2: *And I think HPE is the best lesson to do it in as well because all of your sports and stuff, you use numbers for your scores. And if you can learn it in different areas as well it helps.*
Researcher 1: *What about other subject areas. Can you tell us about some examples where Ms C has put more maths there.*
Student 1: *In Science earlier this year, we done* [*sic*] *a test to see how much one plain peanut – how much exercise you have to do to work off that much.*
Student 2: *It was a cashew!*
Student 1: *Yes a cashew. And we set fire to it. And then I got it with mathematics to calculate how much. And we came up with seven to eleven minutes of handwriting to work off one plain unsalted cashew!*

With prompting, students realised there was mathematics in English.

Student 3: *Yeah, remember we were going to do that thing about how many pence in a dollar. Remember reading the Red Dog book?*
Student 1: *Yeah. When we listened to the recordings of a Fortunate Life* (*a novel*), *it was talking about the old currencies and we were going to do some maths on the amounts of pence and pounds.*
Student 3: *But we ran out of time!*

The students also identified many opportunities to use measurement in their Home Economics class where they were making boxer shorts (mathematical knowledge, tools, context).

Researcher 3: *What are you doing in Home Ec* (*Home Economics*) *at the moment?*
Student 2: *We're doing a bit of sewing. Tomorrow we're making boxer shorts.*
Student 1: *Yeah . . .lots and lots of measuring.*

A number of students also demonstrated that they were able to use mathematics in a critical sense to form judgements within subjects outside of mathematics (*critical orientation*). In Studies of Society and Environment, they described their learning about koala habitats. In this exchange they revealed that they had developed an understanding of the relationship between koalas and specific types of eucalyptus leaves on which they feed.

Student 1: *And we recently did a section on Koalas and the different types of trees they eat. And we did a percentage table of the different types of trees eaten by a Koala. And we did a pie graph for that.*
Researcher 1: *Did that lead you to draw some conclusions or report a finding?*
Student 4: *Koalas are fussy!*
Student 1: *I'm not sure we found what leaf they eat the most.*
Student 4: *It was the Madegal! In South Australia at least. . .and New South Wales.*
Researcher 1: *So if you say they are fussy, it means they only eat certain types of leaves from certain types of trees. So that makes me think about if we ever get to a situation where there is not enough of those trees—if we cut them down.*

Student 4: *Yeah, that's what it was basically about. You know it's alright if we cut them down and you try and regrow them for Koalas but if we put them in the wrong spot and they stave because they don't like the trees.*

Towards the end of the interview, students were asked what they thought of their teacher being involved in the project. Students were enthusiastic about their teacher's involvement as they viewed it as a way she was attempting to upgrade her skills in order to help her students' learning.

Researcher 2: *So what do you think of your teacher being involved in a project like this. Do you think this is a good thing for teachers?*
Students: *Yeah* (together).
Student 2: *I think it is because sometimes they don't know what we're gonna do during a lesson and in this program they get a chance to know how kids like to learn and whether they learn more out of doing things, showing or doing it themselves.*

In general, students said they enjoyed the numeracy learning experiences, for a variety of reasons: they were allowed to work in groups; they participated in extended investigations; they used technology such as the Internet and Excel spreadsheets and graphs. Many commented that they were learning mathematics without realising it.

Students' comments revealed that they believed Clare's new approach to teaching numeracy provided them with opportunities to engage with *mathematical knowledge* within *contexts* that emerged in other subject areas as well as in mathematics classes. These *contexts* were ones students could identify as related to their current or future lives. They were also aware of the important role physical, representational, and digital *tools* played in developing their understanding of and capacity to use mathematics. Their preparedness to use mathematics to solve problems in context and to take risks when applying mathematics to new situations stood in contrast to what students reported during the interview after the first school visit and indicates a healthy *disposition* towards using mathematics. Students also displayed a capacity to take a *critical orientation* to the use of mathematics within subjects outside of mathematics.

Discussion and Conclusion

The challenges of moving from the intended learning outcomes framed by formal curriculum documents to the enacted practices of teaching and learning, in a way that is faithful to the spirit of the original curriculum design, are well known. This chapter outlines an approach where teachers were supported in implementing an intended cross-curricular practice—numeracy—in a way that provided for rich learning opportunities for students. This approach was mediated by the use of a model that made more explicit the essential elements of numeracy and was supported by

social practices in the form of discussions with the project researchers during school visits and interactions with other teachers during whole project meetings.

With a clearer sense of what was intended by numeracy statements within relevant curriculum documents and the support offered by the project researchers, Clare developed adeptness at designing learning experiences that her students found relevant and engaging. This was a gradual process in which Clare found she needed to take the risk of moving away from teacher centred approaches, with which she felt confident, towards approaches where students were challenged to take intellectual risks by engaging with open-ended activities and to look for opportunities to use mathematical knowledge and modes of reasoning in a variety of within school and outside of school contexts. Clare's focus on improving students' numeracy outcomes, the permission to explore numeracy rich topics relevant to students' interests expressed through the numeracy audit, and the personal support offered through the project, encouraged her to move from teacher centred, topic focused modes of teaching practice to a more student focused and inquiry based approach to teaching and learning. This new approach was context rich and aimed at improving students' dispositions towards doing and using mathematics. Clare was now conscious of the need to incorporate the use of digital tools in her teaching practice and to provide opportunity for students to exercise judgements, form opinions, and make decisions based on mathematical evidence.

Students responded to this new approach in ways that demonstrated that they were interested in learning mathematics, provided learning activities were challenging and offered a genuine opportunity to be engaged in their own learning. Students could see their teacher was attempting to create activities where learning was relevant to students' current or future interests and that had a genuine purpose. Clare's approach meant that students learnt about mathematics in classroom contexts that were not specific to mathematics, that is, for example, in Health and Physical Education. In the case of the activity where students investigated their levels of physical activity, students demonstrated that they had acquired new mathematical knowledge, made use of digital tools, and demonstrated positive dispositions to the use of mathematics in inquiring into an issue embedded within a context relevant to students' current interest and well being. The data gathered, as a consequence of this activity, provided students with the opportunity to critically review their personal levels of activity through comparison with those of other members of the class.

This chapter was concerned with how the intent of the numeracy aspect of a curriculum document was enacted in one school classroom through the support of a research and development project. The outcomes reported here appear to be a consequence of the clarity offered by the model employed in the project in relation to the essential elements of numeracy and of the approach to teacher professional learning adopted by the project. These influences have led to positive student views on their mathematics learning and to greater connectedness of this learning within and outside of mathematics itself. Further research is needed, however, in order to demonstrate the effectiveness of this approach on a scale greater than a small group of teachers working within a limited number of project supported schools. In attempting to implement approaches of greater scale, for example, whole school,

school cluster, regional or system wide, the issue of leadership must necessarily be addressed. This implies work must also be done on developing a theory of and vision for numeracy leadership as part of the implementation of curriculum within schools.

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