School is out, but Numeracy is in!

An exploratory case study of the out-of-school numeracy practices of four Year 12 New Zealand students

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Abstract

This exploratory case study investigated the out-of-school and workplace numeracy practices of four Year 12 New Zealand high school students. Student participants were interviewed using a numeracy kit of everyday items as a stimulus for discussion about their use of mathematics out-of-school. The workplace numeracy practices of the student participants were investigated through workshadowing and stimulated recall (Zevenbergen, 2004).

Data from the case studies demonstrated that these young people involved in the Gateway programme were competent users of mathematics both in the workplace and in their everyday lives. Significant differences between school mathematics and out-of-school numeracy practices point to possible explanations of why school mathematics may not transfer to out-of-school settings. Inclusion into a community of practice, willingness to take on work for the purpose of learning and an ability on the part of the employer to offer work experiences that involve numeracy are shown to be key factors in the development of these student participants development of competency. Workplace observations of the student participants' suggest that Lave and Wenger's conceptualisation of the "novice" may no longer apply to young people entering contemporary workplaces. A possible framework for the schools to assess the learning opportunities afforded by Gateway employers is given.

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Chapter 1

Introduction

1.1 Introduction

This research explores the out-of-school mathematics practices of four Year 12 secondary school students. The project arose out of concern over what I see as an increasing disjunction between the culture of the curriculum and the culture of senior high school students. It was motivated by anecdotal evidence that claimed that senior high school students are becoming less engaged with mathematics and that students do not see mathematics as having relevance to their lives. Part of this evidence comes from the poor retention rate of students in mathematics after Year 11 when it becomes an optional rather than core subject. As a mathematics teacher it is my feeling that our current mathematics curriculum is intended to prepare students for university and not the workplace and/or vocational training. Armed with a respect for peoples' experiences in the workplace/world, I wanted to investigate how senior students use mathematics in their work placements and in their everyday lives out-of-school. Motivation for this research also came from a theoretical interest in the concept of mathematics-as-practice, or numeracy practice, a concept akin to the more theoretically developed and researched concept of literacy practices.

1.2 Diversity of Learners

In the past the majority of students continuing on to Years 12 and 13 at secondary school were headed for tertiary education. In 1993 New Zealand raised the school leaving age from 15 to 16 years of age. Over a decade on, anecdotal evidence suggests this change has resulted in a more a diverse population of senior high school students, many of whom are staying at high school for Years 12 and 13 with no immediate intention of studying at university. The advancement of technical expertise as a consequence, has become less critical than does the development of a capacity and disposition to apply mathematics in a range of settings.

The National Administration Guideline (NAG) 1.6 specifies that schools must provide appropriate career education for students identified by the school as being at risk of leaving school unprepared for the transition to the workplace or further education/training (Ministry of Education, 2007). In referring to teachers who care about the diversity of the students they teach Perso (2003) suggests that teachers have much to learn from their students. In conducting this research I have had the opportunity to gain an insight into the out-of-school numeracy practices of four "at-risk" students. In the reporting of this research it is intended that an "ethic of care" is demonstrated by allowing the view of the participants to come through in their own voice.

1.3 Learners in the New Millennium

It is a sobering thought that many young people today are exposed to learning processes outside of school which are richer and deeper than those they experience in schools (Gee, 2003). Gee investigated the learning principles associated with video and computer games which are a major cultural practice of young people. Here learning is based on situated practice where consequences for failure and taking risks are lowered; problems are ordered so that the first ones encountered lead to fruitful generalisations later on in the game; learning is interactive; and there are multiple routes to solving a problem. Players go online to seek and receive help and discuss strategy; there are spaces dedicated to particular games or types of games; the players orient their learning to issues of design and understanding the complexity of the game system. Such learning principles are well supported by a great deal of modern work on cognitive science concerned with how people learn best (Kirshner & Whitson, 1997). It is speculated that such learning principles applied to mathematics would lead to an increase in students' capacity and disposition to use mathematics across a range of settings.

1.4 The Changing Face of Mathematics

Our current mathematics education system might be viewed as a reverse funnel. The narrow neck represents the narrow range of mathematics courses offered to senior students and the opposite, fanned out end of the funnel, represents the diverse range of post-school destinations students are headed for. The introduction of the National Certificate in Educational Achievement (NCEA) offers secondary schools the opportunity to be far more flexible, creative, and future-focused in the courses they offer. The question arises: how will secondary schools respond to this opportunity and how can they best prepare students for the diverse mathematical demands they face in the world beyond the school gates?

The rapid evolution of society, particularly under the influence of information and communication technology must have profound consequences for education. New developments bring new tools, concepts and ways of thinking which are increasingly integrated into everyday life. Up until now, changes in society have been more marked than changes in education (Cornu, 1999). If we are to integrate new developments into education how far should schools follow the led of society? Are there alternative visions for the future of education? (Cornu, 1999). It may, for example, no longer make sense to require students to learn techniques that can be carried out much more efficiently and reliably by machines. To do so may restrict students to the "grammar" of mathematics at the expense of the "literature" (Mukhopadhyay & Greer, 2001). This research is not primarily concerned with developing mathematics curricula and therefore it is not my position to suggest how schools may address the issue of mathematics curricula for the diversity of senior high school students; rather it is to shed light on how well current school and classroom practices are preparing students to meet the numeracy demands they might face in the workplace and their everyday lives.

1.5 International Adult Literacy Survey (IALS) and Adult Literacy and Life Skills (ALLS)

Up until about twenty-five years ago official New Zealand publications stated that our literacy rate was '99%'. However, this figure was based on the assumption that because most New Zealand adults had had at least had some primary schooling, if not two to three years of secondary schooling, they would be literate (Benseman, 2000). In the late 1990s a series of International Adult Literacy Surveys (IALS) was carried out within 22 of the industrialised nations of the OECD. The survey measured adults' literacy across three fields:

1. Prose literacy – the ability to understand and use information from texts such as the newspaper.
2. Document literacy – the ability to locate and use information from timetables, graphs, charts and forms.
3. Quantitative literacy – the ability to use numbers in context, such as balancing a chequebook or calculating a tip (Johnson, 2000).

Instead of defining a person as either literate or illiterate the report put literacy skills on a continuum from level one at the lowest to level five at the highest. Level three on the continuum is considered to be the point at which a person has attained the "minimum level for competence" in everyday life.

New Zealand took part in the IALS in March 1996. Results from this study provided us with the opportunity to benchmark ourselves against the other twenty-one countries which took part in the survey and to establish a baseline against which to measure changes in literacy skills in our population over time.

IALS has since been followed up in 2006 by the Adult Literacy and Life Skills (ALLS) survey - a large-scale comparative study that profiles the skills of adults in 15 OCED countries and also provides national snapshots. ALLS rated peoples' ability to deal with everyday literacy demands.

Key findings from the IALS for New Zealand were:

1. The distribution of literacy skills within the New Zealand population is similar to that of Australia, the United States and the United Kingdom.
2. Approximately one in five New Zealanders is operating at a highly effective level of literacy.
3. New Zealanders do less well at document and quantitative literacy than at prose literacy.
4. The majority of Maori, Pacific Islands people and those from ethnic minority groups are functioning below the level of competence in literacy required to effectively meet the demands of everyday life.
5. Labour force status and income are related to level of literacy.
6. Increased retention into senior secondary school appears to be associated with improving literacy levels.
7. Maori with tertiary qualifications have literacy profiles similar to those of tertiary educated Europeans/Pakeha.

Http://educationcounts.edcentre.govt.nz/publications/assessments/adultliteracy

In addition to these key findings the study also found that one in five (approximately 200,000) New Zealand adults is at the lowest level on the continuum mentioned above and that a further 25% have poor literacy skills (level 2). Literacy skills were found to peak between the ages of 20 to 24 and 35 to 39 and then trend downwards after 50. The high points are considered internationally to be caused by the increase of certain literacy skills during adult and working life.

Given the poor outcome for New Zealanders in the IALS and the fact that it takes approximately 30 years for the workforce to be replaced by the next generation of school graduates, school based solutions need to be well researched before their implementation. Employers also have a responsibility to acknowledge the disparity of literacy levels of their workforce. BusinessNZ (2005) published the following statement:

> Recently announced government initiatives to improve literacy and numeracy in the workplace are a useful response to currently patchy levels of literacy and numeracy that hold back productivity. Business can assist by staying engaged with skills issues, operating ongoing rather than intermittent training programmes, and taking advantage of skills-related assistance offered by government or other parties. (p. 4)

This statement demonstrates that BusinessNZ has already given careful consideration to how they might best support employees in their development of numeracy skills.

1.6 The Mathematical/Numeracy Needs of School Leavers

Mathematics is often considered the 'gatekeeper' school subject, with many tests and qualifications regulating entry into jobs, education and training opportunities. According to Gal (1992) this is an ironic understanding as the academic mathematics used as a 'gatekeeper' does not necessarily reflect the aptitudes and skills needed on the job or in life. Instead Steen (2001) argues that students require both mathematics, which he says needs distance from context, and quantitative literacy "which is anchored in real data that reflect engagement with life's diverse contexts and situations" (p. 58).

The image of mathematics socially, paradoxically, engenders a general belief in the necessity of mathematics alongside a sense of cultural aversion, which often has it roots in students' experiences of mathematics at school - a view which is subsequently promoted by public opinion and media (Cornu, 1999). School activities need be directed at creating a willingness on the part of students to approach problems from a mathematical perspective as well as being directed at encouraging a capacity to critique mathematical applications and the use to which mathematics is put in society.

A decade ago Knight et al (1996) researched the mathematical needs of New Zealand school leavers. They listed the specific skills, required by school leavers as:

Mental and calculator arithmetic skills
Basic computing skills
Measurement skills
An understanding of everyday statistics
Simple geometric skills
Estimation skills
Being able to use a variety of strategies to solve number problems
And most importantly having the confidence and ability to use skills in everyday real life situations

At first glance these skills appear well aligned with our current mathematics curriculum. However, it is debatable whether our current curriculum allows time for students to be given adequate opportunity to apply newly learned skills to a range of new contexts. Such opportunities are important if students are to leave school prepared to face previously un-encountered challenges. This issue of the application and transferability of mathematics will be taken up further in the next chapter.

1.7 New Zealand Research and Initiatives in Transition to Post-secondary School Destinations

Little information is available on New Zealand students' experience of vocational education and training in secondary schools and their transition to post-secondary school destinations (see section 1.9). However, the "Education Employment Linkages" (EEL) collaboration between the New Zealand Council for Educational Research (NZCER), Lincoln University and Victoria University of Wellington is exploring the issue of how formal support systems might best help young New Zealanders to match education choices and employment outcomes to benefit themselves, their communities, and the national economy. This project has been funded by the Foundation for Research, Science and Technology from 2007 to 2010.

The "Careers Education Systems in New Zealand Schools Survey" conducted by Vaughan and Gardiner (2007) feeds into the EEL project. This study aimed to provide insight into the future direction and focus of careers education in New Zealand schools. Results from this survey form baseline information about how schools currently organise career education.

Other initiatives and projects in the area of transition include:

- The Creating Pathways and Building Lives (CPaBL) initiative. It aims to reorganise careers education and help schools to implement careers education as part of their curriculum. CPaBL is aimed at building a school-wide approach to career education. The programme builds on the pilot programme, Designing Careers, which was introduced to 75 secondary schools in 2005. Through provision of career information, advice and guidance within schools, CPaBL aims to assist students in making a smooth transition from school to further training and employment.

- The Secondary-Tertiary Curriculum Alignment Project at Manukau Institute of Technology. This project is funded through the Innovation Development Fund to conduct a national project on secondary tertiary curriculum alignment. The project started in 2002 and aims to create barrier free pathways from secondary schools into tertiary studies. Schools and local technical institutes negotiate alignment to ensure that there is a good fit between the two institutes and future employment. This helps to facilitate the movement of students from one level to the next without experiencing gaps or overlaps in their education. This project has expanded to include 4 technical institutes and their local schools. An example of a programme which has arisen as a result of this research is the SmartPaths Marine Studies – Bay of Plenty Polytechnic's marine studies curriculum alignment programme delivered to Year 13 Biology classes at Mount Maunganui College, Otumoetai College and Whakatane High School. Success of the programme was demonstrated when over half of one schools' Year 13 class enrolled for further studies in marine biology at tertiary level.

- The Secondary Tertiary Alignment Resource (STAR). This initiative provides all state secondary schools with additional funding to access courses that provide greater opportunities for students. The objective of STAR is to enable schools to better meet the needs of students by personalising learning pathways and facilitating a smooth transition to the workplace or further study.

1.8 Gateway

Of particular relevance to the research project at hand is The Tertiary Education Commissions initiative, Gateway. The scheme involves high schools from decile 1 - 6 and has been in operation since 2001. Gateway was designed to enable secondary school students to undertake formal workplace learning whilst continuing to studying at school. One of the main objectives of Gateway is to enhance partnerships between schools and local businesses. Schools receive funding to ensure that students educational and subsequent employment needs are met.

Structured workplace learning set in an actual workplace over a sustained period of time (usually one day a week for the school year) is integrated with clear objectives about the knowledge and skills to be gained, and involves the assessment of achievement and/or unit standards. Students continue with their general education on the other school days of the week. This programme dovetails with Modern Apprenticeships and the National Certificate of Educational Achievement, providing recognition of a broader range of achievement.

The benefits of Gateway are threefold: (i) senior students in Years 11 to 13 are provided with the opportunity to gain specific vocational skills and many students make significant progress towards qualifications, (ii) business benefits through the opportunity to gain more effective and efficient recruitment, which can increase productivity and enhance the company's skills base, and (iii) schools benefit by gaining greater credibility with local communities through their leadership role in easing the transition beyond the school gate.

An evaluation of Gateway shows that the programme has been particularly effective for transition into employment, apprenticeship, and further training as well as for retaining students in secondary school. Integrated school-workplace learning has been shown to provide an effective learning environment for senior students and workplace learning can reinforce and extend students' school-based study (Tertiary Education Commission, 2003).

1.9 Numeracy in Vocational Education and Training

A range of vocational qualifications is now being offered to secondary school students. These courses attempt to motivate students by being vocationally centred. Here mathematics underpins both general skills and more specialised skills depending upon the course. Students taking these courses have chosen not to study 'academic' mathematics; rather mathematics is seen as being of value to their chosen vocational studies. The role of mathematics in these courses is every different here than it is in the traditionally offered senior school mathematics courses (Williams et al.,1999). It is reasonable to speculate that the workplace mathematics for students entering the workforce directly after school will be different, though not necessarily, easier than for those who go on to higher education before entering the workplace. Inclusion of workplace and everyday mathematics does not necessarily mean a reduction in the depth of content covered by the curriculum. On the contrary, it is speculated that contexts give students the opportunity to increase their depth of knowledge and raise their level of conceptual understanding.

1.10 Research Objectives

The transition from dependent student in the classroom to workplace employee is an important milestone in all young people's lives. However, the shift from initial formal education to work no longer implies the front-end loaded model of education. It is increasingly common for working life to be interspersed with periods of training, and for the workplace itself to become a place of learning. It is therefore important that we equip our young people with the skills and attitudes required for them to become life long learners.

This research broadly aims to extend the knowledge that we have about how students develop knowledge, skills and attitudes required by life in the 21st century. Over the past decade researchers have became increasingly aware of the need to talk and listen to students in order to understand their unique perspectives (for example, Rudddock & Flutter, 2000; Young-Loveridge, 2005; Young-Loveridge & Taylor, 2005; Young-Loveridge, Taylor, & Hawera, 2005). It is these perspectives that are sought in the research at hand. Specifically, this research aims to explore the extent to which students' "school maths" is aligned with students' "out-of-school" numeracy practices, how students develop mathematical competence in the new contexts such as in the workplace, and how schools best support students' numeracy development in preparation for the transitions that they face.

1.11 Choice of Method, Data Collection and Analysis

Descriptive case study methodology, using multiple strategies to gather data was employed. Data gathering included "Work Shadowing" (Zevenbergen, 2005). This research method involved the researcher following participants at work and taking photographs over a period of several days. The photographs were then used to discuss work related numeracy practices in a way that did not pre-empt the participants' responses. Participants were also interviewed using a kit containing everyday materials to stimulate discussion about everyday numeracy practices. This technique was developed by Johnston et al. (1997) to provide a non-threatening, non-judgmental way of gaining insight into how young people use mathematics in their everyday lives. Employers and teachers involved in the vocational education of the participants were interviewed and the mathematical content of participants' vocational course work was examined.

This eclectic approach to data gathering was undertaken in order to develop a multi-dimensional view of how the participating students use mathematics outside of the classroom. Workplace shadowing allowed me to observe first hand how the students used mathematics in the workplace. Informal interviews with students, employers and tutors/teachers meant that I was able to triangulate data collected from students, thus strengthening the reliability and validity of the research findings. Interviews using everyday items allowed students to share how they used mathematics in their lives outside of school and this enhanced the study by providing a glimpse of how the students coped with the mathematical demands they faced outside of school.

1.12 Chapter Overview

Chapter 2 analyses some of the research which provides the conceptual basis for how I understand mathematics or numeracy in this project. The studies reviewed contribute to an understanding of workplace numeracy training and practices, mathematics as social practice, situated cognition and the transfer of learning of mathematics. The literature examined is drawn mainly from North America, South America, the United Kingdom and Australia.

Chapter 3 discusses methodology and the research design including the details of the data gathering techniques employed. Justifications of the research design and data collection methods are also provided.

Chapters 4 and 5 report on the findings of this exploratory study. Chapter 4 presents detailed results and some analysis of the four case studies. Chapter 5 discusses the extent to which students' out-of-school numeracy practices were observed to align with our current mathematics curriculum and the mechanisms which were seen to facilitate students' transfer of mathematical knowledge and skills across contexts. Implications from the research in terms of how schools can best support students' development of transition numeracies are also discussed.

Chapter Two

Literature Review

2.1 Introduction

New Zealand's labour market has changed considerably over the past few decades. Factors such as knowledge-dependent, information-based economies, global money markets and the internet all mean that this trend is likely to continue (Johnson, 2000). It is claimed that these changes, coupled with flatter organisational structures in which workers carry out multi-skilled roles, will lead to an increasing demand for workers with high levels of mathematical knowledge and skills (Wolf, 2005). There is also a growing need for workers to be able to integrate their use of mathematical skills with other skills, such as effective communication skills and good technical knowledge (Hoyles et al., 2002). Employers require not only mathematical techniques and knowledge but also skills such as the ability to think logically and to be organised and systematic. For 21^{st} century workers then, the utility of mathematics lies not merely in its application but in the 'thinking tools' it provides (Dorfler,1999).

Literacy and numeracy are connected to some of the key social challenges of our time, namely, poverty, health, and integration of migrants. At a local level the purpose of numeracy is generally considered to be preparation for adult life and work (Cockcroft Report, DES/WO, 1982); for critical citizenship (Evans & Thorstad, 1995) and democracy and empowerment (Johansen & Wedege, 2002). Numeracy can therefore be seen to affect all aspects of a person's life (Johnson, 2000).

2.2 Numeracy Conceptual Issues

In spite of its importance 'numeracy' is still a deeply contested term as evidenced by the fact that there is no internationally agreed upon definition in the research literature (Coben, 2001; Evans, 1989; Gal, 2000; O'Donoghue, 1995; Willis, 1998). While possible definitions of numeracy abound it is important to provide an understanding that has synergies with the ways in which it is interpreted by central government in its policy decisions and by the private sector in influencing access to training.

The notion of numeracy informing this research project is doubled-edged. It involves the conceptual understanding of mathematical knowledge, and the ability to apply this knowledge in the diverse range of demands that individuals meets in their work and personal lives. The definition of numeracy put forward by Coben (2003) seems the most applicable:

> To be numerate means to be competent, confident, and comfortable with one's judgments on whether to use mathematics in a particular situation and if so, what mathematics to use, how to use it, what degree of accuracy is appropriate, and what the answer means in relation to the context. (p.10)

The separate but yet interconnected nature of numeracy and mathematics is apparent in Coben's definition. As will be discussed further in this chapter nearly all definitions of numeracy allude to the need for numeracy to be underpinned by a body of mathematical knowledge and skills.

2.3 International Perspectives on Numeracy

The term numeracy has its genesis in the Crowther Report in 1959 when Crowther called numeracy the "mirror image of literacy" (Crowther, 1959 cited in O'Donoghue, 2002). Internationally, since this time there has been escalating public interest in the concept of numeracy particularly in the UK, the USA, Australia, New Zealand and more recently some countries of the European Union (FitzSimons et al., 2005).

Back in 1982, Cockcroft (UK) (cited in Neill, 2001) stated that to be "numerate" implies an "at homeness" with mathematics and an ability to understand information presented in a mathematical way. More recently the definition of numeracy advocated in the United Kingdom is "the ability to process, communicate and interpret numerical information in a variety of contexts" (Brown, Askew, Rhodes, Johnson, & William, 1997, p. 35). An holistic view is taken by Gal (USA/Israel, 1995) in defining numeracy as

> the aggregation of skills, knowledge, beliefs, dispositions and habits of mind as well as general communicative and problem solving skills people need in order to effectively handle real-world situations or interpretive tasks with embedded mathematical or quantifiable elements. (p. 14)

Willis (1998) describes numerate behaviour as involving a considerable amount of "nous" "some of this nous is mathematical, some is situational (or contextual), and some is strategic" (p. 17). In Australia Association of Mathematics Teachers (AATM, 1997 cited in http://www.aph.gov.au/house/committee/edt/eofb/report/chapter5.pdf retrieved on April 23, 2007) has put forward the following general understanding of numeracy as:

> "Essentially the effective use of mathematics to meet the general demands of life at home, in paid work and for participation in community and civic life. Thus numeracy is:
>
> Distinct from literacy
> More than number sense
> Not only school mathematics
> And cross-curricular. (p. 93)

The above perspectives on numeracy can be seen to challenge the practices of the traditional mathematics classroom, where mathematics is viewed as a set of decontextualised tools to be learned and then applied across a range of settings. Instead it is acknowledged that numeracy is bound in context and as such can not be culture or value-free. Three essential components of numeracy have been identified by Ginsburg, Manly, and Schmitt (2006):

> Context – the use and purpose for which an adult takes on a task with mathematical demands
> Content – the mathematical knowledge that is necessary for the tasks confronted
> Cognitive and Affective – the processes that enable an individual to solve problems and, thereby, link the content and the context. (p. 34)

All three components are said to be necessary in order for a person to "*be* numerate, to *act* numerately, and to *acquire* numeracy skills" (p. 33).

2.4 School-based Numeracy Initiatives in New Zealand

The Numeracy Development Project (NDP) was established in 2000 in response to the poor performance of some New Zealand students in the Third International Mathematics and Science Study (TIMSS) in 1994. The philosophy driving the Ministry of Education's initiatives was that student achievement in mathematics could be improved by improving the professional capability of teachers, specifically by improving teacher pedagogical content knowledge. The definition of numeracy informing the Numeracy Development Project was: "the ability and inclination to use mathematics effectively – at home, at work and in the community" (Fancy, 2001). In the discussion of the Projects that follows it is evident that a strong emphasis has been placed on the essential role of number in numeracy.

The Early Numeracy Project was piloted nationally in 2000 under the name Count Me In Too. Teachers of students in Years 1 to 3 were encouraged to analyse the mental strategies students used to solve problems and then tailor instruction to meet the specific needs of each student. The Advanced Numeracy Project (ANP) was previously known as the Year 4-6 Numeracy Exploratory Study (NEST). The overall aim of this project was to develop teachers' knowledge of number concepts and students' strategies through the use of The Number Framework which relates to levels 1 to 4 of the curriculum achievement aims and objectives (see Ministry of Education, 1992). The Secondary Numeracy Project (SNP) piloted in 2005 built on the findings of the Numeracy Exploratory Study for students in Years 7 to 10. Mental computational strategies are emphasised to encourage students to develop a deeper understanding of mathematics which may then be used to develop students' understanding of algebra.

The New Zealand Council for Educational Research (NZCER) have also produced a working definition of numeracy which is line with the Ministry's understanding:

> Numeracy is the ability of a person to make effective use of appropriate mathematical competencies for successful participation in everyday life, including personal life, at school, at work and in the wider community. It involves understanding real-life contexts, applying appropriate mathematical competencies, communicating the results of these to others, and critically evaluating mathematically based statements and results.

The definition adopted by the NDP and the NZCER both make reference to the use of mathematics across a range of contexts and therefore make the assumption that numeracy skills are transferable. Underpinning these definitions is a view of numeracy as utilitarian – that numeracy woven into the context of work, community and personal life.

The current mathematics curriculum document for schools, *Mathematics in the New Zealand Curriculum*, states that: "mathematics is a coherent, consistent and growing body of concepts which make use of specific language and skills to model, analyse, and interpret the world" (Ministry of Education, 1992, p.8). The *New Zealand Curriculum Framework* (2006) states: "Everyone needs to learn mathematics. It is essential in most areas of employment. It also is a basic necessity in most other aspects of everyday life" (p. 2). Both of these statements stress the importance of a subset of mathematical skills – applied mathematics. It is noteworthy that we do not justify the inclusion of other subjects in the New Zealand curriculum such as art, history or biology, on the basis of their use in everyday life.

A new curriculum that replaces the 1992 document from 2007 puts greater emphasis on thinking. Here mathematics is defined as:

> the exploration and use of patterns and relationships in quantities, space, and time...By learning mathematics...students develop other important thinking skills. They learn to... to carry out procedures flexibly and accurately, to process and communicate information and to enjoy intellectual challenge.... They learn to create models and predict outcomes, to conjecture, to justify and verify, and to seek patterns and generalize.... Mathematics... [has] a broad range of practical applications in everyday life, in other learning areas, and in workplaces. (Ministry of Education, 2007, p. 26)

This definition may be seen to reflect the shift towards developing not merely the competencies and knowledge needed for life in the 21st century but also the *values* that will be needed. A continuing emphasis on the practical applications of mathematics is still evident. Moreover, there is an underlying assumption the key competency approach adopted in the new curriculum will ensure that student learning will be transferable.

2.5 Numeracy and School Mathematics

In defining numeracy, the practical or everyday use of mathematics in contexts such as homes, workplaces, and communities is often emphasised. It is suggested by Milton and Cowan (2000) that numeracy can be viewed as an understanding of mathematical concepts and the ability, in real life situations, to apply mathematical skills appropriately, while school mathematics can be viewed as a set of concepts and skills to be learnt and applied, within the school setting. In this interpretation school mathematics does not necessarily need to focus on the real world; it can involve purely abstract constructs and ideas regardless of application. Those who argue that mathematics is valuable for its own sake often note the beauty and aesthetics of mathematics and the sheer enjoyment of doing it (e.g., Holton, 1998). In talking about his work G. H. Hardy, an English mathematician, said "No [mathematical] discovery of mine has made, or is likely to make, directly or indirectly, for good or for ill, the least difference to the amenity of the world" (cited in Hoffman, 1998, p. 22). Historically, however, a number of purely abstract mathematical ideas have found their way into real-life applications.

Mathematics involves some aspects of abstraction or attention to structure, whereas everyday activities such as gardening, cooking and driving, do not necessarily involve mathematics, because, what might be considered as mathematical is embedded in the practice of the activity. That is not to say the activity can not be mathematised, as is often the case in the classroom. For example, a speed limit sign containing the number 50 in a large red circle may be interpreted by drivers in a number of ways – they may check their speed and make comparisons between their speed and the limit; they may adjust their speed; and they may use their knowledge of speed to judge the distance between them and the car in front of them. These actions are inherent in the practice of driving - they are not mathematical but they can be mathematised.

A useful way to grasp these distinctions is through Bernstein's (2000) concepts of 'vertical discourse' and 'horizontal discourse'. In the educational field these concepts are referred to as schooled versus everyday knowledge. Because of its explicit, hierarchical and systematically principled structure, mathematics is an example of 'vertical discourse'. Numeracy, however, is an example of 'horizontal discourse', as it is embedded in on-going practices and may involve a repertoire of strategies depending on the context at hand. According to Bernstein, the pedagogy of horizontal discourses usually involves modeling repeatedly if necessary until a particular competence is gained. This modeling is usually carried out face-to-face. This notion resonates strongly with the findings of research on workplace numeracy practices (see later in this chapter).

2.6 School Mathematics and the Role of Number Sense

There are many definitions of number sense but most contain reference to three skills: first is the ability to relate numbers to the real world, second, is the recognition of benchmarks or the ability to estimate and third, is the ability to create procedures for solving numerical problems. Case (cited in Gersten & Chard, 1999) notes:

> Number sense is difficult to define but easy to recognise. Students with good number sense can move seamlessly between the real world of quantities and the mathematical world of numbers and numerical expressions. They can invent their own procedures for conducting numerical operations. They can represent the same number in multiple ways depending upon the context and the purpose of this representation. They can recognise benchmark numbers and number patterns: especially ones that derive from the deep structure of the number system. They have a good sense of numerical magnitude and recognise gross errors, that is, errors that are off by an order of magnitude. Finally, they can think or talk in a sensible way about the general properties of a numerical problem or expression without doing any precise computation. (p. 11)

It is argued by Martland (2001) that if children do not develop sufficient numeracy skills in primary school, they develop negative attitudes towards mathematics, which then hinders their progress at secondary school and limits their career choices. The underlying causes of numeracy problems are complex and often involve a combination of problems. Identifying the root of the problem and developing a response requires considerable expertise.

Gersten and Chard (1999) reported that research findings by neuropsychologists and cognitive psychologists indicate three key components that are linked to problems in the construction of number sense. These are:

1. High rates of procedural errors.
2. Problems with representing and retrieving basic facts.
3. Inability to code numerical information for memory storage.

The development of number sense is positively correlated to high socio-economic status and the initial stage of development usually takes place before children start school (Gersten & Chard, 1999). An informal number sense has been pointed to by Griffin, Case, and Siegler (1994) as being a prerequisite for formal arithmetic learning to be built upon in early schooling. The concept of number sense can inform and enhance the quality of mathematics education particularly for those students with learning difficulties (Gersten & Chard, 1999). Research by Gearing (1993), McCloskey and Macaruso (1995) and Griffen et al. (1994) supports the idea that lack of number sense may be an underlying cause of difficulty in learning mathematics and that increasing a person's number sense can increase that person's ability to learn mathematical concepts.

2.7 Transfer of Mathematics Learning

At the heart of all mathematics education is the idea of teaching mathematics so that it can readily to be applied to newly encountered situations. Two types of transfer are discussed in the literature: horizontal (or lateral transfer) and vertical transfer. Mathematics is generally accepted to be an hierarchical subject, with new ideas being built upon earlier, more basic ideas. In this understanding vertical transfer can be seen to be occurring constantly. Lateral transfer is much more contentious. It refers to the idea that learning that has occurred in one context will be available for use in other contexts. The concept of numeracy seems to fit well with this lateral view of transfer.

When looking at the issue of transfer of mathematics learning, Evans (2000) recognises the limitation of traditional approaches where transfer is expected to be relatively straightforward. He acknowledges the results of such approaches are usually disappointing. The problem of the apparent failure of school curricula to produce mathematically literate people, together with the issue of the apparent discontinuity between school mathematics and out-of-school numeracy practices has prompted governments (e.g., Crowther Report, 1959; Cockcroft Report, 1982) and educational researchers (e.g., Willis, 1990; Nunes et al., 1993) to seek possible causes and solutions.

The utilitarian approach, epitomised by the Cockcroft Report (1982) emphasises the numerical skills involved in mathematics and favours the use of behavioural learning objectives. Mathematics is considered to provide a set of decontextualised tools which are used in basically the same way across a range of different settings. These views on mathematics have a continuing influence on education policies and practices (Evans, 2000) and more recently have been expanded to include the cognitive skills being taught in vocational training (Evans, 2000) and through the numeracy projects, not only here in New Zealand but also in the UK, USA and Australia.

One of the limitations of the utilitarian approach, as Askew, Bleicher, and Cooper (1988, cited in Adult Numeracy, 2004) argue, is the assumption that the context of a problem is indicated by the wording and format of the problem, rather than by its socially constructed qualities. Research by Newman et al. (cited in Evans, 2000) found that it was difficult to describe a task, in terms that were abstract enough to allow for the notion of the 'same mathematical task' in different contexts. Importantly, the performance of an individual on what seems to be the same mathematical task in different contexts has been shown to vary dramatically (Lave, 1988).

Research from disciplines such as anthropology, psychology and social theory has also offered insight into the issue of transfer of mathematical learning (e.g., Lave, 1988; Baker et al., 2003; Scribner, 1984), by investigating how people use mathematics in a range of everyday contexts. Findings from such studies challenge the commonly held views of mathematics. As a counterpoint to the utilarian view of mathematics they offer 'mathematics as social practice'. Their proposal addresses the problem of the apparent lack of transfer of school mathematics, and research evidence that reveals that people often invent their own ways of solving the problems they encounter in everyday life. They advocate the theoretical stance that all learning is essentially situated.

'Radical situationists' such as Jean Lave, view the transfer of learning from academic contexts to outside contexts as "virtually hopeless" (Evans, 2000). The two settings are seen as discontinuous and the subjects' thinking is seen as specific to distinct settings. For example, rather than arguing that calculating 20 – 15 in school is the 'same mathematical task' as calculating the change for $15 from $20 at the supermarket, it is claimed that there is a discontinuity between school mathematics and everyday numerate problems. More recently Lave has argued for 'bridges' between "communities of practice", stating that it is difficult to maintain that any practice is completely closed. Similarly, ethnomathematical research suggests that cognition is situated in contexts and that transfer of learning can be made smoother by ensuring that the context of learning is closely related to the context in which the mathematics will be used in real life. For educationists adopting such an approach, Lesh (1985) cautions that many mathematical ideas are unlikely to evolve outside of mathematically rich instructional environments. The idea of mathematics as an organiser of a field of real life experience is poorly founded (Verstappen, 1994).

Like situational cognitists, Evans (2000) recognises that different practices are distinct. He recommends that language and meaning be analysed so that relations of similarity and difference between signifiers (words, gestures, sounds, and so forth) and signifieds (conceptions) can be discovered. In doing so, Evans suggests that it is possible to identify areas of articulation between, for example, school mathematics and everyday mathematics. In his view discourses give meaning to practices precisely because they are an expression of the goals and values within a community of practice which is made up of a group of individuals who share a set of goals and a set of social relationships. In formulating his proposal, Evans draws on de Saussure's structural linguistics when analysing the different discourses that exist. He also uses the poststructuralist idea that signifiers 'slip' into other contexts, and as they do so, they make links with other discourses.

Out-of-school mathematics may overlap with everyday mathematics, particularly when bridges are built to help to facilitate transfer of learning. Adults returning to study, for example, may be confused by the idea that 'multiplication' - which in everyday contexts means an increase - can result in a decrease when fractions are involved. In this example it can be seen that similarities between everyday and pedagogical contexts may be useful up to a point, but it is important the differences between the contexts be made explicit for the learner.

Much of the research on the transfer of mathematical learning has focused on relatively straightforward school mathematics. Research conducted by Magajna (2001) investigated the use of more advanced school mathematics in the learning of computer-aided design in machining. The findings of this research largely confirmed the discontinuity of school and workplace mathematics. However, encouragingly, it was found that school mathematics did form an important foundation, which when combined with vocational training became transformed into practice-related knowledge. Findings from this study also suggest that transfer of mathematical knowledge to other subjects may be impaired by inadequate knowledge of the other subject.

Two conditions necessary for transfer of learning are put forward by Sierpinska (1995): (1) Students must get fully involved with a problem and (2) they must have freedom to act in a way that is not bound to following a set of given rules. Sierpinska (1995) concludes that if people care about contexts in the learning of mathematics it is because they believe that contexts ensure that students will learn something of value to society. She warns, however, that this approach may in fact lead schools to merely reproduce already existing community knowledge. Such an approach would not provide a foundation for the creation of new knowledge, and this is not an approach that society would validate for schools. This point is reiterated by Chevallard (1991). Specifically, Chevallard argues that the use of everyday contexts in the teaching of mathematics contradicts the way society expects schools to operate. A context is needed but only in the sense that it gives meaning to what is being taught.

A compromise between the learning mathematics in real life contexts and the opposite extreme of learning mathematics as a set of decontextualised tools is offered by Silver (1996) in his proposal of learning of mathematics with applications. Here, in this middle ground, it is believed that the ability to apply mathematics is not a natural consequence of knowing a mathematical theory. Instead students are taught the art of application alongside the mathematical theory.

At the level of the individual, Billett (2002) writes that "the capacity to adapt what has been learnt to different situations is a key benchmark of rich learning and a goal to which vocational education aspires" (p. 129). Arguing against ubiquitously promoted generic competences approach to education, Billett (2002) defines competence as the capacity to operate efficiently in a particular domain. He cautions that the broader the generic domain, the less likely it is that it will be useful on any level other than the most general. Instead, he favours a more situated approach to curriculum development.

2.8 Mathematics Anxiety and Affect

Mathematics anxiety plays a crucial role in determining whether transfer of learning between contexts takes place (Evans, 2000; Lave, 1988). Mathematics, as it is taught and learned in schools, takes place in one particular setting and with a specific set of social relationships, whereas everyday practical mathematics occurs in a wide range of complex activities such as playing cards, shopping and work. Thus one's ability to transfer learning to an outside setting successfully, depends upon affective variables such as mathematics confidence and a range of emotions, such as anxiety, associated with the setting.

It is argued by Evans (2000) that emotion is an important aspect in determining whether transfer will occur. This notion is supported by findings from Adda (1986), which showed that whenever a teacher reaches outside of mathematics for an illustration of a mathematical concept, the mathematics is placed 'at risk'. As a case in point, when a teacher uses an example of 'shopping with mummy' the mathematics is "at risk" if mummy is no longer alive or far away. For Evans and Tsatsaroni (1994), this risk potential stems from the fundamental character of language; words have the ability to produce a multitude of meanings.

A wide range of methods have been employed to understand mathematics anxiety and its effect on individual performance. The most frequently used anxiety scales in recent research are: Fennema-Sherman Mathematics Anxiety Scale (MAS), produced within the "gender-inclusive" research programme and The Mathematics Anxiety Rating Scale (MARS) designed for use in Intervention programmes. When comparing the usefulness of the MAS and the MARS:

1. MAS refers only to mathematics in the context of school mathematics in general (courses, classes, problems and tests); MARS refers to a wider range of contexts

2. MARS has 98 items, MAS has 12 items so all things being equal MARS should be more reliable but it is also more time-consuming.
3. MAS has a "symmetrical" five item response scale ranging from strongly agree to strongly disagree, whereas MARS has an "asymmetrical" set of responses (not at all, a little, a fair amount, much, very much). As a result, only the data collected using the MAS can be treated as numerical and hence averaged.

For researchers interested in the transfer of learning mathematics MARS is considered more valuable since it is possible to separate out contexts of learning and doing mathematics which cause most anxiety. It must be conceded, however, that some controversy surrounds the use of both of the MAS and the MARS. For example, Round and Hendel (1980) suggest that the MARS and MAS do not measure the same thing.

As the MAS refers to in-school contexts only and the MARS is very time-consuming to administer, the current research employed the use of an adapted version of Evan's (2000) "Situational Attitude Scale". The "Situational Attitude Scale" reproduces a number of items from Round and Hendel's dimensions of mathematics anxiety, mathematics test/course anxiety and numerical anxiety, as well as a number of items written by Evans. This scale allows the researcher to tap into mathematics anxiety in school and practical contexts in a reliable and valid way. The "Situational Attitude Scale will be discussed further in chapter 3.

2.9 The Role of Context in Mathematics Education

A fundamental goal of mathematics education is the development of competencies needed to solve simple and complex problems which students are likely to encounter in their lives. Students require opportunities to solve problems, the likes of which they have not encountered before. Inclusion of workplace and everyday mathematics in school mathematics curricula does not necessarily mean a reduction in the depth of content covered. On the contrary, contexts give students the opportunity to increase their depth of understanding and raise their level of conceptual understanding.

Traditionally, mathematics as it is taught in schools was divorced from the context in which it developed and unless the teacher had a deep understanding of mathematics, opportunities to make connections with other topics were often lost (Laapan, 1998). Traditional approaches to mathematics education go against more recent theories of mathematical learning which view learning as situated (e.g., Crawford, 1996; van Oers, 1998; Voight, 1994) and contemporary trends in mathematics education which show a shift in interest away from performance towards understanding and thinking. "Learning a mathematical technique is likely to be easier if one can see a real purpose, and if feedback about accuracy is swift and personally relevant" (Ridgway, 2000, p. 196). International recognition of the importance of context in mathematics education can be found in large scale studies such as the more recent PISA which have included context based questions in an attempt to analyse international performance.

School mathematics has the aspect of generalisation as one of its goals. While Masingila and de Silva (2001) acknowledge the need for school mathematics to be generalisable, they question the way in which students are lead to generalised understandings. Without meaningful context, mathematical knowledge is constructed in isolation and is therefore difficult to draw on when appropriate (Masingila, 1993, 1994). It is argued that context alone is not enough; the context must be meaningful to the learner, and this suggests the need for locally specific curricula (Masingila & de Silva, 2001).

2.10 Situated Cognition

Emerging from anthropology, sociology and cognitive science, situated cognition theory is based on the premise that knowledge is contextually situated and is fundamentally influenced by the activity, context, and culture in which it is used (Brown, Collins, & Duguid, 1989). The work of Lave (1988) (with shoppers and Weight Watchers) Carraher, Carraher, and Schliemann (1985) (with Brazilian street sellers) and Nunes et al. (1993) (with Brazilian school children, fishermen, builders and farmers) are just a few of the numerous studies providing examples of learning as a situated phenomenon.

Leaders in the situated cognition movement, Lave and Wenger (1991) describe learning as "an integral part of generative social practice in the lived-in world" (p. 35). Learning is seen as an act of creation, which occurs in partnership with others and in settings that give meaning to the action. Lave and Wenger's (1991) 'novice to expert' conceptualisation of apprenticeships, positions novices at one end of a linear continuum. Experts in the workplace are then seen as training their successors. This notion of novices and experts has been questioned by Fuller and Unwin (2003) in light of recent changes that have occurred in contemporary workplaces since Lave and Wenger's research was conducted. It is speculated by Fuller and Unwin (2003) that Lave and Wenger's conceptualisation of the novice is too simplistic, given that today's young people come to the workplace with a high level of competency in relation to the use of information technology and often have previous part-time work experience.

According to Schell and Black (1997), situated cognition requires that learners are immersed in an environment which is as close as possible to the context in which the learning will be applied. Situated cognition in the classroom would require teachers with a breadth and depth of expert subject knowledge (Schlager, Poirier, & Means, 1996). Moreover, Scardamalia and Bereiter (1990) suggest that teachers would need to be "adventuresome learners" demonstrating the knowledge-acquisition process they aim to foster in their students. Thus, Lave and Wenger's (1991) concept of dynamic communities of practice can be seen as a central component of this theory. Learning involves not merely teacher and students but also experts from the field of interest. Members in such communities are also dynamic in that they assume varying roles at different times; a student may become an instructor when he or she helps another student.

Collins (1988) advocates situated cognition as a theoretical basis for learning, and provides four reasons for its usefulness: (1) the conditions for applying knowledge are taught, (2) by learning in diverse situations students are more likely to be involved in invention and problem-solving, (3) the implication of knowledge is made explicit for students, and (4) by gaining knowledge in context, students are supported in structuring their knowledge in a way that makes it more transferable.

Situated cognition has been argued against, particularly by those how adhere to the notion of information processing. Four central claims of situated cognition are identified by Anderson, Reder, and Simon (1997), (1) action is grounded in concrete situations (2) transfer of knowledge between tasks does not occur (3) training that occurs outside of the context in which it will be applied is of little use and (4) instruction must take place in complex communities. It is asserted by Anderson et al. that these claims do not make sense in light of psychological theories which reject the central tenets upon which situated cognition is based. Responding to this argument Greeno (1997) notes that the four points above are in fact not claims made by situated cognition. From the situated perspective Greeno (1997) states it is more likely that one talks of improved participation rather than transfer of knowledge. Also, Greeno argues, that for learners, the degree of improvement depends on how well they were "attuned to the constraints and affordances" (p. 16) of activity in which the initial learning took place.

2.11 Connectivity – a Theoretical Framework for Conceptualising Mathematics Learning in the Workplace.

Griffiths and Guile (2004) offer a model of work experience that pays greater attention and recognition to workplace (informal) learning. In closing the gaps between formal and informal learning the model is said to assist learners to 'connect' both forms of learning. Griffiths and Guile link their model with Beach's (1999) notion of 'boundary crossing' (transfer) of learning from one context to another.

This model of connectedness is based on four central assumptions: (1) each workplace has its own context and this context needs to be examined in order to identify the kinds of access to learning it provides, (2) learning in the workplace is a purposeful process requiring previously acquired knowledge to be transformed by actions taken in that context, (3) knowledge is expanded by inclusion in a community of practice where problems are resolved together; a co-construction of practices and sensitivity to individual developmental problems is required, and (4) ideally, work experience as a pedagogical approach should provide support for learners to become progressive experts as they use their experience to create new knowledge and more informed practices.

2.12 Workplace Numeracy Research

The role of context in the learning of mathematics has been highlighted by studies in the area of ethnomathematics, situated learning and constructivism. Hence this body of research plays an important role in contributing to the learning and understanding of workplace numeracy. This contribution is important given that workplace numeracy is often described as being hidden or invisible.

New technologies have increased the likelihood of numeracy to be invisible, to the point where it is almost completely hidden from perception (Straesser, 2000). As an example, work by Noss and Hoyles (1996) examined the work of investment bankers and what was described by the bankers' employers as a reluctance to engage in mathematical thinking in relation to transactions. Results from this study revealed that new technology in investment banking contributed to the invisibility of mathematics, and that this presented workers with the challenge of finding ways to make mathematics more visible.

Research on the mathematics knowledge and skills required in the workplace over the last three decades has focused on the "supposed correspondences between lists of school mathematics topics and the required workplace skills" (FitzSimons et al., 2005, p. 11). The Australian Association of Mathematics Teachers (1997) carried out research designed to provide a more informed view of workplace numeracy. This research involved the workplace shadowing of 30 workers by mathematics teachers, for about half a day each. These 'work stories' showed that all of the skills identified as key competencies were involved in complex ways. In completing practical tasks workers drew on a range of skills, attitudes, and knowledge which included: situational knowledge and skills; metacognitive skills and strategies; and personal skills together with attitudes and dispositions toward the workplace. The report summarises the key points in the use of mathematics for practical purposes as:

- Clarifying the outcomes of the task and deciding on what has to be done to achieve them.
- Recognising when and where mathematics could help and then identifying and selecting the mathematical ideas and techniques to be used.
- Applying the mathematical ideas and techniques, and adapting them if necessary to fit the constraints of the situation.
- Making decisions about the level of accuracy required.
- Interpreting the outcome(s) in its context and evaluating the methods used.

(AAMT, 1997, p.59)

The findings above show the skills needed in the workplace are not necessarily found at higher levels within the school curriculum; rather they may be regarded as basic. Yet they are applied in complex ways to ever-changing problems which may not be intrinsically mathematical. Similarly, the investigation of the numeracy practices of chemical handling and spray industries undertaken by FitzSimons et al. (2005) showed that most of the calculations involved mathematical skills initially taught in school. These basic operations involved whole numbers and decimals, ratios, measurement, and estimation. These researchers also reported that previous experience played a significant role in determining the reasonableness of answers calculated by workers.

2.13 Conclusion and statement of research questions

A belief in a skilled workforce as one of the key drivers of economic growth and innovation has informed a number of recent New Zealand government initiatives and strategies aimed at strengthening learning in the workplace. One such strategy, the Education and Training Leaving Age, is premised on the belief that all young people under the age of 19 should be participating in education, training or employment. In order to meet this goal a range of education and training pathways are being put in place. For example, the Gateway programme outlined in chapter one has been designed to help bridge the transition between secondary school to post school education, training and Modern Apprenticeships. Students on the Gateway programme study towards vocational unit standards and qualifications as part of their normal course work. Given the research evidence discussed above, that points to an apparent lack of transfer of school mathematics to other contexts, secondary schools are presented with a new challenge: how can schools best support the numeracy learning needs of students undertaking vocation education and training in schools?

The intersection of numeracy and vocational education and training in secondary school programmes, to date, is under researched internationally:

> Numeracy is now appreciated as a key skill area in VET (Vocational Education and Training), but its conceptual boundaries, cognitive underpinnings, and assessment, require further research. Much of the existing research on numeracy in VET concentrates on professional development needs of curriculum writers, industry trainers and vocational teachers...There is no objective research that examines the literacy and numeracy implications of VET-in-Schools programs....A coherent suite of research projects is needed to document and evaluate the implications of the nature and scope of transition literacies and numeracies required in a diversity of VET-in-School programmes, and special methods of incorporating these explicit competencies in student and staff learning courses (Falk & Millar, 2001, p.5).

Since the field of numeracy in VET-in-school programmes is still at a formative stage the research base is sparse. Therefore, this current research was exploratory in nature. A key purpose was to contribute to the emerging perspective of how secondary schools in New Zealand support the numeracy needs of students undertaking vocational programmes of study. Specifically the research aims to explore the questions:

> What do the out-of-school numeracy practices of young people on the cusp between secondary school and work and/or further education look like?
>
> To what extent does students' 'school maths' align with students' vocational course work and 'out-of-school' numeracy practices?
>
> How do students learn to develop numerical competencies in their vocational workplace experience?
>
> How might schools best support the numeracy learning of students undertaking vocational courses and workplace experience?

Chapter 3

Methodology and Research Design

3.1 Introduction

In qualitative research the researcher is the primary instrument in data collection. While a researcher's background can be useful and positive, according to Locke, Spirduso, and Silverman (1987) it is noteworthy that one of the main obstacles for researchers undertaking research within the workplace is the researcher's own preconceptions. Culture provides us with a means of viewing the world, while at the same time, often on an unconscious level, it can skew the research. It is therefore important that the researcher makes clear to the reader their world view and perspectives on the phenomenon of interest in order to present an holistic interpretation of the findings (Lincoln & Guba, 1985).

The aim of this research was to capture and understand the numeracy practices used by the participants in the workplace and in their everyday life. I was not merely interested in the types of mathematics used by students but also in the role of numeracy in the various settings. I brought to this research the assumption that young people possess significant mathematical skills and knowledge, some of which may have been learned in school and some of which may have been developed in out-of-school settings.

To engage with the issue of students' numeracy practice and to get as close as possible to their practices, a naturalistic approach was required. Studies of the culture of mathematics, according to Barton (1995), fall into two broad categories – those which view the mathematics with a western mathematics lens and those which view the mathematics through the participants' eyes. This research falls into the second category and it is acknowledged here that the difficulty with this approach is that often the participants do not see themselves as mathematising. They may be reluctant or unable to articulate how they carry out the mathematics involved in their work.

3.2 Mathematics as Culture

D'Ambrosio (1985) described mathematics as "the study of the generation, organisation, transmission, dissemination and [the] use of jargons, codes, styles of reasoning, practices, results and methods" used to make mathematical meaning (p. 1184). He challenged the idea of decontextualised, transposable mathematical knowledge, calling for a reformation of mathematics education which recognises the contextualised and cultural practices of mathematics. For him, the mathematics researcher should seek to represent the culture of a community from the perspective of those within that community and should attempt to uncover unique cultural features of local sites - in this case the mathematics embedded within the workplace.

Examinations of how mathematics is used in the workplace have revealed that the types of mathematics developed are much more efficient and effective than the types developed in school-based mathematics. In particular, workers have been shown to use highly contextualised skills, knowledge and processes to solve problems in the workplace (Masingila, 1993; Millroy, 1992; Zevenbergen, 1996). Studies have demonstrated that as a result of their goals and motivations, participants are able to develop their own strategies in order to solve the problems that confront them in their work. Zevenbergen (2000) has argued that by studying novices in the workplace, researchers become attuned to much of the workplace culture and hence the mathematics involved. Studying experts may not be so revealing because experts are so enculturated that they may no longer be able to explain their actions.

3.3 Connectivity – the theoretical framework used for conceptualising the learning of workplace numeracy practices

Griffiths and Guile's (2004) connective model of work experience has been used as a framework for conceptualising the numeracy practices of students in this study. Their model is based on the assumption that learning and development processes are, in Bernstein's (2000) terms, both vertical and horizontal in nature. The socio-cultural approach to learning is highlighted with the practice of work experience being viewed as a collaborative application and development of knowledge, skills and 'boundary crossing'. Connected skills and 'polycontextual' knowledge are seen as the outcomes of work experience. Under this model the role of schools, in programmes such as Gateway, might be seen as developing the relationship with workplaces to create 'environments for learning'.

3.4 The Sample

Much of the sampling used in educational research is non-random sampling (Vogt, 2007). The two most common non-random sampling methods are convenience and purposive sampling; both techniques are employed in this research.

Phase One

Convenience sampling: Students in the Year 12 Practical Mathematics Course at my current college were invited to complete a questionnaire and maths anxiety rating scale. This sample of students was chosen after discussion with my supervisor, the school principal and the Head of Department at the school. Year 12 students are over 16 years of age and this meant that it was deemed unnecessary to gain parental consent for students to participate in phase one of the study. The academic Year 12 course is extremely intensive, so a mutual decision was made not to include this class in the survey as their involvement would have meant the loss of two class periods. Students were very keen to be involved and all 19 students in the Year 12 Practical Mathematics course agreed to take part in phase one of the study. In addition 2 other students not in the Practical Mathematics course asked to join the study. One of these students was a Year 13 student who had taken Year 12 Practical Mathematics the previous year; the other had taken alternative Year 11 mathematics and had chosen not to continue her mathematics education in Year 12.

Convenience sampling, while probably the most widely used sampling in educational research, is the least justifiable (Vogt, 2007). Vogt warns that while there is nothing wrong with using this technique, discussions should be confined to the sample at hand and that generalisation should be avoided or undertaken with extreme caution. While there is no precise way of generalising from a convenience sample to a population, the purpose of the research must be taken into account (McMillan, 2004). The research at hand does not aim to generalise the results of the study; rather it is primarily concerned with gaining a better understanding of the mathematical practices of young people. McMillan poses the question that were there "no probability sampling, should we conclude that the results are not valid or credible?" (McMillan, 2004, p.112). He concludes that dismissing the results is too extreme; "rather it is more reasonable to interpret the results as valid to those studied" and "that as more research is accumulated with different convenience samples, the overall credibility of the results is enhanced" (McMillan, 2004, p. 112).

Phase Two

Purposive sampling: A key concept in qualitative research is the purposeful selection of respondents (Creswell, 1994) who will best enable a research question to be answered. Purposive sampling was used in the selection of four students to be involved in the detailed case studies. These students were chosen because of their involvement in Gateway, their low maths anxiety ratings and their reported use of mathematics in out-of-school contexts. The use of purposive samples, when the researcher takes steps to ensure that the cases studied are as representative as possible in a 'purposive sense', is supported by Shadish, Cook, and Campbell (2002) and Vogt (2007). A single case study would not allow cross-case analysis of results while studying too many cases would risk diluting the 'depth' of the research. The selection of four cases seemed to balance these opposing forces.

Characteristics of the case study student participants

Catherine

Catherine is a 16 year old New Zealand European student. She lives with her mother, father and younger sister. Her mother works part time in administration and her father is a mechanic. Catherine has had ongoing health problems which have caused her to miss a considerable amount of school time in Years 9 and 10. Her health has started to improve recently. Catherine's decision to become a vet nurse stems from her love of animals. She owns two cats and in the future would like to own a dog.

Catherine is a Year 12 student studying towards NCEA level two. Her school subjects are English, history, biology, religious education (all at level two) and Gateway. Catherine's Gateway programme includes working in a veterinary clinic one day a week and completing unit standards towards the Otago Polytechnic Rural Animals Technicians Certificate and Agchallenge for Veterinary Nursing Certificate. Level two and three unit standard credits gained from these courses contribute towards her NCEA level two certificate. Catherine intends to return to school next year and complete the current qualifications she is working towards as part of her involvement in Gateway. She then intends to either study full time towards a vet nursing qualification or get a job as a vet nurse and study via correspondence for a Certificate in Veterinary Nursing.

James

James is a 16 year old Maori student. He lives with his mother, father and younger sister. He also has an older brother who has left home this year after starting work the previous year. James's mother does not work in paid employment. His father is on a sickness benefit and does some part time work as a caretaker at their church when his health allows.

James presents as a happy, easy going 16 year old. He is interested in becoming a builder because he enjoys practical work. His Year 12 courses are food technology, practical mathematics, materials technology, religious studies and Gateway. James's Gateway programme involves his working one day a week on a building site, as well as studying towards a National Certificate in Carpentry. James already has NCEA level one and is currently studying towards level two.

Tracey

Tracey is a 17 year old New Zealand European student. She lives on a farm with her mother and father. She has an older brother who has left home. Tracey's mother works full time as a receptionist at a local real estate office and her father is a dairy farmer. Tracey owns several dogs and a horse. She has lived and worked on farms all her life. She says this experience has given her a passion for working with animals. The practice manager at Tracey's Gateway workplace commented on Tracey's "fantastic" compassion and commitment towards animals.

Tracey is a Year 13 student who has completed NCEA level 2. She is currently working towards completing NCEA level 3. Her school subjects are Year 13 biology, information management, graphics, religious studies and she is also taking Agchallenge for Veterinary Nursing Certificate as part of the Gateway programme. This is Tracey's second year in the Gateway programme and she has chosen to continue working at the same veterinary clinic.

Zane

Zane is a 16 year Maori student. He lives with his mother and two younger sisters. Zane's mother works full time at a local retail shop. Zane commented that his mother works hard, taking on as many extra shifts as she can. Zane's father is associated with a local gang and his involvement in Zane's life is intermittent. Zane is also a father himself. His girlfriend became pregnant at the start of Year 10 and had a baby girl in December of that year. Zane's daughter is being brought up by his now ex-girlfriend's aunty.

Zane communicated a strong desire to become a builder. He remarked that his mother has encouraged him to do so in the hope that he will be able to own his own home. Zane did not think that any of his extended family had owned a house. Zane's Year 12 courses are graphics, practical mathematics, materials technology, religious studies and Gateway. Zane's Gateway programme involves his working one day a week on a building site, as well as studying towards a National Certificate in Carpentry.

Research Setting

This research was set in a small rural co-educational Year 7-13 decile 5 school. The student composition of the school is:

Boys 52%
Girls 48%

New Zealand/ European	80%
Maori	10%
Other ethnic groups	10%

Catherine's Gateway workplace – Veterinary Clinic

The clinic has three full time veterinarians, two full time office staff and three veterinary nurses (one full time and two part-time). The clinic provides small and large animal care in a rural setting. The workplace observations took place before the clinic's busiest time of the year in spring when the vets and vet nurses are out of the clinic due to their involvement in calvings and lambings. This timing was chosen so that observations would occur within the clinic setting thus avoiding the need to gain consent from farmers for observing Catherine at work. Catherine worked at the clinic every Friday for the full school year as part of her involvement in the Gateway programme. Catherine was workshadowed on three separate mornings between 9 am and 12pm to ensure that Catherine was observed carrying out a variety of tasks.

Tracey's Gateway workplace – Veterinary Clinic

The clinic has a full-time and a part-time veterinarian, a full-time office manager and a full-time veterinary nurse. The clinic provides small animal care in a large rural town. Tracey worked at the clinic every Thursday as part of her involvement in the Gateway programme. Workplace observations took place over three Friday mornings from 9am to 12pm to ensure that Tracey was observed carrying out a variety of tasks.

Zane and James's Gateway workplace – Building Company

The building company employs four builders and currently has 1 apprentice. The majority of the houses built by the company are kitset homes. Workplace observations took place over four Friday mornings from 9am to 12pm to ensure that Zane and James were observed carrying out a variety of tasks.

3.5 Data Collection Methods

PHASE ONE

One of the challenges facing researchers who employ the use of case study is the need to identify their case or cases among a host of possible candidates. Phase one of the study addresses the issue of who to study.

The Questionnaire

The questionnaire (see Appendix C) used in this research was designed to identify students who would meet selection criteria for the case study research in phase two. Key selection criteria included students who attained low mathematical anxiety rating scores, reported using mathematics outside of the classroom and were involved in some form of work outside of school.

The questionnaire was trialled on a group of four Year 11 students to ensure that questions were clear and that they would elicit the information required. Only small adaptations were required after this stage. The questionnaire was then administered by the researcher during a Practical Mathematics class lesson. Students were invited to participate in the study a week prior to its administration and were asked to discuss their participation in the study with their parents. Student Information Sheets and Consent Forms were issued at this stage. All nineteen students in the class chose to participate in the study. Before the questionnaire was administered the students where reassured that their responses would not affect their treatment at the college, that their responses would be treated in confidence and that they could remain anonymous and withdraw from the study at any stage. The researcher remained in the classroom while participants completed the survey so that any questions arising from the questionnaire could be addressed at the time.

The Maths Anxiety Rating Scale

A quantitative mathematics anxiety rating scale (see Appendix D) was employed because a review of literature relating to transfer of learning revealed that mathematics anxiety may play a vital role in determining whether transfer takes place (Evans, 2000). A slightly adapted form of the Situational Attitude Scale (SAS) used by Evans (2000) in his study of adults' mathematical thinking and emotions was used in this study. This scale has been designed to tap into "maths anxiety in school and college contexts and in practical contexts in a valid and reliable way" (Evans, 2000, p. 243). It was necessary to adapt some questions to suit local conditions. Item 24, for example, on Evans' scale asked participants how comfortable would you be "Figuring out VAT at 15% a purchase which costs more than one pound." This was changed to "How comfortable would you be calculating the GST on an item that costs more than $10." The SAS uses a symmetrical seven-point scale so that results can be analysed statistically. No advanced statistical analysis was undertaken in the current study as the purpose of administering the SAS was to identify students with low anxiety ratings.

PHASE TWO

Case study

Case study has its roots in hermeneutics. As was intended in the current research it may involve the ability to understand phenomena from somebody else's point of view. Descriptive case study methodology, using multiple strategies to gather data, was employed to create a richer picture of students' experiences than might have been possible with a single method. Descriptive case study is useful in presenting information about educational areas where little research has been conducted - in this case, the workplace numeracy practices of young New Zealanders. Here the intent was to produce findings for future comparison and theory building.

The strengths of a particular research design are intrinsically linked to the research problem at hand. One of the foci in this research is the transfer of learning which is a complex issue involving many variables of potential significance. In such instances the use of multiple cases has been well supported (Bourma, 2001; Thomas, 1998; Stake, 1995) as it allows cross-case analysis, thereby improving "the level of confidence that can be placed in conclusions drawn about such phenomena" (Thomas, 1998, p 82). Case study research provides "an intensive, holistic description and analysis of a single instance, phenomenon, or social unit" (Merriam, 1988, p. 21). Here it is speculated that the particularistic nature of this case study may help 'illuminate' the research problem in general by examining specific instances in detail.

As soon as people are involved, assumptions, beliefs and opinions influence how the world is viewed and as such, all social research is bound in the confines of context and bias (Melrose, 1996). However Dillion, O'Brien, and Heilman (2000) state that a variety of research approaches are needed to gain insight into the complexity of learners. While quantitative research, makes valuable contributions to the generalities of understanding education, qualitative research is valuable because if looks at real people in real life contexts.

Workplace shadowing

Teachers have shadowed people in the workplace previously in order to identify numeracy practices. The objective in these studies has been to forge links between school mathematics and workplace practices (Hogan & Morony, 2000). However, this approach has tended to legitimise current school curriculum. It is argued that such interpretations occur because the researcher interprets the work through a mathematical lens rather than allowing the participant to interpret his or her own activity (Dowling, 1998; Skovsmore, 2001; Zevenbergen & Zevenbergen, 2005).

Acknowledging this limitation, Zevenbergen and Zevenbergen (2003) recommend the use of stimulated recall as a means of data collection. This technique could involve taking still photographs of the participant at work and using the photographs "as a catalyst for discussion and reflection on action" (Zevenbergen & Zevenbergen, 2003, p. 6). In this study, photographs taken during workplace shadowing were used for free discussion so as not to pre-empt any event (Zevenbergen & Zevenbergen, 2003). Participants were asked to talk about their work in their own terms, whilst being aware of the focus of the study. The researcher acknowledges that at times it took some effort to suspend judgment of what was being said.

Methodological Detail

Using a case study approach four participants were selected to take part in workplace observations. A pre-observation interview was carried out to illuminate work routines, attitudes to work and how the participants felt about school mathematics. Participants were shadowed in a non-intrusive manner so that they could complete their routine work. In all cases it was deemed important that participants were observed completing a variety of activities, and so observations took place over three to four mornings. Workplace visits included taking photographs and making notes on interactions with other employees. Resources used were also noted.

The aim was to find out as much as possible about how the students were using mathematical thinking. Over a period of time I began to *look for* rather than *look at* mathematicisable events. After completion of the workshadowing participants were asked to look at the photographs of themselves at work and discuss what they were doing and thinking at that time and they were asked if there was any aspect of their work that had not been photographed. They were also asked about how well they thought school had prepared them for the workplace numeracy demands they met. All interviews were audio taped and transcribed. The researcher then had a final interview with the participants to ensure that interviews had been reported objectively.

Employers, co-workers and tutors of the vocational courses participants were enrolled in were also interviewed about the level and types of mathematics that they expected future employees would need. Course work from the vocational qualifications in building and vet nursing that the participants were completing was examined to identify the mathematics being taught. In addition I examined the next level course material that the case study participants would be moving on to if they continued on with this path. This was undertaken in order to gain a better understanding of what mathematics would be needed to support the participants' future studies.

Numeracy Kit Interviews

An interview technique similar to the one developed by Johnston et al. (1997) in their study of young unemployed people's everyday use of mathematics was used in this current research. This involved interviewing students using an 'everyday numeracy kit' to uncover the ways in which they used mathematics in their daily lives. This added to an overall view of how participants were using mathematics outside of the school environment. The 'everyday numeracy kit' used here included the following items:

- Cell phone boost voucher used to top-up cell phone accounts
- A supermarket docket
- A supermarket fuel discount docket
- A cell phone
- A cookbook
- An ATM receipt
- A simple calculator

- An analogue waist watch
- A digital alarm clock
- Income Tax Return form
- An instant kiwi ticket
- A mailer outlining a local boarding kennel's charges.
- A retractable 20m tape measure

Students were asked to look at the items in the kit and discuss their use of the items and any mathematics that they felt was associated with their use of the items. They were also asked to complete two tasks – the measurement of a table in the interview and the completion of a calculation (see Appendix C).

3.6 Data Analysis

In analysing the data I chose to allow themes to emerge naturally rather than attempting to impose a set of preconceived themes on the data. This approach enabled the holistic and meaningful characteristics of the real life events described to remain intact.

3.7 Ethical Concerns and Considerations

Ethical considerations within qualitative studies are extremely important (Lock et al., 1987). Researchers working in this paradigm have become increasingly aware of the potential influence of preconceived ideas and have expended considerable effort developing safeguards to ensure the integrity of the research (Kirk & Miller, 1986; Lincoln & Guba, 1986). It is crucial that the rights and values of the participants is respected.

This research was granted full ethical approval by the Massey University Human Ethics Committee (MUHEC). Approval to carry out the research was also gained from the College's principal and Board of Trustees. A letter outlining the aims and scope of the research and involvement of participants was given to the students involved. This letter of introduction informed participants that their involvement in the study was entirely voluntary and that they may withdraw from the study at any stage. Assurance was given as to the confidentiality of data collected and anonymity of participants in the final report. Because of their age potential participants were asked to discuss their involvement in the study with their parents or caregivers. The parents of participants chosen to be involved in the case studies were approached directly to gain consent for their child to be involved in the study as this involvement required more time commitment than merely completing initial questionnaires. At all times only the researcher and the supervisor had access to the questionnaires, photos and interview transcripts.

3.8 Validity and Reliability

Validity and reliability are major concerns in any research. This section deals with internal validity, - how well the results line up with reality, and external validity, - the extent to which findings can be generalised, and reliability; the degree of consistency in results.

Internal validity

"Reality is what we chose not to question at the moment" (Becker, 1993).
Internal validity is concerned with whether findings are congruent with reality. Reality is described by Merriam (1998), as an holistic, multidimensional and ever-changing phenomenon, rather than a single fixed entity waiting to be discovered.

Five strategies where employed to enhance internal validity (Merriam, 1998):

1. Triangulation – data in this study were collected from a survey questionnaire, maths anxiety rating scale and multiple observations of participants at work, as well as interviews with

employers and teachers. Triangulation may produce inconsistencies which rather than detracting from the validity of the research could be seen to add to the holistic understanding of the phenomena being studied.

2. Member checks – data from interviews and provisional interpretations were given back to case study participants for checking.

3. Repeated observation – case studies where shadowed at work over at least three different mornings in order to increase the validity of the findings.

4. Peer examination – my supervisor and Head of Department were asked for feedback about results and interpretations of findings.

5. Researcher bias – the researcher has discussed her worldview and theoretical orientation throughout this research.

Reliability

Reliability is concerned with the extent to which results of research can be replicated. This is particularly problematic for education researchers because "human behaviour is never static" (Merriam, 1998, p. 205). Reliability in the traditional sense does not align well with qualitative research. Instead Lincoln and Guba (1985) suggest the use of the concepts of dependability and consistency. Reliability, then, is not a question of whether results can be repeated, but whether results are consistent with the data.

Techniques to improve the dependability of the findings included the researcher stating her assumptions and position in relation to the group under investigation, triangulation of data and inclusion of an audit trail, a detailed description of data collection, researcher decisions, and so forth. All of these techniques have been employed in this study.

External Validity

External validity is concerned with how generalisable the findings of the research are to other situations. Here Stake's (1995) re-conceptualisation of generalisability as naturalistic generalisation and Firestone's (1993) case-to-case transfer are more applicable to the qualitative nature of the research undertaken. Naturalistic generalisation relies upon having a detailed knowledge of a particular case and using this knowledge to see similarities in other contexts. Firestone's (1993) idea of case-to-case transfer where it is up to the reader to decide whether the findings are relevant to their situation, is also applicable.

The onus is on the researcher to provide the reader with sufficient detail to ensure that the reader can decide whether the findings can be transferred to their particular situation. Purposeful sampling where several case studies are chosen to maximise diversity in the phenomenon of interest, as was employed here, also helps enhance the external validity of the research findings.

3.9 Limitations of the Study

Limitations of the methodology employed

Case study methodology is not without its limits. One of the weaknesses of case study methodology is that it is limited by the "sensitivity and integrity of the researcher" (Merriam, 1998, p. 42). Case study researchers are presented with increased ethical problems because of the vast amounts of data they collect which could virtually be used to illustrate any point they like (Lincoln & Guba, 1981). Thus there is a risk that the researcher's own motives and values may contaminate the reports findings (Burns, 1997).

While much educational research seeks to generalise and contribute to educational theory, Bassey (1981) points out that:

> the merit of a case study is the extent to which the details are sufficiently appropriate for a teacher working in a similar situation to relate his decision making to that described in the case study. The reliability of a case study is more important than its generalisability. (p. 9)

It is acknowledged that it is not possible to generalise broadly from case study data. However, it could be argued that the fact that some students have used mathematics in a particular way means that it is possible that other students may also use mathematics in similar ways.

Other challenges facing case study researchers include getting enough information at sufficent depth. This issue was addressed by limiting the number of cases studied to four, collecting data from a number of different sources (student workplace observations, tutors/teachers, employers, course work) and by reflecting on the data collected and then going back to participants to gain further insight and to check my interpretation of events.

Data collection and analysis were time consuming. Results from qualitative research are more easily influenced by researcher's personal views and idiosyncrasies. However the detailed data situated and embedded in local contexts and collected in naturalistic settings, does provide the reader with the opportunity to decide whether the results are relevant to them in their set of circumstances.

Limitations of the sample

One of the primary limitations of this study stems from the decision to limit the cases studied to four students from the same college. It is acknowledged that the experience of students in lower or higher decile schools may be different. Also due to the small number of the case studies undertaken in this research only two different jobs, nursing and building, were investigated. It is likely that students undertaking workplace experience in other fields will have different experiences. However the four students in this study form part of an important cohort. This importance is tied to the fact that this particular year group of students at this school have experienced a number of new educational reforms and initiatives:

- They started school in 1996, the year that *Mathematics in the New Zealand Curriculum* was fully implemented in secondary schools.
- They form part of the first group of students to complete their schooling having been involved in the Numeracy Project for four years.
- The case study participants were involved in the Designing Careers pilot study in 2005.
- They entered Year 9 in 2004, 2 years after the introduction of NCEA, so their learning opportunities in secondary school have been influenced by performance based assessment.

All of these factors come together to make this small sample of particular interest.

CHAPTER 4

The Results

Introduction

A close examination of the broader social activities in which mathematical activities occur can generate an understanding of why particular responses occur and why particular strategies are used. It can also provide teachers with a rich source of authentic mathematical material to use as a starting point in curriculum development. It is intended that data in this chapter will allow the reader to see how the student participants made sense of their out-of-school numeracy practices.

This research was qualitative in nature and generated a large amount of valuable data. Given the constraints of presenting this data within a Masters thesis, the results are presented in the form of excerpts. These excerpts have been selected to demonstrate the variety and complexity of the mathematical responses, and to illustrate the different ways that the young people invented or appropriated mathematical procedures to solve their everyday and workplace problems. The results are presented in two sections: Section A reports data produced from interviews with student participants using a kit containing everyday items, and Section B reports data collected from workplace observations, post-workshadowing interviews with students and interviews with employers and teachers. Data in Section A have been organised by themes which were allowed to emerge naturally. Data in Section B have been divided into two sub-sections based on vocation: (i) veterinary nursing data and (ii) building data.

Section A

Data from Interviews Using the Kit Containing Everyday Items

(1) Money Management

In the following excerpts a range of activities – spending money (shopping, socialising and budgeting), earning money and being "ripped off" in relation to dealing with money, are discussed. In some instances the students drew extensively on their formalised mathematical skills and knowledge, while on other occasions more social, less mathematical strategies were adopted. Data presented also demonstrate how the level of interest and enjoyment impacted on the degree of mathematisation used in different contexts.

> Catherine's parents are on a tight budget as they are renovating the family home. As Catherine has had ongoing health problems she does not work part-time as many of her friends do. Instead, her parents give her a weekly allowance of $20. From this allowance Catherine pays for items such as clothing and movie tickets. School related expenses are paid for by her parents. Catherine reported that her parents valued her getting a good education.

Catherine's approach to managing money is highly representative of the mathematised approach adopted by the students in this study. She mathematised most of her dealings with money and showed obvious enjoyment in doing so. For her, there was a heightened sense of control gained through careful budgeting of her allowance.

Catherine reported regularly going with her mother to do the weekly grocery shopping. She stated that her mother encouraged her to come so that "mum can teach me about getting good food and sticking to a budget, cos there's lot of... um... temptations to spend more money than you've got at the supermarket." $200 per week is budgeted for their family of four. Pac'n'Save's 'Shop and Go' was used because it "speeds up the shop and lets you know how much you've spent so far. Like I know that if we get all the meat and fruit and veggies in the first part of the shop for less than about $70, the rest of the shop should easily be under $200." There was both a sense of enjoyment and a sense of control gained in this situation.

When it came to social activities that involved money, Catherine's approach fluctuated between being highly mathematised in some incidences and more socialised in others.

When talking about going out to the movies with a group of friends in the weekend Catherine commented that a lot of her friends "waste the money they earn on food and stuff and they don't even have anything to show for it." Catherine took pride in the fact that through careful calculations and budgeting she had managed to buy her own cell phone. "I looked around for a while, you know, and talked to friends and stuff before I decided which phone I wanted. Then I went home and worked out how much I would have to save every week - how long it would take me to get the money. So I worked out when I'd get it."

> This example epitomised her highly mathematised approach. However, Catherine described another incident when she and a group of friends were getting a takeaway meal "because only three of us had any money and it was cheaper to get a 'meal deal' we all just put in the money we had, we didn't work out how much each person should pay. Well we couldn't, not everyone had money. So we just put our money together. I suppose over time it all works itself out, you know, with friends. But there are some, you know, friends who never want to pay for anything and that just makes you mad."

Tracey's approach to managing money was quite different to Catherine's. While Catherine had little control over the amount of her allowance, Tracey was able to increase the amount of money she earned by taking on extra work.

> "If I want more money I just pick up extra work. Like I'll work on one of dad's mate's farms. Sometimes I'll work for dad. The money's usually pretty good and they pay you straight away." Tracey's ability to access extra money through extra work is reflected in her more laid back approach to budgeting. "When you're out with your mates you don't think about money, you're just having a good time." Tracey explained that her friends take turns paying for food and drink saying "I really hate it when people start wanting to work out how much everyone should pay. It just takes the fun out of it. I've got one friend who's really tight with money and it gets to you after awhile. I don't go out with her much. It's just too annoying."

Tracey's demonstrated a more mathematised approach to managing money in describing how she saved for approximately two years to purchase a car. However, unlike Catherine's carefully calculated approach, Tracey's approach to saving money was more *ad hoc*.

> One of the ways in which Tracey earned money for the purchase of her car involved "fattening" ten weaned lambs. "I got them for $10 each and I sold them for $85. It was easy money, they just take care of themselves and fattening them up didn't cost anything. But dad did say that they're eating good cow grass." When I asked Tracey how much money she made from this venture she said she could not recall and made no attempt to calculate the amount.

However, Tracey did draw on knowledge gained in her Year 12 Practical Mathematics class when purchasing her car.

> "The unit standard we did in maths last year helped. If I'd got a loan instead of saving up the money it would have cost heaps more in the long run, especially if you, you know, got the money from the car dealer or whatever."

The unit standard (7127 Exercise informed choice in deciding on a major goods or service purchase) referred to by Tracey requires the demonstration of knowledge and skills within an actual or simulated context. It is speculated that this approach to assessment may have led to Tracey developing more flexible knowledge and skills which she was then able to apply when purchasing a car in real life.

In talking about money Zane makes a clear distinction between his own inclination to operationalise his mathematical knowledge and skills and his two friends lack of inclination to do so. In the excerpt below Zane describes an incident in which two of friends were 'ripped off'.

> Zane described how two of his friends had been 'conned' into getting free phones by signing up to an expensive call plan: "They didn't even think about it - how much it was going to cost them. They just wanted a free phone. The sales guy didn't tell them they would have to fork out every month and for two years. He wouldn't have conned me, I'm too smart for that..." Here Zane makes the distinction between his ability to think mathematically 'on his feet' in contrast to his two friends who had been taken in by the appeal of getting a 'free phone'.

Zane's experiences like the one described above may have contributed to his suspicions that his employer was deliberating not paying him for extra shifts that he worked.

> "I always work out how much pay I should be getting and I check my balance. You have to watch them, cos if you work an extra shift or something, they'll try not to pay you for it. But they never over pay you, do they?!" Zane vigilantly kept a record of the hours he worked in his part-time job by entering it on his cell phone and calculated the amount of pay he should receive by multiplying the hours worked by his hourly rate of pay after tax.

This detailed and mathematised approach is in contrast to the way Zane actually spent his income.

"I usually take out half my pay on Friday. I know how much I get because I always work it out - like if I earned $75 dollars I get $40 out. You can't get exactly half from the money machine - just about half." Zane reported that he spent the money "food and drink - stuff in the weekend" and that he did not keep track of what he spent his money on. When it came to saving Zane said "I only get money out on Friday, so if I run out I bludge off mates...[laughs]...you know, for food at the tuck shop or whatever."

Discussion with the participants in relation to the earning of money through part-time work raised issues involving the motivation to learn and apply mathematical skills in their part-time employment.

Zane's intention to become a builder meant that he saw his part-time job at a local supermarket as a temporary means to earning money. He was not very motivated to learn new knowledge or skills related to this work – "it's not like I'm going to be working forever...next year I'll be building." This apparent level of motivation towards learning in his part-time job was much lower than that demonstrated by Zane in his approach to learning in his vocational studies.

James did not have a part-time job because he could not be "bothered." His parents paid for the things he needed but he was not given a regular allowance like Catherine. Instead James did odd jobs around the house like mowing the lawns for which he received $5.

"Mum won't just let me mow the lawns whenever - they have to need it. I get $5 and mum puts in one of those plastic money bags you get from the bank." James described how his mother got him to sign in a notebook every time money was either put into or taken out of the bag so that there were "no arguments" over the amount of money that should be in the bag. James reported that he wasn't sure how much money he had at the moment "probably about $45 - not enough for the phone!" James estimated that it would take him another 3 or 4 months to save up enough money to purchase the cell phone he desired. Further questioning revealed that this was just a guess and was not based on any form of calculation.

James's approaches to managing money were the least mathematised of the four students studied. It is speculated here that this may be for one of two reasons: James may not place much value on material things, making money less important to him, or James's proficiency at carrying out mental arithmetic may have been poor, limiting his ability to mathematise in relation to money.

(2) Cell phones- a new medium for numeracy practices

The student participants described a variety of numeracy related uses for their cell phones across a number of different settings. These uses included:

A clock
An alarm clock
A diary to record appointments and remind themselves of important dates such as birthdays
A place to record hours worked (see Zane's account in the above section on money management)
A calculator

It is noteworthy that all four of these students were observed to use the calculator function on the cell phone in preference to the simple four function calculator that was in the kit. A possible reason for this became apparent in further discussion with the students. They described how they were rarely without their cell phones, even during school time, notwithstanding that this was against school rules. Zane's comment below epitomised this point:

> "You always have your phone on you - at school everyone does. You use it all the time. Not just texting, like reminding yourself about stuff. Mum was really surprised cos I remembered her birthday. But I only remembered cos of my phone."

The ubiquitous nature of cell phones in the participants' lives may have been instrumental in their developing new ways of mathematising old problems. Some possible pedagogical implications of this aptitude for the use of technology in relation to numeracy will be discussed in chapter five.

(3) The "Lady Mead" problem

A local boarding kennel's mailer, including their fees schedule (see Appendix E) was used as a resource in the following question:

> How would you calculate out how much it cost to have a medium sized dog stay at the kennels from December 24 to December 28?

The purpose of this question was two-fold. First, this question was deliberately designed to stretch these students' number skills as it was set at a level equivalent to an excellent level NCEA level 1 Number achievement standard problem. Second, it was included to observe how the students coped with the extra demand of the numerical information being embedded in the text and tables of the resource.

> Catherine's careful approach to handling money, as previously described, was also evident in her approach to solving this problem. Catherine was the only student to completely read the mailer. She used a pen and paper for working. However, she calculated the accommodation charges based on the incorrect assumption that accommodation would be charged by the number of days, not the number of nights stayed. Catherine correctly calculated the additional charges related to December 25 and 26 being public holidays, and she was also the only student to pick that the kennel stated that its charges would be increasing from September 1. The only error that occurred in her calculation was due to the incorrect assumption about how accommodation is charged. Catherine commented that she was good at problems involving money and her pleasure in solving the problem at hand was evident "It's natural, you know, you've always done it. It's just natural." It is noteworthy that Catherine was able to fluently read aloud the information contained in the mailer. Therefore it is likely that this problem did not pose a great demand on her literacy skills, making it possible for her to concentrate on the numerical aspects involved in solving the problem.

Tracey's approach to this problem seemed more hesitant and almost defensive:

> When presented with this problem Tracey sat back in her chair and folded her arms. She then picked up the resource sheet and correctly identified the charge per night for a medium sized dog.

> Then she used the cell phone in the kit to calculate 4 x $12 getting the correct answer of $48. When asked whether there were any additional charges she shrugged her shoulders saying "I wouldn't have this problem in real life. Dad looks after my dogs if I'm not there. Anyway if I wanted to know I would just ring up the kennels and they'd tell you."

While avoiding the need for Tracey to operationalise her mathematical knowledge and skills, her strategy of phoning the kennel is undeniably valid. Such strategies should, perhaps, not be quickly dismissed by teachers wanting to help their students meet the numeracy demands they might face beyond school.

The following account shows how, with some scaffolding, Zane was able to solve this problem.

> Zane used the calculator on the cell phone to add $12 together four times saying to himself "25, 26, 27, 28... um I think..., is it $48?" It was then pointed out to him that there where additional charges. He looked at the resource sheet again and asked what a public holiday was. This was explained to him. He then correctly added an extra $6 to the $48 by counting on, on his fingers. It was hinted to him that he was not finished yet as December comes after September. Zane then spotted the charge increase from September 1 and was able to correctly calculate the full cost of $71.

Catherine's approach of reading through the resource completely first before attempting any calculation contrasted to the *ad hoc* interaction Zane had with the written text. A possible explanation for Zane's apparently 'piece-wise' interaction with the resource text is that Zane spends a lot time on the computer and playing video games. The literacy skills needed in such contexts are rather different to the literacy skills required in solving the problem at hand.

When faced with the 'Lady Mead' problem James was able to locate the correct charge of $12 per night though he was not able to move beyond this point.

> "Um...I don't know what to do next." When asked if there was another way to solve the problem apart from calculating a solution himself, James replied "um...nah, not that I can think of... guess?... maybe."

This excerpt reiterates the point that arose in the excerpt of Tracey's response to this question. Mathematics education should arm students with a range of valid strategies for solving problems.

(4) Measurement

The student participants were asked to measure a table in the interview. This task was intended to provide data about how these students coped with a practical task. However, as the excerpt below demonstrates, the data collected from this task shed light on why some students have difficulty ordering decimals.

> Catherine, Tracey and James all correctly measured the length of the table at 1.35m. However, they read this measurement as one point thirty five rather than one point three five. Further discussion with these participants revealed that these students had difficulty in correctly ordering decimals. In discussion with Tracey, for example, it become clear that reading the decimal as one point thirty five lead her to believe that one point nine must be smaller than one point three five because nine is less than 35.

This observation lead to the speculation that moving from a practical task, such as measuring objects of different lengths, to an abstract mathematical concept, the skill of ordering of decimals may improve understanding and retention. This notion will be built on further in the pedagogical implications of this study in chapter five.

(5) Practical tasks and transfer of learning

The excerpts below illustrate some possible mechanisms that aid transfer of mathematics knowledge and skills across settings:

> Zane measured the table as "1350mm or 135cm or 1.35m." Zane stated that he had learned to convert between units as a result of completing work in the building calculations unit standard taken as part of his Gateway course work. When asked what he thought had facilitated this transfer of knowledge, Zane replied "When I was learning it, it was in my mind. 'I'll use it when I'm a builder'. So I wanted to really get it."

Here, transfer of mathematical knowledge learned from a course book in a classroom setting, to the practical task of measuring, may have been facilitated by three mechanisms: (1) Zane was aware of how this knowledge would be useful to him, (2) Zane was motivated to fully understand the work because he saw it as having relevance to him and (3) the transfer was "near"; that is the relationship between the context in the course work and the practical task of measuring the desk were closely linked.

The measuring cup in the kit stimulated conversations with both Tracey and Catherine about their knowledge of measurement as developed through their veterinary nursing work experience:

Tracey recalled "Before I started working at the clinic I didn't know what 10mL looked like. But, I can get pretty close just guessing. You get a feeling for it." Tracey also described how this "feeling" for volume had been useful to her outside of her work at the clinic. She had needed to drench some lambs as part of her farm work. As the drench gun was not operating properly, Tracey had had to estimate the amount to give the lambs based on the dose rate written on the drench pack.

Catherine recounted an occasion when her vocational knowledge of volume had been of use to her in baking a cake from a packet recipe requiring 80mL of oil. "I worked out about how much 80mL would be by imaging how big a 20mL syringe is. I added four times that amount to the recipe. It must have been close because the cake turned out O.K."

It is speculated that mathematical knowledge acquired through practical tasks may be flexible enough to facilitate transfer to other practical contexts.

(6) Lottery tickets and probability

An 'instant kiwi' lottery ticket was included in the kit to shed light on students understanding of probability within the bounds of a familiar everyday context. When asked about ways to increase the chances of winning a prize from lottery tickets the students in this study did not draw concepts related to probability taught in school mathematics. Rather the chances of winning were linked to personal beliefs:

> Tracey responded that "buying more tickets isn't going to make you win. You're either meant to or you're not." For Catherine this question evoked the belief that "The way to get rich is to work hard." While for Zane the lottery ticket was associated with an addiction to gambling "She was addicted to them. She wasted heaps on them - never won much either."

It is speculated that an attempt to teach this particular group of students probability in the context of lottery tickets may not be very successful because of the personal beliefs held by the students.

(7) Invisible mathematics - Using a local street map

The student participants were asked to use the index on a local map to locate a street. All four of the students were able to complete this task quickly and easily. Two of the students queried whether this task involved the use of mathematics:

> Zane's immediate response to the task was "Ah? That's not maths, its geography!" Catherine commented "Is that maths? I learned how to do that in social studies."

When it was pointed out that using the map involved co-ordinate geometry both Catherine and Zane agreed that they had worked on similar problems in mathematics. Catherine's comment below is particularly pertinent:

> "We only did it in the textbook in maths. In social studies we used a real map."

It is speculated that Catherine might have been able to make connections between co-ordinate geometry in mathematics, geography and map reading if she had used "real maps" in her mathematics class.

(8) No solution! No problem

At the conclusion of the interview student participants were asked if they had encountered in their everyday lives a situation in which they had not been able to cope with the mathematics involved:

> James reported "I don't use maths much, so, um, I don't think so."
>
> Catherine's response to this question was "Not out of school. Only in school." Catherine's response here may have been related to on going health issues in Years 9 and 10 causing her to "fall behind" in mathematics. As a result of this Catherine and her parents requested that she be moved from the top Year 11 mathematics class to the alternative Year 11 mathematics class last year
>
> Tracey's response to this question was "Um, no never." It is possible that Tracey's response here may be linked to her earlier response to the 'Lady Mead' problem – Tracey appeared to call on a number of valid strategies for solving mathematical problems in her everyday life, many of which did not require her to operationalise her own mathematical capabilities.
>
> Zane recalled having to file a tax return this year as he had turned 16. (Up until this age the Inland Revenue Department automatically calculates and refunds any overpayment of tax. It is noteworthy that the researcher was not aware of this fact and this reiterates a point

about mutual learning that was raised in the introduction of this study. Zane coped with this demand by seeking help from his Year 12 practical mathematics teacher. The teacher then incorporated the filing of tax returns into the course by including a life skills unit standard on filling in forms. Zane commented that he was able to help his mother file her tax return. His pride in being able to do so was evident.

The responses of Catherine, Tracey and James to this question will be examined in more detail in chapter 5.

Section B
Work Shadowing Observations

Part 1: Veterinary Nursing

As part of their Gateway programmes Catherine and Tracey undertook work experience one day a week in a veterinary clinic. This workplace learning experience is supported in school by students undertaking vocational course work. Both Catherine and Tracey undertook vocational unit standards which contributed to the Otago Polytechnic Rural Animals Technicians Certificate, Agchallenge for Veterinary Nursing Certificate and NCEA at level 2 and 3.

The vet nursing job description

Regular duties performed by Catherine and Tracey in their respective clinics included assisting veterinarians during consultations and surgery, serving customers, dispensing drugs and general cleaning.

Data presented in this Section have been categorised according to themes that arose naturally from the data, as opposed to categorising data according to predetermined themes.

(1) Inventing strategies to meet workplace numeracy demands

Both Catherine and Tracey were observed drawing up and administering drugs to animals at the request of a veterinarian. This task is routinely carried out by veterinary nurses. The excerpt below comes from observations of Catherine. It illustrates her development of number sense in relation to small quantities:

> Catherine explained that when she first started working at the clinic she often did not know which size syringe to use. With time she has become familiar with the quantities used and has developed her own rule for dealing with such problems.
>
> The clinic has 1, 2.5, 5, 10, 20 and 50mL syringes. The application of Catherine's rule required her to work out which is the smallest possible syringe she could use for a task - "this makes sure that I am accurate. You know the scale on the side of the syringe is the most detailed for that job so I can get as close as possible to the amount I'm supposed to give. With some drugs it's really important, like anaesthetics. But others it doesn't matter so much, like antibiotics. "

Here Catherine demonstrated a good understanding of the important of accuracy in the context of administering drugs. This level of contextual understanding may have been instrumental in her development of the rule described above.

(2) Thinking in Context – proportional reasoning as opposed to the use of an abstract formula

For veterinary nurses the skill of converting between units is extremely important. Drugs used by the clinics are sold in bulk quantities, not individual doses. So, veterinary nurses routinely convert dose rates of drugs prescribed by veterinarians into quantities to be administered to animals. An incorrect dose could make treatment ineffective if it is too small, or deadly if it is too large. The following account demonstrates how Tracey dealt with this demand:

> Tracey was asked to administer 0.5mg/kg of morphine to a 15kg dog. Tracey mentally calculated that 5mg would be required for 10kg and that 2.5mg would be required for 5kg. Therefore a total of 7.5mg needed to be administered. Tracey explained that morphine comes in 1ml vials containing 10mg, 15mg and 30mg and that she needed a 10mg vial in this instance. Tracey then stated "half a ml, has 5mg and half of that is 2.5mg. So, half a ml plus quarter of a ml is 0.5 plus 0.25. That's 0.75mls." Tracey then drew up 0.75mls of morphine from the 10mg vial.

While Tracey's approach may appear awkward it allowed her to preserve the context in which the quantities were situated, thus enabling her to solve the problem without the abstract use of the formula. It is speculated that a break in Tracey's capacity to hold onto the context of the problem may occur on occasions when the numbers become too difficult to calculate mentally. On such occasions, Tracey might be forced to revert to the use of the abstract formula she recited early – "what you want, over what you've got, times what volume it comes in".

Similar examples of proportional reasoning were noted in observations of Catherine and Tracey when they handled client queries related to animal nutrition. In the excerpt below Catherine helped a client to estimate how long a particular bag of pet food would feed her cat.

> First the client asked Catherine how much food she should be feeding her cat per day. This required Catherine to read the table on the back of the cat food bag. From this Catherine was able to inform the client that two cups of feed per day would be required. (Note that the cat food came with a measuring cup.) The client then wanted to know how long that bag would last so she could compare the cost with her usual brand of pet food. At this stage Catherine sort the help of an experienced vet nurse, Haley. Haley looked on the back of the pack were she found that approximate weight per cup of feed was 50g. Haley explained to Catherine and the client that the cat would eat 100g of feed per day and that as the bag contained 5kg, it should last approximately 50 days.

In a post shadowing interview Catherine made the link between the above task and her Gateway course work related to energy requirements of animals (see Appendix for details of this course work). Catherine commented that although she had read material related to this task, it was not until she observed Haley helping the client that she fully understood what was involved. Tracey made a similar comment after helping a client with a query about an overweight dog

> "The course work does cover food needs and that, but at work, it's like everybody that comes in wants to know something different. It's not until you actually help them, then you think I know that or I don't know that. Then you ask someone and you remember and next time you can help the client yourself. That's what's good about working there. I know that what I have learned will help me next year."

Here Tracey acknowledged the role of her workplace learning in preparing her for future veterinary nursing studies. When asked whether she thought the mathematics she had been taught at school was helpful Tracey replied:

> It might have, if I'd listen. But I didn't think I would need percentages and stuff. I just thought, nah, I'm not going to use this. I just mucked around.

In hindsight, it seems Tracey might see some relevance between school mathematics and the mathematics that she now requires in her veterinary nursing duties.

(3) Technology

In many workplaces technology is used to undertake calculations. In the case of the veterinary nurses, computer systems are set up so that clients' accounts can be calculated by entering the type of product and the quantity used. This system reduces the numeracy demand of the task since calculations are undertaken by the computer. This is not to say that calculations are not undertaken by the veterinary nurse, as the following excerpt from a post shadowing interview of Tracey demonstrates:

> "Sometimes it's just look up the drug and get strength. Then you put in how many tablets. The computer works how much it is. Sometimes they just say, "I'm sending them home with five days of antibiotics". Then I have to work out how many tablets that is before I can put on the computer."

In this excerpt Tracey stated that "the computer works" out the cost, but at times she was required to perform calculations, depending on the form of information she had been given by the vets. Such instances required Tracey to be able to switch between calculating herself and deferring to the computer when appropriate, thereby completing the whole task quickly and efficiently.

> "Usually I like doing bills for clients on the computer. But if they've got a dog pulling on the lead or something and you know they're in a hurry I usually get someone else to do it. They'll be quicker and that's what the client wants – to get out fast."

This comment shows how Catherine's concern for customer service influenced the way is approached the task, her orientation was to serve the customer quickly, rather than to calculate the bill. This example is highly representative of the holistic approach to tasks both Catherine and Tracey were observed to have in their respective workplaces.

(4) Workplace artefacts

When Catherine first started work at the clinic she was given a procedures manual which contained a page on "Mathematical Formulations" (see Appendix D). The Practice Manager stated that this page had been included to help reduce the error rate in the charging out of drugs to clients. The following extract is an example taken from this page in the manual

8mls used out of a 250ml bottle = .03
$8 \div 250 = .03$

The example given in the manual shows how to calculate the proportion of the bottle dispensed as a decimal. However, it does not show how to complete the calculation by multiplying proportion dispensed by the cost of a full bottle. The excerpt that follows describes a situation in which Catherine used the "Mathematical Formulations" page of the procedures manual.

Catherine was requested by a client to dispense some Tectonic (a multivitamin supplement) for his dog. This required Catherine to estimate the weight of the dog by discussing the breed and size of the dog. The weight was estimated to be approximately 20kg. The dose rate for dogs is 2.5mL per 10kg of body weight. Catherine explained that double this amount, a dose of 5mL, would be required three times per day (15mL per day total). Catherine checked her calculations on a calculator. Since the client required 10 days supply Catherine multiplied the total daily requirement by 10 again checking the calculator. Then to work out how much to charge the client Catherine used the "Mathematical Formulations" page in her staff handbook. After the client left Catherine discussed how she calculated the cost to the client. She explained that a bottle of Tectonic contains 1L, which is 1000mL so she divided the number of mL needed (150mL) by the total in the bottle (1000mL) and then multiplied that amount by the cost of buying the whole bottle ($21.80).

Taken individually each part of the calculation is fairly simple. The complexity of the problem stems from the need for an understanding of how to progress through the steps in order to correctly calculate the cost involved. This type of problem is similar to the type of problem posed in excellence questions in the NCEA level 1 Number Achievement Standard.

(5) Percentages

As the clinic that Catherine works in services a large rural area a number of clients are farmers. As most farmers are GST registered, they often want to know the GST exclusive cost of items as they can claim the GST back on business related expenses. The procedures manual contains an example of how to carry out such calculations:

"To work amount of an inclusive amount back to an exclusive amount

Amount ÷ 9 x 8 =
i.e.
$11.25 ÷ 9 x 8 = $10.00"

Although I did not observe Catherine carrying out this calculation when asked whether there were any other aspects of her work that involved mathematics Catherine referred to GST calculations.

> "I know we did GST, I didn't get it. It was like blah, blah, blah, I thought I'm never going to use this. But now, I think, if I listened, it might be easier at work. But it's not that hard, the way Karen [the practice manager] showed me. It's more multiplying and dividing. You don't have to use the percentages button like at school, here's it just divide by this, multiply by that!"

In a way similar to Tracey above, Catherine acknowledges that there are links between her use of mathematics in her workplace and the mathematics taught at school. It appears that school mathematics, for these two students, was not seen as relevant to them at the time it was taught. There are some possible pedagogical implications of this for secondary school mathematics teachers in particular, but also for teachers, in general. These implications will be expanded upon in the discussion chapter.

(6) The Voice of Experience

Nearly every aspect of vet nurses' work involves some degree of mathematics. The types of mathematical problems encountered are as diverse as the vet nurses' duties. Data gathered from informal interviews with Jen, a veterinarian and veterinary nursing tutor, and Haley, an experienced and highly qualified veterinary nurse, led to a compilation of the mathematical knowledge and skills required by veterinary nurses in order to be competent in their work:

- A deep understanding of the metric measurement system and the units involved.

- A capacity to manipulate numbers in different systems and units of measure in order to be able to calculate drug dosages and to cost out the price of product for clients.

- Understandings of long division and scientific notation, so that these calculations can be performed in the absence of a calculator or at a minimum, engender a capacity to recognise that a wrong button may have been pushed.

- The faculty to recognise whether answers to calculations seem reasonable in the context in which they occur. In particular the ability to recognise errors that are 'off' by a scale of magnitude such as 6 instead of 0.6 is important.

- An appreciation of the importance of accuracy and consistency in recording numerical information. For example, in recording decimals the zero to the left of the decimal place should always be written in order to avoid misreading. For example, .6mL should always be written as 0.6mL so that it will not be misread as 6mL. This is important as such errors could lead to an animal getting ten times the intended dosage of medication.

- An understanding of fractions, decimals and percentages and the ability to convert between them preferably without the aid of a calculator.

- An understanding of ratio and proportion in relation to calculations involving dilutions, drug dosage rates and nutrition.

- An ability to be able to communicate mathematical information in layman terms to clients, particularly in relation to medication and nutrition.

With such a list it is not surprising to learn that Jen commented "Maths is probably the most daunting aspect of the vet nursing syllabus for students."

Looking ahead: Where Catherine and Tracey's school mathematics might lead them?

The following excerpt has been included to allow the reader to gain an appreciation of the complexity of mathematical problem solving which Catherine and Tracey will face if they continue with their veterinary nursing studies after leaving secondary school.

Example of a test question with judgment statements for Unit Standard 5158 Assist the veterinarian with animal anaesthetic and analgesic procedures Level 5 Credits 18.

PC 3.2 Intravenous anaesthetics and reversal agents are prepared for use as directed by the veterinarian.

> *A **30-kg** spaniel dog is going to be given a barbiturate anaesthetic of Thiopentone (Trade names Bomothal, or Pentothal.)*
>
> *The vet wishes to use a **2.5% solution** and the required dose rate is **10mg/kg.***
>
> *You have a fresh **5% solution** made up already, and some new sterile water available to use.*

For the following calculation ***show your workings****. Exact quantities are required, even though you might prepare extra "in practice".*

a. How many mls of 2.5% solution will you prepare to anaesthetise this dog?

Student calculates how many mls of 2.5% solution is required. First the student recognises that 2.5% is 25mg/ml, then W x D/C = 30 x 10/25 = 12mls. Students must show workings and correct answer 12mls is required. (Emphasis original)

Part two: Building

Overcoming a research dilemma

Although Zane and James were visited at their Gateway workplace on four separate mornings I was not able to observe them using any mathematics. The focus of their workplace experience seemed to be on learning the skills involved in using tools. The building supervisor explained that it was important for the "boys to get some hands on experience with tools" so that they could complete unit standards such as 12998 Demonstrate knowledge of carpentry hand tools which form part of the National Certificate of Carpentry. It was inquired as to whether it would be possible for Zane and James to be involved in work that required some mathematics such as the laying out of studs. The builder explained that such tasks were crucial to their building projects, and involving the students might increase the "risk of errors" which could be "costly in terms of time and money."

The builders working on site with Zane and James reported that they had learned how to lay out studs and so forth at polytechnic, before being involved in such work onsite. It is speculated that the builders' approach to teaching the students mirrored their learning experiences. It is noteworthy that the building supervisor mentioned that he had always "hated maths at school" and had "only just passed" School Certificate mathematics. It is speculated that he may not have felt confident enough to teach Zane and James mathematically related building skills. This possible lack of confidence may have contributed to his reluctance to involve the students in work that involved mathematics.

As a result of not being able to observe Zane and James using mathematics in their workplace a decision was made to examine the vocational course work that was being completed as part of their involvement in the Gateway programme. The unit standards undertaken contributed to the National Certification in Carpentry. This qualification is designed to lead to career opportunities such as carpentry apprenticeship, assistant tradesperson or construction retailer.

A request by the researcher to examine Zane's and James's course work led to a conversation in which the researcher was requested, by the participants, for help with the mathematical content. At this point in the research the distinction between my roles, as a researcher and a mathematics teacher at the school in which this research was carried out, became blurred. I felt compelled to help the students and spent several hours working alongside Zane and James helping them with the level 3 unit standard (13001) Demonstrate Knowledge of Building Calculations. This experience enriched the research process as I became a participant, learning about building calculations alongside Zane and James. The accounts below describe the types of mathematical knowledge and skills required, and the learning experiences of the student participants demonstrate the transformation of mathematics into vocational knowledge.

Building calculations course work

(1) Types of measurement

Individual, running and overall measurements.

On working drawings, the individual and overall measurements are given. In practice running measurements are used to eliminate cumulative errors. If the studs for a house were set out room by room, an error in one room would lead to a cumulative error over the entire length of the house (see Appendix for a detailed example of this). This system of measurements increases overall accuracy and can reduce set-out time.

Both Zane and James struggled to understand this concept from the text in their coursework. As this method of carrying out measurements was new to me I became a student together with Zane and James. In order to fully understand how this technique worked in practice I played around with some pieces of wood in the garage at home. As this helped my own understanding I decided to take Zane and James over to the woodwork room at school and show them how builders might perform this task onsite.

This excerpt shows how teachers might become "adventuresome learners" alongside their students. The pedagogical implications of this for teachers involved in vocational education and training of students in secondary schools will be taken up further in the next chapter.

(2) In and Over

Builders use a method of measuring the gap and one of the studs as a quick way of calculating the mid-point from one stud to the mid-point on the next stud when the studs are the same width. When I was explaining this to James and Zane, Zane said he had observed builders using this technique when they were putting up gib board. Here Zane's knowledge of mathematics learned in the building calculations unit standard might be seen to be transformed into vocational knowledge.

(3) Applied building calculations – Trigonometry

Builders need to be able to transform drawings into three dimensional objects. Often they need to calculate and interpret information that is not written on the plans. This may require the application of trigonometry. At first glance the level of calculations involving trigonometry may not appear to be complex. However, the context in which these problems are set requires a two-dimensional drawing translated into a three-dimensional building. It is this context that raises the level of complexity.

Students are required to gain a good level of conceptual understanding of

Triangle Theorem (angles of a triangle add up to 180°)
Pythagoras Theorem
Sine, Cosine and Tangent Rules

When teaching Zane and James to use Pythagoras Theorem I showed them how to enter the data into their calculator in one step thus eliminating rounding errors which may occur with different approaches. To calculate the hypotenuse the formula $\sqrt{(\text{short side}^2 + \text{short side}^2)}$ is entered into the calculator and to calculate a short side, $\sqrt{(\text{longside}^2 - \text{short side}^2)}$ is entered.

Before introducing Zane and James to this method I checked with a builder at their Gateway workplace to ensure that this method would be acceptable on site. The builder commented "as long as you get the right answer... nobody's going to argue over how you got it."

Solving the trigonometric ratio problems involving building plans required knowledge of the related terminology, such as hip rafter length and rise. Again this point shows how when mathematics is integrated with other knowledge it is transformed into vocational knowledge.

Conclusion

The young people in this study were observed to take an holistic approach to solving problems involving numeracy. Some of these approaches involved strategies that while very valid avoided the need to operationalise their skills. Approaches such as Tracey's solution to the "Lady Mead" problem were highly grounded in real life contexts. Other approaches to solving problems relied heavy upon the use of technology. For example, Zane, who was concerned about "keeping" his employer "honest", kept meticulous records of hours worked and how much he should be paid by entering information into his cell phone.

Chapter 5

Discussion and Conclusion

Introduction

The findings reported in chapter 4 will be discussed in relation to the research questions in this chapter. Implications of the study will be discussed at the individual, institutional, community, national and international levels. Suggestions for future research will also be made.

Research question 1: What do the out-of-school and workplace numeracy practices of young people on the cusp between secondary school and work and/or further education look like?

The impact of technology

Using Bourdieu's theoretical framing and data from a three-year study of the numeracy needs and practices of young people in contemporary work Zevenbergen (2005) hypothesises that young people have built up ways of thinking, behaving and doing things that draw heavily on technology. For young people part of their habitus predisposed them to deferring calculations to technology. This disposition is often not valued by older people in positions of power; however as more young people gain positions of power it is likely that this will change (Zevenbergen, 2005). Intergenerational differences between this generation and the one before it are said by social commentators (Mackay, 1997; Howe & Strauss, 2000) to be greater than ever before because of a wide range of technology. This generation of young people is characterised by these commentators as possessing traits such as the need for immediate gratification, rushing in, failing to listen and of risk taking.

The young people in this study have grown up in a technology rich society. They were observed to have high levels of confidence in approaching tasks which involved the use of technology that was unfamiliar to them or that involved new applications of technology that they were familiar with. The employers of both Catherine and Tracey commented that they had quickly learned how to make up client accounts using the clinic's computerised system. Zane and James were observed to be confident in taking on tasks that required them to use tools with which they were unfamiliar. In their out-of-school numeracy practices the student participants reported novel applications of the technology afforded by cell phones. Zane, for example, was suspicious that his employer was deliberately under paying him. His resolution to this problem involved a methodical system he invented, involving entering his work hours into the diary of his cell phone. This novel application of technology Zane did not merely involve entering numerical data into his cell phone. It reflected his capacity to think systematically and logically which is a skill highly valued in mathematics.

No solution! No problem!

One important skill observed to be required by the student participants in their out-of-school and workplace numeracy practices was the capacity and inclination to recognise how the application of mathematics can enable problems to be solved. The student participants in this study reported no instances when they were not able to solve an everyday problem because of the mathematics involved. It is speculated that this may be due to the differences that exist between out-of-school numeracy practices and formal school mathematics. In their out-of-school activities students may not recognise that the problem that they are not able to solve could be solved through the application of appropriate mathematical knowledge and skills. Another possible explanation for this phenomenon is that outside of school these students might draw on strategies that allow them to bypass the need for them to operationalise their mathematical knowledge and skills. Tracey's response to the "Lady Mead" problem illustrates one such valid strategy. Instead of calculating the cost of accommodation herself she would have phoned the kennels to ask the cost.

Research question 2: To what extent does students' "school maths" align with students' vocational course work and "out-of-school" numeracy practices?

The material in Table 1 below summarises differences in the use of mathematics, as observed from all four of the students who participated in phase 2 of this study. My objective was to highlight the systematic differences that exist between out-of-school numeracy and traditional in school mathematics.

Out-of-school numeracy tasks may look like in school mathematics tasks but out of school students have their own methods, which are often self invented, for solving problems. Out-of-school tasks are often solved by working collaboratively and a number of different solutions may be acceptable. Students may receive feedback about their mathematical decisions based on the practical implications of the task. This feedback may not necessarily be in a mathematical form. For example, Tracey talked about avoiding socialising with a friend because of the way she dealt with money. Traditionally in school mathematics students work individually on problems which are deemed to have one correct answer. Feedback about the solution is mathematical and designed to ensure students continued improvement in mathematical knowledge and skills.

Table 1. Comparison of out-of-school and workplace numeracy practices with mathematics in school.

Out-of-school and Workplace numeracy practices	Mathematics in school
The solution to a problem has practical implications. Feedback about the solution used may not be in a mathematical form. For example, if a drug dose is miscalculated and therefore incorrectly administered the feedback from this situation will be the effects of the drug overdose on the animal.	Solutions to mathematical questions posed in class do not have practical implications and feedback about the solution is related to the mathematics used.
The problem may be ill-defined and numerical information pertinent to solving the problem at hand may not always be readily available.	The problem is framed in the wording of the question and all the numerical information required to solve the problem is contained within the wording of the problem itself.
People work together solving problems within social and workplace settings. Usually there is a shared goal in reaching a solution to the problem.	The ability to solve problems individually is highly valued and often the environment is competitive.
Solving the mathematical component is merely one aspect of the task. Other factors may be equally or more important depending upon the task.	The solution to the problem, sort by the teacher, is based solely on correct application of mathematics.
Real life problems trigger the need for mathematical knowledge and skills to be applied.	Mathematical knowledge and skills are practised in the context of real life problems.
Mathematical knowledge and skills are taught with a specific application in mind.	Mathematical knowledge and skills are taught with the aim of generalisation.
Numbers used in solving problems always have units and these units play an important role in the context of the problem.	Problems are often decontextualised and therefore numbers are not associated with units.
Context determines whether accurate calculation or estimation is the most appropriate approach.	The level of accuracy is often set down in the problem, for example, calculate to 3 decimal places.

Research question 3: How do students learn and develop numerical competencies in their vocational workplace experience?

In the workplace, "educative and work processes are tightly interwoven and difficult to disentangle" (Hart-Landsberg, Braunger, Reder & Cross 1993). The context in which knowledge is learned and applied is a fundamental part of what is learned. As Brown, Collins, and Duguid (1989) put it "situations might be said to co-produce knowledge through activity" (p. 36).

Onstenk's (1998) distinction between learning on the job and on-the-job training is useful in analysing the data gained from my research. Learning on the job does not involve structured pedagogical activities as training on-the-job does, instead it is characterised by the work itself offering opportunities for learning. Using this distinction the student participants in this current research can be seen to be involved in learning on-the-job.

The data produced in this current research here lead to the identification of several factors impacting on the student participants' opportunities for learning on the job:

- An ability or willingness on the part of the employer to offer students on Gateway the opportunity to be involved in work that will provide opportunities to be involved in workplace numeracy practices. For example, the employer of Zane and James was not able, due to workplace constraints, to offer the students an opportunity to be involved in work such as the laying out of studs.

- The student participants' interests and preference for being involved in certain types of work. For example, Tracey was interested in helping veterinarians during surgery. This interest led her to spending a considerable amount of time observing surgeries and afforded her the opportunity to gain experience in calculating drug dosages.

- Inclusion into a community of practice, Catherine and Tracey were observed to be included in the veterinary nurses' community of practice through what Lave and Wenger, and others, name as 'legitimate peripheral participation'. While Zane and James worked together on tasks they were not observed working alongside experienced builders working on site. This exclusion from the community of builders limited their opportunity to learn on the job.

A possible role of vocational knowledge in facilitating transfer of mathematical knowledge and skills

In workshadowing observations of Catherine and Tracey transfer of mathematical knowledge and skills improved as their knowledge of wider work related contexts improved. For example, their knowledge of drug calculations was enhanced by knowledge about the drug involved, such as how the drug acts on the body and the degree of accuracy needed in administration of the drug. Learning such information may have helped them to think more critically about their numeracy practices in relation to the safety of animals in their care. Inadequate knowledge of a new context may prevent students from recognising similarity between contexts and thereby prevent the transfer of mathematical knowledge. This speculation is supported by findings from Magajna and Monaghans' (2003) investigation of the use of more advanced school mathematics in the learning of computer-aided design in machining. In this study it was suggested that transfer of mathematical knowledge to another subject may be impaired by inadequate knowledge of that subject.

Possible links between reflection and transfer of mathematical knowledge and skills

Brown (1998) suggests that students should be encouraged to see their learning on the job as continually developing rather than as the acquisition of a fixed body of knowledge. Learning develops from reflection on workplace experiences. Reflection is described by Billington (1992) as the process of focusing on previous events and then accepting or adjusting ideas previously held. For Davis (1988) reflection involves holding on to mentally important events so that they can be referred back to when a similar event occurs.

It is suggested here that reflection may be a key mechanism in facilitating the transfer of mathematical knowledge and skills. The student participants in this research where observed to reflect on their workplace learning. For example, Catherine discussed that she had been taught percentages in school but that she had not been able to gasp when to apply a particular procedure. However, in her work Catherine reported reflecting on previous workplace tasks involving percentages. She was then able to decide whether similarities existed with the task at hand and whether or not it was appropriate to apply the approach previously used.

Research question 4: How might schools best support the numeracy learning of students undertaking vocational courses and workplace experience?

The use of mathematics in the workplace is often seen as a simple matter of transfer of knowledge and skills (Kanes, 1996). However, separating workplace mathematics from the context of workplace simplifies the complexity of what is required for competence in the workplace (Wedege, 2002). "Workplace practices do not distinguish mathematical knowledge from other knowledge helpful to cope with the professional problem" (Straesser, 2000, p. 5). If knowledge is to become meaningful to the students beyond the classroom, it must be integrated with other knowledge and skills used in the workplace.

In vocational numeracy courses mathematics is taught principally for its application and therefore the teachers require an approach which is different to that commonly adopted in traditional mathematics classrooms. Teachers need to recognise students' existing mathematical knowledge and skills and they need to use this as a starting point for constructing *vocationally* related numeracy skills. Students need to be given the opportunity to reflect critically on their mathematical practices so that they identify areas of weakness which can then be improved by the teacher helping them to gain a better understanding of the mathematical knowledge and skills underpinning their workplace numeracy practices.

International studies provide a body of evidence-based knowledge about how numeracy is acquired in the workplace. These studies show that numeracy in the workplace is subsumed into routines. Munby et al. (2003) proposes that instruction on the metacognitive theory of routines can be used to enhance learning in the workplace. Here workers are encouraged to ask themselves questions such as: What is the routine? What initiates the routine? "How can the routine be made more efficient?" (Munby et al., 2003, p. 101). This theory is compatible with Billet's (2001) 'guided workplace learning' and Lave and Wenger's (1991) notion of legitimate peripheral participation. It is suggested by Munby et al. (2003) that in learning complex routines learners should become familiar with parts of routines first and then integrate these parts to complete the task.

A possible pedagogical approach which could be adopted in secondary schools in dealing with individual numeracy "needs" would be to ask students to identify tasks in their workplaces that require mathematics. Students could then record examples of problems involving the application of that mathematics using the questions suggested by Munby et al. (2003) above as a framework for solving the problems they report. The mathematics teacher may then be in a position to help scaffold to student to see ways to new applications for this mathematics.

A possible framework for schools to assess workplace learning opportunities for Gateway students

It is suggested here that the concept of connectivity from work by Griffiths and Guile (2003, 2004) may provide a useful theoretical framework for schools assessing the workplace learning opportunities offered by Gateway workplaces. In this framework the socio-cultural approach to learning at work is emphasised.

Drawing on Griffith's and Guile's conceptualisation of workplace learning the following points have been identified in this research as being important in terms of supporting students in their specific workplace needs in their Gateway programme:

(1) An examination of the workplace needs to be carried out so that the different kinds of access to learning can be identified.

(2) An examination is required of the mathematical content of course work undertaken by Gateway students together with the identification of underpinning mathematical concepts related to the workplace's numeracy practices.

(3) An assessment of the opportunities made available to students to be included in the workplaces community of practice.

Ideally work experience, as a pedagogical approach, should provide support for learners to become experts progressively as they use their experience to create new knowledge and better practices. A shared will towards expanding knowledge is required. Employers must be willing to give of their time and knowledge and learners must be willing to take on work for the purpose of learning.

Implications of the Study

The individual level

People with poor numeracy skills tend to leave school at the earliest possible opportunity, usually without qualifications. Their employment is often poorly paid and offers little opportunity for further education (BSA, 1997). The Gateway programme is an example of a New Zealand government initiative aimed at encouraging students "at risk" of leaving school unprepared for the transition to work. Gateway provides an important opportunity for young people to try-out possible career paths, as they face a burgeoning number of possible post-school destinations. In this study Gateway was seen to afford James the opportunity to "try-out" building as a possible career path in a low risk environment. His current level of mathematical knowledge and skills acted as a "gatekeeper' preventing him from being able to pursue this path and may have contributed to his decision to leave school a few months after his sixteenth birthday.

The complexity of mathematics involved in the vocational course work varied greatly. At the more difficult end of the continuum noted in this research was the trigonometry involved in the building calculations level 3 and 4 unit standards (equivalent to Year 13/ first year university level). At the other end of the continuum the vet nursing coursework contained only one relatively simple reference to mathematics (see Appendix E).

Gender differences might exist in terms of workplace preference. It is noteworthy that veterinary nursing is a female dominated field of work while building is a male dominated field of work. This leads to the following speculation: gender differences may exist in terms of preference for the setting in which vocationally related mathematics skills and knowledge are taught. Young women students might prefer to learn mathematics on the job, for example, via legitimate peripheral participation (see Lave, 1988). Young male students might prefer to gain mathematical knowledge and skills within more formal settings, such as polytechnics, and then transfer their knowledge and skills to the workplace. This is a possible area for future research.

The institutional level

The following implications have been written for the secondary school in which this research was conducted. However, it is likely that these recommendations may be useful for other schools offering Gateway and the Designing Careers programme.

Students taking Gateway attend school four days a week and spend the fifth day in their work placements. Gateway students are timetabled four lessons per week in which to work on their vocational studies. At present these lessons are supervised by a person with a limited authority to teach. The level of mathematical study required by the building students demands a qualified mathematics teacher to be available to attend at least one of these timetabled lessons per week. This is crucial if students' vocational mathematics learning is to be supported.

In Year 10 students spend a week in a workplace of their choice. This offers the mathematics department an opportunity to ask students to explore the links between the school mathematics curriculum and workplace practices. Students might, for example, be required to find mathematical artefacts in the workplace that they were interested in studying further. On their return to class students could discuss these artefacts so as to uncover the mathematics embedded in that workplace. This may go some way towards improving student motivation and increasing awareness of the utility of mathematics. Such a pedagogical approach offers an alternative to the traditional approach in which application-based materials are written by developers who live in social worlds that may be far removed from those of the students for whom the materials are written.

The community level

This research aims to make a useful contribution to improving the transition from school to work. At present our New Zealand education system suffers from the legacy of a division between vocational (historically offered by technical colleges) and academic education. Parents and the community in general regard programmes that deviate from the traditionally offered academic courses with suspicion. Care needs to be taken to ensure that unit standards and achievement standards do not recreate this historical distinction. The focus should be on how we can best meet the individual needs of students whether they intend to enter the workforce after secondary school or go on to higher education.

Schools benefit from their involvement in Gateway as they are seen by local businesses as providing educational programmes relevant to local opportunities for employment. Local businesses benefit by having the opportunity to see how a potential future employee operates in their workplace. Students also benefit by being offered educational programmes which have been specifically tailored to their needs and interests. The Gateway programme needs to be actively promoted so that communities are made aware of these benefits.

The national level

Changes in society and individuals' expectations mean the end of one job for life (Vaughan, Roberts, & Gardiner, 2006). In New Zealand, careers guidance has been mandated for schools since 1996. Schools have been supported in this role through the Careers Information and Guidance (CIG) grant, through the Ministry of Education's publication *Career Education and Guidance in New Zealand*

Schools and through a range of Career Services resources and tools such as Plan-It books and CareerQuest. Schools must play a role in helping to guide students in managing their transition from school and in making career choices. Data collected on students' involvement in the Gateway programme could provide a benchmark to the development of supporting schools that would help ensure successful transitions to post-school destinations.

The National Certificate of Educational Achievement (NCEA) is a major initiative. Schools are now able to assess students on unit standards and achievement standards in conjunction with industry training providers. This has initiated an increase in the breadth of options schools offer senior students as they look for possible career paths. This research shows that students need workplace experience alongside their vocational course work so that the knowledge and skills learned in school and in vocational courses can be transformed into useful vocational knowledge and skills. Context based word problems are not enough for this transformation to occur. Data from this study also suggests that work-bound students will be better prepared for work if they are offered a high quality curriculum that integrates school-based learning into work-based applications.

The integration of vocational and academic education through initiatives such as Gateway is an important strategy for preparing students for work after high school. The research findings reported in this study add to a growing body of evidence that such an approach may also be effective for teaching academic skills and preparing students for tertiary study. Teaching academic skills in the context of workplace applications can provide motivational benefits and may lead to a deeper understanding of concepts as students learn how to apply their knowledge. Retention is also enhanced as students experience the application of material which they may then call on when presented with a similar problem in the future.

Teachers of mathematics and those working to set academic standards need to continue to try to understand the use of mathematics in the workplace and in everyday life. Such understandings offer insights that could inform curriculum development and provide better foundations for teaching realistic applications of mathematics.

The international level

Internationally, the teaching approaches, curriculum and assessment methods employed in mathematics education in secondary schools have been under criticism. Some of those critical of the current practices have called for a "back to basics" approach to mathematics educational reforms the influence of which can be seen in reforms in many countries. Drawing on Zevenbergen's (2005) finding that people, in general, place high value on mathematical skills, such as mental computation, it is speculated here that this stance on reforms related to mathematics education may be an attempt by some to hold on to these old values. Instead, the research findings of this study suggested that attention should be paid to Wedege's (2002) conceptualisation of numeracy needs. Attention needs to be paid to "needs" in terms of relevance to an individual's preferences, to changes in technology and to workplace demands.

Further Research

Issues concerning the teaching and learning of mathematics in vocational training, particularly within high schools, have been largely ignored (Zevenbergen, 2000). It is acknowledged that it is impossible to consider the individual "needs" of every secondary school student involved in vocational training. However, more research on the intersection of numeracy and vocational training in schools would be helpful to build a body of evidence about what such "needs" look like. This will allow a deeper exploration of data so that generalities across different vocations can be identified.

If students are to achieve maximum benefit from workplace learning, attention needs to be paid to school and vocational curricula and teaching methodologies. This research was carried out in a small co-educational, decile 5 secondary school situated in a rural town. From 2008 it is intended that all decile 1 to 5 secondary schools will offer their students the Gateway programme. More research of the type carried out here would be useful so that a greater body of evidence surrounding the intersection of numeracy and vocational training in our New Zealand secondary schools can be constructed. This is important as it is likely that the experiences and future focus of students from decile 1 schools or large city schools will be different from those reported here. Research needs to expand to include the range of different Gateway workplaces, as this research only reports data related to veterinary nursing and building. It is likely that other vocational areas will raise new issues.

This research is relevant to secondary school mathematics education because:

- It may challenge the assumptions that our current teaching, learning and assessment practices are based upon.
- It provides an impetus for mathematics education to keep pace with rapidly changing workplace practices.
- It provides teachers with actual examples of mathematics being used in the workplace, and in doing so, it may go some way towards solving the recurrent problem of 'motivating' to learn mathematics.

Young people come to the workplace as competent users of IT and they often have previous work experience from part-time jobs held whilst at secondary school. These experiences were seen to impact on the workplace practices of the student participants in their Gateway workplaces. Both Catherine's and Tracey's employers commented on the ease and speed at which they became familiar with the computer systems in their respective workplaces. Tracey's IT skills enabled her to show her co-workers some "shortcuts" when using their workplace computer system. This led the researcher to question who is teaching whom in the workplace. It is argued here, along with Fuller and Unwin (2003), that the term 'novice' as is it was conceived by Lave and Wenger (1991) may be too narrowly conceived to apply to students undertaking experience in contemporary workplaces. More research around this issue is required.

Conclusion

The Gateway programme offered in many New Zealand high schools offers senior students an opportunity to smooth the transition from being dependent school student to being a young independent working adult. Despite a lack of national and international research surrounding such programmes the case studies presented in this research suggest that both students and employers are benefiting. These students showed high levels of motivation towards learning as the material covered held real relevance to them and they were able to gain a significant number of credits towards their level 2 and 3 National Certificate in Educational Achievement.

The research presented in this thesis contributes to the construction of a New Zealand perspective of what we think mathematics is and how vocational training in schools can best be managed to meet the needs of students. Implications of this research stretch across all areas of the school curriculum that may have applications in the workplace. School and work are not polar opposites that separate learning from doing. "People do and learn in both settings, and we need to continue to develop theories of learning that look outside the institution of schooling, as it is traditionally conceived, for productive ways to organise both teaching and learning" (Hall, 1999, p. 44). The challenge for secondary schools will be in ensuring that effective workplace learning takes place whilst simultaneously ensuring that the underpinning knowledge and skills are also being taught.

As Ingrid Bengis once said, “Words are a form of action, capable of influencing change.” It is hoped that the words presented here will help encourage the future exploration, testing, and fine-tuning of the ways in which students are prepared to face the demands of the ever changing world beyond school.

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APPENDIX A: Student Information Sheet and Consent Form

School Is Out But Numeracy Is In

An Exploratory Case Study of the Out-of-School Numeracy Practices of Four Year 12 New Zealand Students

STUDENT INFORMATION SHEET

Dear Student

I write to invite you to participate in the School Is Out But Numeracy Is In An Exploratory Case Study of the Out-of-School Numeracy Practices of Four Year 12 New Zealand Students. This project is being conducted to fulfil the requirements of a Master of Education thesis at Massey University.

I have chosen to research the out-of-school numeracy practices of Year 12 students who have been involved in the Numeracy Project. The purpose of this study is to investigate the ways in which young people use mathematics outside of school. If you join the study you will be asked to complete two questionnaires. The first questionnaire is designed to find out about your involvement in the Numeracy Project and to gain a brief history of any part time work you have been involved in. A second questionnaire will be administered at the same time; this questionnaire is designed to assess your level of mathematics anxiety. This is an important part of the study as research has shown that anxiety can affect the transfer of mathematical knowledge from one setting to another. Four students will then be invited to take part in the second part of this study; this will involve workplace shadowing and being interviewed using a kit containing everyday items related to numeracy.

It would be great to have you in the study. If you do participate anything you say will remain confidential to the researcher. No information relating to you will be passed on to your teacher or school. All data collected during the study will be kept secure and will be disposed of after five years. If you do not want to be part of the study this will not affect you in any way at the school.

If you do want to participate you will have the right to:

- Withdraw from the study at any time
- Ask any questions about the study at any time during the research process
- Provide information on the understanding that your name will not be used and that your school will not be identifiable in any material produced from this study
- Access a summary of the finished report when the study is concluded

I will be pleased to answer any queries about the research which you may have.

Yours sincerely

Meg Nicholls
Ph (06) 377 1317
Email: meg.megnicholls@gmail.com

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other that the researcher(s), please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 06 350 5249, email humanethics@massey.ac.nz.

School Is Out But Numeracy Is In An Exploratory Case Study of the Out-of-School Numeracy Practices of Four Year 12 New Zealand Students

STUDENT
CONSENT FORM

I HAVE READ THE Information Sheet and have had the details of the study explained to me.

My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/ do not agree to participate in this study under the conditions set out in the Information Sheet.

Signature: ____________________________

Full Name: ____________________________

Date: ____________________________

APPENDIX B: Principal/BOT Information Sheet and Consent Form

School Is Out But Numeracy Is In

An Exploratory Case Study of the Out-of-School Numeracy Practices of Four Year 12 New Zealand Students

Principal/BOT INFORMATION SHEET

Dear Principal/BOT

I write to invite your school to participate in the School Is Out But Numeracy Is In An Exploratory Case Study of the Out-of-School Numeracy Practices of Four Year 12 New Zealand Students. This project is being conducted to fulfil the requirements of a Master of Education thesis at Massey University.

I have chosen to research the out-of-school numeracy practices of Year 12 students who have been involved in the Numeracy Project. The purpose of this study is to investigate the ways in which young people use mathematics outside of school. If you join the study students in the Year 12 Practical Mathematics class will be asked to complete two questionnaires. The first questionnaire is designed to find out about students involvement in the Numeracy Project and to gain a brief history of any part time work you have been involved in. A second questionnaire will be administered at the same time; this questionnaire is designed to assess students' level of mathematics anxiety. This is an important part of the study as research has shown that anxiety can affect the transfer of mathematical knowledge from one setting to another. Four students will then be invited to take part in the second part of this study; this will involve workplace shadowing and being interviewed using a kit containing everyday items related to numeracy.

It would be great to have your school in the study. If your school does participate anything that students say will remain confidential to the researcher. No information relating to students will be passed on to teachers or school. All data collected during the study will kept secure and will be disposed of after five years.

If you do want to participate you will have the right to:

- Withdraw from the study at any time
- Ask any questions about the study at any time during the research process
- Provide information on the understanding that your school will not be identifiable in any material produced from this study
- Access a summary of the finished report when the study is concluded

I will be pleased to answer any queries about the research which you may have.

Yours sincerely

Meg Nicholls
Ph (06) 377 1317
Email: meg.megnicholls@gmail.com

This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other that the researcher(s), please contact Professor Sylvia Rumball, Assistant to the Vice-Chancellor (Ethics & Equity), telephone 06 350 5249, email humanethics@massey.ac.nz.

School Is Out But Numeracy Is In An Exploratory Case Study of the Out-of-School Numeracy Practices of Four Year 12 New Zealand Students

PRINCIPAL/BOT
CONSENT FORM

I HAVE READ THE Information Sheet and have had the details of the study explained to me.

My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/ do not agree my school's participation in this study under the conditions set out in the Information Sheet.

Signature: ______________________

Full Name: ______________________

Date: ______________________

APPENDIX C: Mathematics Use Survey

Mathematics Use Survey

These questions ask you about your experience with mathematics.
PLEASE CIRLCE OR FILL IN YOUR ANSWER IN THE SPACE PROVIDED NEXT TO THE QUESTION

1. Which years were you taught numeracy mathematics (e.g. Years 7 to 10)?

   ____

2. Have you used the mathematics that you were taught as part of the numeracy project in other non-mathematics classes?
   YES / NO

   If yes, which subjects did you use the numeracy mathematics in?

   ____

3. Have you used other maths that you have been taught in school in other non-mathematics classes? YES / NO

   If yes, which subjects did you use non-numeracy mathematics in?

   ____

4. Have you used the mathematics you were taught as part of the numeracy mathematics out-of-school? YES / NO

If yes, please give an example of this use:

____

____

____

____

____

5. How often do you use mathematics in your everyday life? E.g. in checking your change, keeping score at a sports game, etc. (please circle answer which applies to you)

    i. Not at all
    ii. Once or twice a week
    iii. Once or twice a day
    iv. Several times a day

6. How much difficulty have you experienced in using numbers generally in everyday life? (please circle the answer which applies to you)

    i. No difficulty
    ii. A small amount of difficulty
    iii. A moderate amount of difficulty
    iv. A great deal of difficulty

7. Have you ever or do you currently have a part-time paid job?

YES / NO

If yes please list the jobs you have had

____

____

____

____

8. How much have you used mathematics in your paid employment?

   i Not at all
   ii A small amount
   iii A moderate amount
   iv A great deal
   v I have not worked in paid employment

9. Would it have been useful to be able to use mathematics in your paid work more often than you have?

   i No, not at all
   ii A little bit more often
   iii A moderate amount more
   iv A lot more
   v I have not worked in paid employment

10. How many level 1 mathematics credits have you got?

11. How much difficulty did you experience in numeracy mathematics?

   i None
   ii A small amount
   iii A moderate amount
   iv A great deal

12. How much difficulty did you experience in NCEA level 1mathematics?

   i None
   ii A small amount
   iii A moderate amount
   iv A great deal

13. How much do you expect you will need to use mathematics in your work when you leave school?

   i None
   ii A small amount
   iii A moderate amount
   iv A great deal

14. How much do you expect to use mathematics in your everyday life outside of work when you leave school?

   i None
   ii A small amount
   iii A moderate amount
   iv A great deal

15. Is there anything you would like to add about your experience of mathematics?

____

____

____

____

____

APPENDIX D: The Mathematical Anxiety Rating Scale/ Situational Attitude Scale

The Mathematical Anxiety Rating Scale/ Situational Attitude Scale

For each of the following items please indicate to what extent you would generally feel either relaxed or anxious in the situations described. Please rate the situations according to your immediate feelings, using the following scale:

1. I would be very happy
2. I would be very relaxed
3. I would be fairly relaxed
4. I would be neither relaxed nor anxious
5. I would be a little anxious
6. I would be moderately anxious
7. I would be very anxious

Please write the appropriate number from the scale in the box next to that question.

1. Working out the amount of change you should get from a purchase involving several items	
2. Asking a stranger which bus to catch in a strange town	
3. Enrolling for a course which includes a compulsory mathematics class	
4. Buying a recommended mathematics revision guide	
5. Calculating which item is the best buy out of several similar items at the supermarket	
6. Dividing a five digit number by a two digit number in private with pen and paper	
7. Finding a street on a map	

8. Walking into a room before maths class begins	
9. Listening to another student explain a maths formula	
10. Having someone watch you as you add up the total of a row of numbers	
11. Adding up 976 + 777	
12. Asking someone to do you a favour	
13. Listening to your maths teacher in class	
14.Totalling up the bill where you think you have been overcharged	
15. Walking into school and thinking about maths class	
16. Choosing an item of clothing	
17.Reading your payslip	
18. Being asked a question by your teacher in maths class	
19. Being responsible for keeping track of the amount of money colleted for an organisation	
20. Sitting in a maths class and waiting for a teacher to arrive	
21. Deciding which film to go and see	
22. Reading a cash register receipt after you have bought something	
23. Raising your hand in maths class to ask a question	
24. Calculating the amount of GST on an item that costs more than $10	
25. Taking an exam for a maths class	
26. Climbing a ladder	
27. Working out a concrete, EVERDAY APPLICATION of a mathematics problem that has meaning for you; e.g. calculating how much money you should have in your bank account after you get paid.	
28. Realising that you need to get a certain number of mathematics credits to get into the career of your choice	
29. Raising your hand to ask a question in English class	

30. Being given a set of numerical problems involving addition to solve without a calculator	
31. Getting back the results of an important maths test	
32. Being asked a question by the teacher in an English class	
33. Working out your monthly budget	
34. Getting back the results of an important English test	
35. Completing a maths quiz	
36. Talking to a group of strangers (people from a similar background to you but unknown to you)	
37. Doing this questionnaire	

APPENDIX E: The Lady Mead Mailer Resource used in the Numeracy Kit

LADYMEAD
BOARDING
KENNELS AND
CATTERY

Dear Friend,

<u>Accommodation rates increase effective from 1 September 2007</u>

As you are aware Ladymead is committed to giving your pet(s) the best possible care and TLC when they board with us. For the last 12 months the costs of goods and services to Ladymead have slowly increased and we are now forced to review our accommodation charges.

From <u>1 September 2007</u> our accommodation rates will increase by:

Dogs $1.00 per dog per day and Cats $0.50c per cat per day

<u>Ladymead does not charge any extras for dogs or cats that has special needs e.g. medication, special diets etc.</u>

Dogs:	Single	Double (same family only)	Cats:	Single	Double (same family only)
XOS	15.00	N/A		8.00	14.00
Large	14.00	26.00			
Medium	12.00	22.00			
Small	11.00	20.00			
Large /Medm		24.00			
Large / Small		23.00			
Medium / Small		21.00			

Minimum charge = 2 days - All animals are charged per calendar day regardless of drop off or pick up time. ***<u>No discounts</u> for supplying own food***

Pick up and Delivery charge $10.00 per trip within Wairarapa

An additional $3.00 per day per pet will be charged on all public holidays

****

We can Hydrobath your dog

Charges for this service: (No rate change)

Extra Large Dog (XOS)	*$25.00*
Large	*$20.00*
Medium	*$15.00*
Small	*$10.00*
Two small dogs together	*$15.00*

Open 7 Days except:
Good Friday, Easter Sunday, Christmas Day Boxing Day and New Years Day.

Opening Hours:
8:00am – 11:00am and 4:00pm to 6:00pm Daily

Phone 06 377 5595 or email: Ladymead@xtra.co.nz Owner / Director: Barbara O'Byrne