

**New Zealand women and their numeracy skills: What  
the Adult Literacy and Life Skills survey tells us and  
doesn't tell us about the numeracy skills of New  
Zealand women**

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## **Attestation of Authorship**

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of any university or other institution of higher learning.

Janet Coup

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## **Abstract**

The extant findings of the 2006 Adult Literacy and Lifeskills survey (ALL) are examined and some further quantitative analysis is undertaken to clarify the numeracy skills of New Zealand women. Fundamental questions are raised about both the design of the ALL survey and the relevance of the numeracy assessment questions used in the survey for investigating women and their numeracy skills used in everyday social practices. The ALL survey assessment uses a pen and paper test and poses questions which are reminiscent of school-based arithmetic testing. A distinction is drawn between ALL survey numeracy “scores” and actual numeracy “skills”.

The ALL survey findings based on these assessment “scores” suggest over half of New Zealand women have inadequate numeracy skills. However, women overwhelmingly rate their numeracy skills as sufficient for both their daily life activities and their work demands. Women with the lowest levels of numeracy scores come from both the youngest and oldest age groups. This could be because numeracy skills of the youngest develop with age and the skills of the oldest decrease with lack of use. Furthermore, the oldest age group participated in significantly fewer years of formal education than the youngest age group. The evidence suggests that the amount of educational participation affects the development of numeracy scores. The ALL survey assessment questions were available only in English language and the complexity of the language nuances in the questions may have, in part, reflected language competence rather than numerical competence.

New Zealand-born women show markedly poorer attitudes towards learning mathematics than their overseas-born counterparts. These attitudes may be learned early in life and may not be learned within the family.

Several aspects of the design of the ALL survey are questioned, particularly the use of imputed skill scores based on limited demographic variables.

In light of the limitations of the ALL survey, in terms of its design, administration, assessment-type questions and subsequent extant findings, the conclusion is drawn that

the numeracy skills of women are likely to be greater than the ALL survey scores suggest.

# 1 INTRODUCTION

This study is undertaken with two main aims in mind. Firstly, it seeks to examine and then evaluate the extant findings of the 2006 Adult Literacy and Life Skills survey (ALL) inasmuch as they represent the numeracy skills of New Zealand women. A distinction is drawn between the numeracy scores obtained by the ALL survey assessment tasks and numeracy skills embedded in daily life and work tasks. Secondly, some further analysis of the ALL survey data set is conducted to enable a deeper understanding of the numeracy scores and skills of New Zealand women.

The construct of numeracy used in framing the questions in the ALL survey is compared and contrasted with some key conceptualisations in the current literature. The question is asked as to how well both the explicit and implicit constructs surrounding the ALL survey accurately represent the actual numeracy skills of women in their everyday lives and work settings. The definitions of adult numeracy are discussed in light of the ALL survey findings which are used in New Zealand (as they are overseas) as the justification for programmes aimed at increasing numeracy and literacy skill levels among the adult population (Ministry of Education, 2007; Tertiary Education Commission, 2008a). Several major critiques of the International Adult Literacy Survey (IALS) are reviewed (Blum & Guerin-Pace, 2000, 2001; Carey, 2000; Goldstein & Wood, 1989; Hamilton & Barton, 2000a). Insofar as the design of the ALL survey is very similar to that of IALS, this research assumes that, in many respects, the critiques of the IALS also applies to the later ALL survey.

In this thesis, the reasonableness of some of the interpretations that have been drawn from the ALL survey data on New Zealand women and their numeracy skills is examined in light of the IALS survey critiques. This examination of the ALL survey findings is particularly important because, as noted above, the ALL survey findings have been a key driver of government policy directed at improving adult numeracy and literacy skills, in the belief that this will improve New Zealand's economic productivity (Benseman & Sutton, 2008; Ministry of Education, 2007; M. Walker, Udy, & Pole, n.d.).

Considerable international and New Zealand evidence is presented of possible statistical relationships between adult numeracy and literacy ALL Survey scores and economic

and social advantage (Murray, Owen, & McGaw, 2005; OECD & Statistics Canada, 2000; Satherley, Lawes, & Sok, 2008a; St Clair, Tett, & Maclachlan, 2010). However, whether improving the kind of numeracy and literacy scores constructed by the ALL survey would lead to economic gains is by no means certain (Fenwick, 2006; G. Johnston, 2004; Mason & Osborne, 2007).

The nature of work in modern economies is changing (MacCormick, 2008; OECD, 2007; Parsons & Bynner, 2007). Numeracy “skills” are now often cited as essential skills for the workplace (Addis, 2003; Gray, 2006; Tout & Johnston, 1996; Vignoles, De Coulon, & Marcenaro-Gutierrez, 2010). As a consequence, literacy and numeracy policies and programmes have been developed in New Zealand (as internationally), based on the findings of the ALL survey with the dual purpose of improving skill levels and, hopefully, building a more inclusive society (Appleby & Bathmaker, 2006; Department of Labour, 2008; Tertiary Education Commission, 2008a).

One avenue to such an inclusive society could be to see people with low skill and education levels able to improve those skills and obtain work which would provide greater than the minimum income (Appleby & Bathmaker, 2006). This, apparently, is especially the case for women (Parsons & Bynner, 2005).

With the premise that numeracy skill levels have different impacts for women than for men, this study examines gender differences found in the ALL survey relating to numeracy scores and explores the possible reasons for these findings (Satherley & Lawes, 2008a). One key issue is that the very nature of numeracy questions in the ALL survey may, to some extent, have a cultural bias (Blum & Guerin-Pace, 2000; Hamilton & Barton, 2000; Sticht, 2005) or practices that are not entirely gender neutral despite the purported gender neutrality of the test items (Gal, van Groenestijn, Manly, Schmitt, & Tout, 2005).

The examination of various conceptualisations of adult numeracy will look at the possibility that the IALS survey and the ALL survey measure a particular valued form of numeracy. The ALL survey assesses purported numeracy skills and asks respondents to self-evaluate their skills. There is a wide discrepancy between the ALL survey scores and the self-ratings, with women overwhelmingly viewing their numeracy skills as meeting their personal needs as well as the demands of their employment tasks. The

views of women and their beliefs in personal numeracy competence and the apparent discrepancy with the actual scores shown from the ALL survey numeracy questions is a theme throughout this thesis.

This thesis questions the conceptualisations of numeracy underpinning the ALL survey and discusses research in New Zealand and international research that finds numeracy is already commonly and successfully embedded in the everyday actualities of women (Harris, 1997; McMurchy-Pilkington, 1996). It will question how well the ALL survey captures this embedded everyday numeracy.

The ALL survey data set is used to examine the characteristics of women who are more likely to have poorer numeracy “skills” as constructed by this survey. At the same time, this study will describe and acknowledge the limitations of the ALL survey data. The findings are then used to suggest further research which could enquire into the numeracy skills of women in situ rather than as evidenced by pen and paper tests.

## **1.1 Research questions about women and numeracy**

This research will evaluate the New Zealand ALL survey data in relation to its design, implementation and findings about women and their numeracy skills in an attempt to answer the following questions:

- What particular constructs of numeracy underlie the ALL survey?
- What are the demographic characteristics of those New Zealand women described by the ALL survey as having inadequate numeracy skills?
- What are the demographic characteristics of those New Zealand women who perceive their numeracy skills to be inadequate?
- Why does the ALL survey indicate that women perceive their numeracy skills to be much better than their actual scores in the survey’s numeracy questions?
- How much reliance can be placed on the ALL survey findings relating to New Zealand women and their in situ numeracy skills?

## **1.2 Overview of the thesis**

Chapter 2 reviews the literature including the conceptualisations and constructs of adult numeracy and the literature relating to women and numeracy skills in particular. This chapter considers some of the theoretical approaches to adult numeracy and questions the appropriateness of internationally comparative numeracy assessments.

Chapter 3 describes the ALL survey methodology, questionnaires and assessment processes used for the ALL survey, and the numeracy content in particular. The critiques of the earlier IALS survey and the applicability of these critiques to the ALL survey are evaluated.

This study utilises quantitative data from the ALL survey which has been interpreted in light of a range of qualitative studies and theoretical perspectives from the adult numeracy and literacy field.

The methodology used to undertake this study, as distinct from the methodology used for the ALL survey, is described in Chapter 4.

Chapter 5 presents the results of revisiting the extant ALL survey findings in the light of a more theoretically informed notion of adult numeracy. It goes on to present the results of further original analysis of the ALL survey data. The reliance that can be placed on the original extant findings in relation to international theoretical perspectives and research on adult numeracy is evaluated. The findings of the further analysis into the ALL survey data set are also discussed in the light of both New Zealand and international research into the realities of adult numeracy.

Chapter 6 summarises this research and discusses the findings. This chapter also discusses the contribution that this study makes. Furthermore, it suggests further research that may prove informative and relevant.

Chapter 7 summarises the key findings from this project and discusses the limitations to the research

## **2 LITERATURE REVIEW**

### **2.1 Introduction**

This literature review begins with a discussion of the definitions and conceptualisations of mathematics and adult numeracy in particular, including the definition used in the ALL survey. The review discusses the construct of numeracy skills and, in the light of this discussion argues that the ALL survey may implicitly assume the transferability of numeracy understanding and usages from one context to another. Consideration is given as to the likelihood of learning transfer.

Evidence is presented that women have numeracy skills that are embedded in both culture and everyday activities which may not be recognised by the ALL survey or sometimes by the women themselves. This may be because the skills are developed and used within contexts that are everyday social practices. Research is also discussed on adults' identities as knowers and users of numeracy or mathematics and the relevance of this to acquiring or developing numeracy skills.

This literature review describes international research on the possible long-term effects on women of a lack of numeracy skills which may be necessary to achieve both personal and social change.

### **2.2 The concept of numeracy**

The term “numeracy” is reported as first appearing in the 1959 Crowther Report from the United Kingdom, which described numeracy as a mirror image of literacy (“Numeracy,” n.d.; Tertiary Education Commission, 2008b). Crowther described well-educated people as being both literate and numerate (“Dictionary of British Education,” 2005). Furthermore, Crowther included some understanding of scientific method and the development of science under the concept of numeracy (O'Donoghue, 2002).

More recently the term numeracy has been described, in a comprehensive review of adult numeracy research and related literature, as “a deeply contested and notoriously slippery concept, the subject of lively debate by commentators concerned with the education of adults” (Coben, Colwell, Macrae, Boaler, Brown, & Rhodes, 2003, p. 9).

These authors describe numeracy as “more than” computational and functional processes. Together with other writers, they see the concept of numeracy as incorporating aspects of computation and knowledge but being more than elementary mathematics or arithmetic (Baker, 1998; Evans, 2000; B. Johnston, 1994) although specific mention of understanding scientific method is no longer evident. However, the nature of “more than” requires further explanation. (Tout, 1997) defines numeracy thus:

We believe that numeracy is about making meaning in mathematics and being critical about maths. This view of numeracy is very different from numeracy just being about numbers and it is a big step from numeracy or everyday maths that meant doing some functional maths. It is about using mathematics in all its guises – space and shape, measurement, data and statistics, algebra and of course, number – to make sense of the real world and using maths critically and being critical of maths itself. It acknowledges that numeracy is a social activity. That is why we can say that numeracy is not less than maths but more. It is why we don't need to call it critical numeracy – being numerate is being critical (p. 13).

In these definitions of numeracy, the interrelationship between numeracy and mathematics is a key factor. However, in understanding the distinction between numeracy and mathematics we also need to understand the concept of mathematics itself. Plato, following from Pythagoras, viewed the universe as having a pre-existing order which could be explained mathematically. This view of mathematics is of fixed universal truths uninfluenced by human beings. In contrast to Platonist tradition in mathematics, Wittgenstein, in his later philosophy, viewed mathematics as a social practice whereby knowers and users themselves establish the very meaning of mathematical objects and processes (Christensen, 2008). However, this dichotomy is by no means certain with assertions that neither the language of mathematics, nor the processes for developing mathematical knowledge are universal (FitzSimons, 2002).

With echoes of a Wittgensteinian social practice approach, Tout considers numeracy (which we have already seen as more than mathematics) a part of everyday life. This suggests numeracy, like everyday life, is variable, socially negotiated and idiosyncratic. Thus, Tout's proposal that numeracy includes being critical of mathematics itself, raises the possibility of people being competent in classroom mathematics but not necessarily competent in numeracy. This could be the position if competent mathematics users failed to use mathematics critically to make sense of the world.



Coben et al. (2003) provide a definition which implicitly includes the critical element present in Tout's definition and also encompasses the complexity of decision making surrounding practical use and understanding:

To be numerate means to be competent, confident, and comfortable with one's judgements on *whether* to use mathematics in a particular situation and if so, *what* mathematics to use, *how* to do it, what *degree of accuracy* is appropriate, and what the answer means in relation to the context (p. 35). (Original author's italics)

Coben's definition incorporates the situated nature of numeracy and numeracy's relationship with mathematics implying again, that numeracy is "more than" mathematics. Furthermore, Coben's definition suggests that in real life situations there may be many correct solutions to mathematical or numeracy problems, depending on the context. Indeed, FitzSimons (2002) suggests that the plurality and fallibility of mathematics should be identified, as well as respect given to less orthodox and in situ mathematical practices that diverge from the mainstream.

Ginsburg, Manly, & Schmitt (2006) describe numeracy thus:

Numeracy connotes mathematical topics woven into the context of work, community, and personal life. Moreover, numeracy requires the ability and inclination to explore this situational mathematical content, thus is owned differently by each person. Unlike pure mathematics, numeracy has a distinctive personal element (p. 1).

Whilst Ginsburg et al. (2006) view numeracy as mathematical topics woven into work, community and personal life they do not venture into the political contexts of numeracy as does the definition of Tout (1997).

One clear distinction has been made between mathematics and numeracy. Bernstein (1999) suggests that there are two distinct discourses operating in the domain of mathematics and numeracy. He suggests that mathematics, because of its hierarchical and esoteric knowledge structure, forms a vertical discourse which is coherent, explicit, systematically structured and hierarchically organised. According to Bernstein, vertical discourses use specialised languages and modes of interrogation and, rather importantly, can be graded. In contrast, numeracy can be seen as a horizontal discourse which is every-day or common sense knowledge, often learned face-to-face or orally. Horizontal discourses are available to all who wish to seek them. They may be local and context dependent. Bernstein's dichotomy appears persuasive, but possibly overlooks the

highly complex mathematics that may be involved in some specialised horizontal discourses. For example, a mathematical process such as manipulating formulae may be taught face-to-face and used in a particular trade setting, but still involves complex processes and understanding from algebra. This process has been described as mathematics being hidden in “black boxes” which may include machinery, ideas and scientific knowledge (Williams & Wake, 2006). Bernstein argues that transfer of knowledge from the vertical to the horizontal involves the development of a new language rather than the acquisition of new skills. However, as will be discussed later, transfer of mathematical learning appears to be more complex than simply the acquisition of new language.

Underlying all these definitions of numeracy is the relationship between context, skills, numerical knowledge and social situations and the variable nature of numeracy as opposed to the fixed, commonly accepted Platonist concept of mathematics.

### **2.2.1 The ALL survey definition of numeracy**

Returning to the concept of numeracy, the ALL survey defines numeracy as: “The knowledge and skills required to effectively manage and respond to the mathematical demands of diverse situations” (Gal et al., 2005, p. 151). However, in designing the ALL survey the authors acknowledged that this definition was unsatisfactory for capturing the breadth of numerate practices. As a result of this difficulty, the authors decided to focus on “numerate behaviour” as providing evidence of numeracy skills, with the assumption that numeracy scores provide evidence of numerate behaviour.

Numerator behaviour is observed when people manage a situation or solve a problem in a real context; it involves responding to information about mathematical ideas that may be represented in a range of ways; it required the activation of a range of enabling knowledge, factors and processes (Gal et al., 2005, p. 152).

Gal et al's (2005) ALL survey definition of numerate behaviour does not specifically include the critical element in Tout's (1997) definition or acknowledge that mathematics and numeracy incorporate ways of thinking and knowledge that are embedded in culture (Burton, 1995; D'Ambrosio, 1997). This ignoring of culture is particularly relevant for the internationally comparative aspects of the ALL survey. The IALS assessment questions have been strongly critiqued for the subtle, but crucial,

cultural assumptions (Blum & Guerin-Pace, 2000; Carey, 2000; Hamilton & Barton, 2000) The ALL survey definition of numerate behaviour acknowledges that numeracy is a skill used in real life contexts to solve real problems or questions. A distinction is made in this study between numeracy “skills” and “scores”, whereby the latter refer to findings exclusively from the ALL survey. The ALL survey, as will be discussed in the following chapter, uses a pen and paper test to assess numeracy skills in contexts that are purported to represent real-life numeracy, rather than the observation of behaviour that this definition suggests is necessary to explore numeracy skills. This is despite the evidence discussed later in this review, that pen and paper tests are a poor reflection of numeracy skills (Devlin, 1999). Furthermore, through using the phrase “may be represented in a range of ways” the ALL survey definition of numerate behaviour clearly implies the ability to transfer knowledge from one context to another despite the evidence that this is questionable (Devlin, 1999; Lave, 1988; Nunes, Schliemann, & Carraher, 1993).

Thus, a shortened definition of numeracy, which is constantly reiterated in the New Zealand findings on the ALL survey, may be closer to the realisation of ALL survey definition than the definition of numerate behaviour quoted earlier. The shortened definition is: “numeracy is the ability to understand and process mathematical and numerical information” (Satherley & Lawes, 2008a, p. 11, 2008b, p. 11; Satherley et al., 2008a, p. 11; Satherley, Lawes, & Sok, 2008b, p. 11).

The importance of understanding the concept of numeracy cannot be overstated. It provides points of reference against which to gauge the assessment tasks and the findings of the ALL survey. A dichotomy is also evident between numeracy as a learned cognitive skill and numeracy as learned in social practices.

### **2.2.2 Numeracy as a cognitive skill**

Underlying the ALL survey definition and the range of other definitions of numeracy remain questions of not only a Platonist or a Wittgenstenian view of mathematics but questions of whether numeracy is a learned cognitive skill or acquired through social practices. There is ample evidence that numeracy skills begin to be acquired prior to formal education by both adults and children (A. Rogers, Hunter, & Aftab Uddin, 2007; Saxe, 1988; Walls, 2006). The development of numeracy skills outside the education

system suggests that the cognitive skills necessary for numeracy are learned in social and cultural contexts. Research studies are often founded on the notion of numeracy as either a cognitive skill (Gibbs, 2010; Kane & Mertz, 2012; Maloney, Waechter, Risko, & Fugelsang, 2012) or as situated in social practices (Baker, 1998; Heath, Fuller, & Johnston, 2010; A. Rogers et al., 2007). Thus, the separation of the cognitive and social practice aspects in the development of numeracy skills may not be as apparent as some of the research studies imply.

Many of the research studies investigating gender differences in numeracy or mathematical skills are cognitive in nature and experimental in design (Maloney et al., 2012; Mendick, 2005a). One outcome of these methodologies is to suggest that an individual variable (for example, spatial processing ability) may be the cause of gender disparity when spatial processing may be learned or tested within gendered contexts. Alternatively, spatial processing skills *in situ* may be different from online spatial imaging questionnaires (as used by Maloney et al.) or in two-dimensional pen and paper tests.

This issue is relevant to this thesis because a standardised pen and paper numeracy test, such as the ALL survey assessment, may have inbuilt gender differences as a result of using two dimensional representations of numeracy.

Deeming numeracy as a mainly cognitive skill implies the acquisition of a range of stratified cognitive abilities, transferrable from one context to another and largely independent of culture (FitzSimons, 2002) despite the acknowledgements in the ALL survey definition that numeracy is situated within real contexts which are overlaid with social beliefs and culture.

### **2.2.3 Ethnomathematics**

Ethnomathematics contributes to an understanding of how the notion of numeracy includes cultural and sub-cultural dimensions. D'Ambrosio (1997) argues that mathematics and numeracy are not fixed, universal truths, but are situated within culturally determined modes of thought and knowledge. There is a growing school of research on ethnomathematical perspectives, and D'Ambrosio challenges the absolutist, Platonist conceptualizations which are still popular in the academic world of classroom

mathematics. There is, then, an emerging body of evidence of culturally constructed numeracy understanding (Lekoko & Garegae, 2006; McMurchy-Pilkington, 1996; Nasir, 2002; Nunes et al., 1993; Reed & Lave, 1979; Saxe, 1988; Scribner & Cole, 1981; Street, Baker, & Tomlin, 2005).

This is of relevance when considering the ALL survey. If numeracy is known to be constructed differently in different cultures then using a form of skill assessment that is purported to be independent of culture may be inadvertently reflecting or valuing, for example, western academic culture. An appreciation of the theoretical and research foundations of ethnomathematics enables us to consider mathematics and numeracy within cultural activities.

Ethnomathematicians argue that although belief in the universality and fixed nature of mathematics is common, different modes of thought and ways of thinking, embedded in culture, lead to different forms of mathematics for different cultures or subcultures (D'Ambrosio, 1997; Wedege, 2010a). D'Ambrosio would argue that the children selling candy in Brazil, for example, have developed a form of mathematics that is particular to the "ethnos" of the context, the situation, and the users.

Lave marks a further divide between "school" and "street" mathematics (Lave, 1997). Lave's research draws on the use of arithmetic by dieters, supermarket shoppers and Vai and Gola tailors in Liberia. Her research supports the arguments that schools teach different mathematical processes from those used in "street" mathematics (Greiffenhagen & Sharrock, 2008). Indeed, one issue with numeracy and mathematics may be that people cannot do "school" numeracy and mathematics rather than they cannot do numeracy or mathematics (Devlin, 1999). A small number of research studies in New Zealand illustrates some distinctive facets of culture and mathematics (Macfarlane, Glynn, Grace, Penetito, & Bateman, 2008; McMurchy-Pilkington, 1996; Ohia, 2002; Rawiri, 2006).

New Zealand has both an indigenous Maori population and a Pasifika population who have been identified in the ALL survey literature as having lower numeracy skills than other sectors in the New Zealand population (Lawes, 2009a; Satherley & Lawes, 2009a, 2008a).

Consequently, the question should be posed as the extent to which people from these minority groups have poor skills and the extent to which their numeracy skills are culturally embedded and may not be recognised or captured by the ALL survey assessment questions.

A study by Macfarlane, Glynn, Grace, Penetito, & Bateman (2008) provides significant insight into pedagogy and cultural practices involved in numeracy in Maori culture.

A Maori worldview is based on learning within caring, respectful and supportive human relationships. A collective identity and accepting group responsibility for others, underpins Maori learning contexts as distinct from the individual often competitive European educational models. Furthermore, pivotal to a Maori view of learning is the concept of “ako” or a free exchange of the learner and teacher roles (Macfarlane et al., 2008). This is relevant because it contrasts the difference between the philosophical and pedagogical approaches to learning within indigenous cultures and the subtle implicit cultural underpinnings of the ALL survey assessment process. If knowledge is communally rather than individually constructed (as in Maori society) then individual assessment processes may be seen as a cultural imposition. This example of the cultural dimensions of learning and of mathematics, highlights the difficulty of using definitions, teaching approaches and assessment processes of mathematics or numeracy that ignore the cultural dimension. The result can be a view of numeracy as a set of discrete and individual skills. In turn, this possibly stigmatises adults with cultural backgrounds and practices that position them in terms of their ALL survey scores as having ‘poor’ numeracy skills. As FitzSimons (2002) points out, mathematics is not universal in its language, knowledge construction or the values portrayed in its teaching and assessment.

The distinction has been made between ethnomathematics with its origins in culture and socio-mathematics with its origin in society (Tett, Hamilton, & Hillier, 2006; Wedege, 2010b). Social practice views of numeracy suggest that numeracy reflects the complexity of practices situated not only in culture of society but within social contexts which may be special interest groups, workplaces or other groups with discernible common interests (Tett et al., 2006).

## **2.2.4 Social Practice approaches to numeracy**

A social practices understanding of numeracy has emerged strongly in the last two decades. Social practice theories emphasise that people personalise, adapt and utilise numeracy (and literacy) within socially constructed activities rather than seeing numeracy purely in cognitive terms (Street, 2003).

Social practice theory acknowledges that adults can have widely differing numeracy (or literacy) skills in different contexts (Baker, 1998; Barton, Hamilton, & Ivanic, 2000; Lerman, 2001; Reder, 2009; Saxe, 1988; Street, 1984). For example, a dressmaker may be highly skilled at reading pattern instructions, and yet be unable to read or use instructions for sending emails. In addition to number skills, real-life tasks may require spatial understanding and pattern identification (Harris, 1997). The previous discussion of vertical and horizontal discourses suggests that many of these practical contexts for using and learning numeracy are horizontal discourses that may be taught face to face. Furthermore, such methods of transmission of skills may or may not include deliberate language acquisition. It is quite likely that the learning of these discourses may require some input from traditional theoretical mathematical underpinnings (Bernstein, 1999).

Social practice theories emphasise the links between everyday life and learning as well as the relevance for adults of accessing learning that builds on and enhances these links (Ivanic, Appleby, Hodge, Tusting, & Barton, 2006; A. Rogers, 2003; Tusting & Barton, 2003).

Illustrating both a social practices and an ethnomathematical approach is a New Zealand study which investigated the links between everyday life and numeracy used by Maori women in a cultural context – the “marae” (McMurphy-Pilkington, 1996). “A marae, at its simplest, might be referred to as an agglomeration of separated, functional buildings on an area of reserved land, usually deemed to be sacral to some extent” (Bennett, 2007, p. 5).

Hospitality has great cultural importance for Maori, particularly on the marae. Provision of adequate quantities of good quality food affects the mana (or prestige and status) of the marae (McMurphy-Pilkington, 1996). Interviews with Maori women who provided food for such community-organised marae functions showed that decisions

about what to cook in relation to the numbers of visitors, the type of food and the cooking time were made by the women organising the catering, through oral discussions. Different ratios were used for the proportions of food for Maori and Pakeha (non-Maori) visiting the marae. Different food types (including potatoes, kumera, pumpkin, chicken, pork, steamed pudding) had different ratios. For instance, one steamed pudding would feed 25 Maori or 60 non Maori. The women using these ratios had learnt this knowledge informally in the kitchens from the older women. The important point is that, in this study, the women made no connection between the ratios used in the kitchen and mathematics of ratios they had been taught at school (McMurchy-Pilkington, 1996). Here is an example of numeracy skills learnt and used in a specific cultural setting for a specific purpose and not the result of these skills learnt in a formal education setting and transferred to a desired context – the study can be seen through the lens of ethnomathematics, sociomathematics or social practices, with each perspective highlighting different aspects of how a conceptualisation of numeracy might be formed.

A further example of numeracy skills informally acquired and used, comes from the work of Saxe (1988) who described the mathematical processes and discourses negotiated by mostly unschooled, candy-selling children in Brazil. At the time of Saxe's study, the annual inflation rate in Brazil was 250%, indicating the need for frequent repricing of the candy. Saxe found there was interplay between both social and developmental processes in the mathematical learning relating to candy selling, with the older children (in their early teen years) using more complex pricing ratios than the younger children. Saxe (1988) found the children's cognition relating to this mathematical concept was developed through the social processes involved in candy selling (Saxe, 1988).

Case studies in Bangladesh highlight the successful acquisition of numeracy skills by men who had no schooling. The men required numeracy skills to establish and run their own businesses, including one business that expanded overseas (A. Rogers et al., 2007). Numeracy was also a vital business tool for women street vendors in Botswana (Lekoko & Garegae, 2006). The women street vendors used informal strategies for their day-to-day buying and selling processes, manipulating figures through verbal exchanges in much the same way as the Maori women in the marae kitchen negotiated the volumes



and ratios for different foods. The Botswana street vendors, in contrast with the Maori women, had little understanding of budgeting costs or the profitability of their businesses.

This selection of research on examples of numeracy skills acquired by individuals to meet social, economic or practical needs shows some of the variety and complexity of both the numeracy skill needs and the social practices in which these skills may be embedded. Examples also include how families informally incorporate teaching numeracy into their everyday activities under such guises as planning for a school ball, understanding and using baseball statistics or practically evaluating and selecting public transport options (Goldman & Booker, 2009). Other contexts for developing numeracy skills include nursing (Coben, 2007), health (Huizinga et al., 2009; Wister, Malloy-Weir, Rootman, & Desjardins, 2010), tailoring (Shiohata & Pryor, 2008), and financial literacy (Balatti, Black, & Falk, 2009; Coben, Dawes, & Lee, 2005; Lusardi & Mitchell, 2007) or workplace skills (Kell, 2009; Reid, 2008; Wedege, 2003). These contexts are but a small selection of possible social practices within which numeracy knowledge and skills may be learned, taught or used. These contexts emphasise the placement of numeracy as a situated practice that occurs within social and cultural domains rather than a set of skills learned as part of a hierarchical mathematical discourse and transferred into practical uses.

### **2.3 Transfer of learning**

Transfer of learning takes place when learning in one context (for example, a classroom) can be “transferred” and used in other contexts or situations (Perkins & Salomon, 1992). The concept of transfer of learning is at the very foundation of formal education processes with the expectation that, upon leaving school, people will be able to adapt and use learned processes in multiple contexts (Tusting & Barton, 2003). As discussed previously, such a concept also underlies the ALL survey. A review of learning transfer found extensive research in human resources literature but relatively few corresponding studies in the adult education sector (Merriam & Leahy, 2005). There is surprisingly little research on the transfer of numeracy learning in particular. Some very basic, internalised aspects of numeracy (for example, some basic number knowledge) may transfer readily (Coben et al., 2003). However, the transfer of higher level skills is more doubtful. Factors that may contribute to the transfer of learning

include intelligence (Mikulecky, Albers, & Peers, 1994) and the cognitive distance between the learning situation and the application of the learning (Merriam & Leahy, 2005; Williams & Wake, 2006). Factors that affect the transfer of learning from education programmes into the workplace include involving the learner in planning the educational programme; building strategies for transfer into the programme design and fostering of a supportive work environment to enable transfer (Cameron et al., 2011; Merriam & Leahy, 2005). However, these studies are about transfer of learning from the learning context *into* the practical context rather than about measuring skills from practical contexts rearranged into ALL survey questions. Pragmatic workplace and life contexts are often different from learning and assessment situations (Henningsen, 2006; Tusting & Barton, 2003; Wedege, 2010c).

Transfer of learning implies a form of knowledge that is objective, analytical and detached from the learned context. Some writers (Ernest, 2002; Zohar, 2006) distinguish between two forms of knowledge which Zohar suggests may be gender related. These forms are “connected knowledge” which aims to understand, as distinct from “separate knowledge” which is knowledge that can be detached from the context and which uses fixed rules and procedures (Zohar, 2006). Zohar’s literature review shows that women tend to prefer connected knowledge.

There is a suggestion in the literature that high level mathematical strategies may not transfer as automatically but require specific teaching and focused practice (Mikulecky et al., 1994). The implication of this need for specific teaching and practice of numeracy tasks suggests that adults with less mathematics education (or specific teaching and practice) may find completing the numeracy tasks in the ALL survey more difficult than those with greater education. However, this does not imply that those adults are unable to perform in situ numeracy tasks, particularly after receiving specific teaching and practice. Nor does this suggest that adults are unable to acquire and learn skills in specialised personal interest fields. However, personal motivation and attitudes, as will be discussed later, are important influences on the willingness and the ability of adults to acquire and use numeracy skills.

Sierpinska (1995) argues that mathematical knowledge is generated from personal problem-solving either in classroom situations or everyday situations. She suggests that skills and information are not transferrable although knowledge can be transferred from

one situation to another. This begs the question of whether the ALL survey is assessing “skills” or “knowledge”. The survey purports to assess skills but, as has been argued, is likely to assess *transferable* skills. Alternatively, the ALL survey may be assessing “knowledge” and the subset of “separate” knowledge whilst calling it “skills”. This is a dichotomy that should be considered when evaluating the ALL survey questions described in the next chapter.

Consideration should also be given to the distinction between “school” mathematics and everyday mathematics and the implications of this difference for the ALL survey. It is arguable that the mathematics that many adults struggle with may be “school” mathematics rather than real-life mathematics, in part because of a large gap between the two contexts (Devlin, 1999). If the ALL survey actually assesses “school” mathematics rather than real-life mathematics, then the survey possibly underestimates the skills of adults in real life.

The distinction between everyday numeracy and school numeracy tasks has several dimensions. Everyday tasks imported into numeracy classrooms tend to change nature and become “school” tasks. These tasks are then transformed into academic questions which are imbued with power and status, often with right and wrong answers. As a result of this transformation, a gap develops between school contexts and real-life contexts, despite the reality of the original context (Sierpiska, 1995). Furthermore, real-life mathematical problems are frequently solved in a collaborative or “connected” knowledge manner rather than separate or isolated situations (Devlin, 1999; FitzSimons, 2002; Williams & Wake, 2006). This dissonance between real-life or everyday contexts and school or academic contexts is a repeated theme throughout this study.

Two further points affect the transfer of learning – the distance and/or the time gap between the learned activity and the test questions. The ALL survey incorporates the first of these points but overlooks the second point (Gal et al., 2005). However, the time gap between initial learning and usage, or lack of usage, could also be critical for answering the ALL survey questions.

The thinking and problem-solving problems and processes of informal everyday life contexts are often different from more formal learning and assessment situations and the transfer of learning may be problematic (Henningsen, 2006; Tusting & Barton, 2003).

However, co-operative learning with authentic tasks may be the best context for transferring complex learning (Mikulecky et al., 1994). Despite the research evidence that indicates the complex nature of transfer, transfer of learning is situated at the heart of the ALL survey numeracy tasks.

Coben et al. (2003) identify the question of learning transfer as a key question for all mathematics educators and suggest a need for further research on this issue.

Transfer of learning presupposes a sense of empowerment relating to mathematics. Confidence in using mathematics as well as a sense of control over the use and creation of mathematical knowledge develops identities as knowers and users of mathematics. The next section will address identity and the following section attitudes and emotions towards numeracy although these two facets are interrelated.

## **2.4 An identity as a knower and user of numeracy**

Understanding identity and its development further contributes to understanding adults and their mathematical skills. Beliefs about oneself, both positive and negative, as a knower and user of mathematics can have an effect on learning transfer and on mathematical performance (Cobb & Hodge, 2010; de Freitas, 2008; Solomon, 2007a; Tomasetto, Alparone, & Cadinu, 2011). When students have constructed and negotiated identities that are comfortable with the discourse of mathematics they enjoy mathematics and are more likely to continue to study the subject (Boaler, William, & Zevenbergen, 2000; Buerk, 1985; de Freitas, 2008).

Researchers have been investigating identity in an attempt to explain gender differences in numeracy performance (Evans, 2000; Forgasz, Becker, Lee, & Steinhorsdottir, 2010; Nasir, 2002; Solomon, Lawson, & Croft, 2011; Swain, 2005). In general, researchers have found men and women have differing mathematical identities.

Identity is both internalised and dynamic and constructed partly through culture and language (Cobb & Hodge, 2010; Solomon, 2007a). However, the concept of identity is articulated somewhat differently through different theoretical lenses within the schools of psychology. Post-structuralists such as Foucault and Derrida see identity as discursively and semiotically constructed as well as potentially unstable (Grootenboer, Smith, & Lowrie, 2006; Van De Mierop, 2005). Cognitive psychologists (such as

Erikson and Piaget) view identity as individual and internalised. Social psychologists (for example, Wenger, Vygotsky, Bourdieu and Bernstein) view identity as socially constructed and situated (Grootenboer et al., 2006). Consequently, identity can be seen as changeable, constructed through language, social attitudes and behaviour but remaining individual and internalised. Identity can, thus be seen as the result of accumulations of experience within social contexts (Solomon, 2007a).

One feature of identity is its multiple facets – one individual can have many different identities, for example, as a parent, student, teacher, worker, neighbour or as a knower and user of mathematics. Fortunately for people with negative mathematics identities, such identities are not fixed during a lifecourse but are changeable and renegotiable (Cobb & Hodge, 2010; Mendick, 2005b; Swain, 2005).

Positive mathematical identities may provide benefits and advantages to such holders (Ernest, 2002). Confidence in one's mathematical ability can have valuable social benefits such as employment or educational opportunities and is central to developing a positive mathematical identity (Ernest, 2002; Parsons & Bynner, 2005). Mathematical identities are influenced by educational institutions, teaching approaches and assessment (Ernest, 2002; Solomon, 2007b). However, mathematical identity can also incorporate negative identities or *disempowerment* through mathematics with women often feeling anxiety and alienation in relation to mathematics (P. Rogers & Kaiser, 1995; Solomon, 2007b; Swain, 2005).

Such alienation can take several forms: it can be alienation with the way maths is taught, with the nature of mathematics itself, or with attitudes surrounding mathematics learning. With a social constructivist view of identity in the main, Klein (2002) suggests that effective mathematics teachers create discursive spaces within their mathematics classrooms whereby learners have the opportunity to construct identities as doers of mathematics. However, some adult learners may have been so disempowered in relation to mathematics that they need to acquire appropriate language in order to access and use mathematical concepts in such discursive spaces (Fullerton, 1995; Helme, 2002; Lerman, 2001). Thus, the creation of discursive spaces and a mathematics register is then seen as necessary to develop positive mathematics identities.

Identity can incorporate a sense of affiliation with mathematics which results in persistence and motivation to engage with mathematics activities (Cobb & Hodge, 2010). However, personal conflict can arise with identity. Cobb & Hodge (2010) describe three forms of identity: normative, core and personal. Normative identity in the mathematics classroom is developed through adopting and using the mathematical conventions or developing a mathematics register, to operate effectively in a mathematics classroom. Adopting a normative identity in mathematics includes using mathematical logic and arguments, reasoning, using appropriate written symbols and notations and engaging with the social context of the classroom. Core identity is the person's sense of who they are, who they want to become and where they belong in the world so a mathematics identity may or may not relate to core identity. Personal identity in the mathematics classroom concerns who the learners are becoming in particular mathematics settings and is the outcome of a reconciliation of the normative and core identities. However, conflict can occur between the normative and core identities (Cobb & Hodge, 2010), which could be the situation with gender-ascribed mathematics identities (Cobb & Hodge, 2010; Solomon, 2007a; Walkerdine, 1998). In relation to numeracy, adult educators may strive to develop durable and positive changes in identity; however, achieving this is not straightforward. Making connections between learners' lives and mathematics teaching as well as de-emphasising directed learning in the mathematics classroom while attend to interactions and relationships that produce identities as mathematics users and knowers are two strategies that can be adopted (Coben et al., 2007; Klein, 2002; Lerman, 2001; Swan, 2006).

There may also be a disconnect between mathematical identity and a numeracy identity, insofar as adults may see mathematics as something they cannot do, whereas everyday numeracy is so commonplace it is regarded as common sense rather than mathematics (Coben et al., 2003; McMurchy-Pilkington, 1996). This suggests an identity as a person of common sense but not necessarily as a knower and user of mathematics or numeracy. Consequently, identities as knowers and users of mathematics or numeracy may need to be recognised as such by the individual operating in different contexts.

Associated with mathematical identity is the concept of empowerment. This affects identity because a positive identity develops in parallel with empowerment through the learning and use of mathematics (Ernest, 2002). There is a range of mathematical

empowerment from passive, silent acceptance of mathematical knowledge to, at the other extreme, integrated, self-constructed mathematical knowledge. At this highest stage the knower has developed a strong sense of identity as a knower and user of mathematics (Ernest, 2002). However, Ernest suggests most individuals do not reach this highly developed stage of empowerment. Indeed, some highly skilled women mathematicians do not recognise themselves as “mathematicians” (Damarin, 2008).

The complexity of this dissonance between numeracy, mathematics and identity in focussing on the individual, could overlook the processes of connected or communal knowing, despite the evidence that this is a common way to develop and use numeracy skills and understanding (McMurchy-Pilkington, 1996; Williams & Wake, 2006).

The ALL survey is able to shed some light onto identity relating to mathematics through a series of questions that ask about school experiences relating to mathematics. This issue has relevance for the survey insofar as such an identity can contribute to either engagement with or withdrawal from engagement with the numeracy questions. If a personal identity is associated with, for example “I can’t do fractions” then the survey respondent may refuse to answer those questions, irrespective of the complexity of the actual numeracy content of the question or of the respondent’s capacity to complete the task. The ALL survey differs from real-life, however, because it is locked into an individual assessment process rather than the collaborative and communal way in which numeracy skills are often used and known.

As has already been discussed, identity is formed through an accumulation of experience in social contexts. Associated with mathematical skills and identity are a range of emotions which influence both willingness to engage with acquiring numeracy skills or undertake numeracy tasks.

## **2.5 Emotions and numeracy**

Emotions and identity, because of their origins in social contexts and prevalent discourses, affect engagement with learning and using mathematics and numeracy (Evans, Morgan, & Tsatsaroni, 2006). As far back as 1982, the Cockcroft Committee argued that teachers of numeracy should be addressing affective factors in mathematics classrooms (Coben et al., 2003). However, despite thirty years having passed, strong negative emotions relating to mathematics and numeracy, such as anxiety, avoidance

and a lack of confidence, remain common among adults. Such attitudes are particularly evident in women (Ashcraft, 2002; Coben et al., 2003; Klinger, 2008). Potentially damaging attitudes towards mathematics are not the sole preserve of people with poor skill levels but may also be evident in women with high mathematical skills (Buerk, 1985; Damarin, 2008).

Mathematics anxiety is a well-documented phenomena that may be sufficiently severe as to result in physical as well as emotional effects (Hembree, 1990; Ingleton & O'Regan, 2002). Such anxiety is often associated with assessment tasks, particularly school-like assessment tasks (Ashcraft, 2002; Beilock, Gunderson, Ramirez, & Levine, 2010; Ingleton & O'Regan, 2002). High levels of mathematics anxiety may have affected the ALL survey findings in several different ways, which will be discussed shortly.

Many of the research studies suggest two aspects as the cause of mathematics anxiety: the ways mathematics is presented in school classrooms and the social factors which reinforce these practices (Beilock et al., 2010; B. Johnston, 1992; Klinger, 2008).

High maths anxious adults often report alienation with mathematics such as not seeing the relevance, not having time to think through or talk through mathematical concepts or being detrimentally affected by a view of mathematics as detached, logical, objective and often male. Mathematics anxiety amongst women and girls is often reinforced by teachers, male siblings, parents, peer groups or other people resulting in lost self-esteem (M. Burkley, Parker, Stermer, & E. Burkley, 2010; Fullerton, 1995; Park, Young, Troisi, & Pinkus, 2011).

Buerk (1985), in a seminal study, researched able math-avoidant women and found that these women believed mathematics to be absolute rather than a human construction. They saw mathematics in terms of single correct answers, strict rules and precise symbols. In contrast Buerk saw mathematics as interrelationships influenced by historical thinking including developments in the philosophy of mathematics. Buerk's view of mathematics as creative, dynamic and constantly evolving was in sharp contrast with the negativity associated with the absolutist visions of mathematics by the math-avoidant women. Buerk found that the absolutist view prevented women from making personal and emotional connections with mathematical material and ideas and thus



becoming more mathematics avoidant (Buerk, 1985). Buerk's study reinforces both the importance of emotions and mathematics as well as the relevance of philosophical and pedagogical approaches towards mathematics.

Studies of elementary school teacher trainees, the majority of whom are women, have shown that math anxiety and avoidance is often present, and may in turn have been affected by teaching approaches the trainees themselves experienced (Ashcraft, 2002; Goldman & Booker, 2009; Greiffenhagen & Sharrock, 2008; Klinger, 2008). The concern of these authors is that mathematics anxiety and avoidance may be transferred by these future teachers to their learners.

In addition to a formal education system, family and peers also influence attitudes to mathematics. Schools may try to encourage attitudes to mathematics that are at variance with the values or attitudes of family, peer groups or community. Such contradictions may result in identity conflicts (Burkley et al., 2010; Cobb & Hodge, 2010; Greiffenhagen & Sharrock, 2008; Park et al., 2011; Steffens & Jelenec, 2011).

These factors may have all influenced the approaches ALL survey respondents brought to answering the numeracy assessment questions. Whilst it could be argued that adults may also bring emotions to undertaking numeracy tasks in real life, there is evidence of a disconnect between tasks undertaken and completed in real life and school tasks (McMurchy-Pilkington, 1996; Williams & Wake, 2006). If, however, the ALL survey numeracy assessment tasks are viewed by the respondents as school-like numeracy tasks with right and wrong answers, with the tasks embedded in confusing language and of little relevance to personal interests or the respondent's real life, then the emotions that surround school mathematics learning may influence the approach the respondents bring to the assessment. This may result in panic, lack of persistence and the use of guesswork or intuition rather than logic when answering assessment questions (Kahneman, 2011). The importance of affect and emotion in the way respondents may have addressed the ALL survey questions could result in the survey underestimating the numeracy skills adults have and use frequently and easily in everyday life.

As has already been mentioned briefly, emotions and attitudes towards mathematics are related to, although not determined by gender.

## 2.6 Gender and numeracy skills

Gender differences in numeracy skills are well documented (Beilock, Gunderson, Ramirez, & Levine, 2010; Coben et al., 2003; T. S. Murray, et al., 2005; Parsons & Bynner, 2005; Satherley & Lawes, 2009a). These differences have been attributed to attitudes, feelings, stereotype threat and the consequences of affective issues as much as to actual cognitive differences (Beaton, Tougas, Rinfret, Huard, & Delisle, 2007; Coben et al., 2003; Hyde & Mertz, 2009; Mendick, 2005b; Rivardo, Rhodes, Camaione, & Legg, 2011; Tomasetto et al., 2011). Clear gender differences in skill are not only apparent among those with low skills but are also apparent at advanced levels of mathematics (P. Rogers & Kaiser, 1995; Sommers, 2008; Stoeger, 2004; Willis, 1989). Research suggests that the effects of poor numeracy skills may be greater on women than on men (Parsons & Bynner, 2005; Reder & Bynner, 2009). Gender differences in numeracy skills are of relevance to the ALL survey information because of the tacit assumptions with respect to gender that underlie the survey and the assessment tasks. This section will investigate the literature on gender differences relating to numeracy including teaching approaches, biological differences, personal sentiments, and social or cultural attitudes.

As has been discussed previously, there may be gender preferences with men and women tending to prefer different ways of knowing and learning mathematics. Consequently, some of the gender differences in mathematics performance may be an outcome of teaching approaches that do not relate to preferred learning styles (Zohar, 2006).

Alternatively, there is some indication in the literature that gender differences in approaches to mathematics may have a biological basis – an example being differences in spatial processing (Maloney et al., 2012). However, there is also evidence from investigations of the spatial processing aspects of intelligence tests, which suggests spatial processing itself is culturally defined (Clifford, 2008). Consequently, current research is unable to provide incontrovertible answers to this question. If gender differences were biological in origin, one could expect to see consistently similar patterns of gender differences in mathematics ability from cross-cultural studies, but this is not the case (Kane & Mertz, 2012).

A United States 1990 meta-analysis of studies on gender difference in mathematics performance showed that while a very small gender difference in early mathematics skills was apparent at elementary levels, “a gender difference favouring males emerged in high school” (Hyde & Mertz, 2009, p. 8801). These authors suggest that differential patterns of course-taking may account for this difference, with socialisation and discrimination as lesser factors. There is, however, considerable international difference in findings in mathematics performance with respect to gender, with girls having the same or better mathematics performance in countries other than the United States. As a result, Hyde & Mertz (2009) argue that gender differences in mathematical performance are due to changeable socio-cultural factors rather than innate biological differences. Support for the argument that gender differences in mathematical scores are socio-cultural in origin is common (Ceci & Williams, 2010, 2011; Lindberg, Hyde, Petersen, & Linn, 2010; York & Clark, 2007), although there is research suggesting that self-confidence (Carr, Steiner, Kyser, & Biddlecomb, 2008) or sexism (Sommers, 2008) cause or contribute to these differences.

Stereotype threat may also affect the ALL survey numeracy findings. Stereotype threat occurs when the “motivational, affective, psychological, and cognitive processes interact to impair performance in a stereotype-relevant context” (Schmader, Johns, & Forbes, 2008, p. 336). Stereotype threat has been shown to affect mathematics and numeracy test results through interfering with concentration and co-ordinating information processing. Such stereotype affect has been shown to affect the mathematical performance of girls (Steffens & Jelenec, 2011; Tomasetto et al., 2011).

A 2005 report from the United Kingdom on two longitudinal studies into numeracy and literacy skills using cohorts from 1958 and 1970 found that men had stronger numeracy skills than women (Parsons & Bynner, 2005). For women, the United Kingdom research reports that “while the impact of low literacy and numeracy skills is substantial, low numeracy has greater negative effect (than for men) even when it is combined with competent literacy” (Parsons & Bynner, 2005, p. 7). This research suggested that the modern job market demands numeracy and ICT skills for the types of jobs that appeal to women (particularly office and administration work). A lack of numeracy skills for women was more likely to lead to full-time home caring roles, belonging to non-working households, poor physical health, depression and factors that

can indicate social exclusion (non-voting, no interest in politics and feeling a lack of control over their lives)(Parsons & Bynner, 2005).

The IALS survey conducted in 1996 in New Zealand showed a gender difference on the quantitative literacy scores (which covered a subset of numeracy skills rather than the range of numeracy skills covered in the ALL survey) but the difference (around 5%) was not statistically significant (Culligan, Sligo, Arnold, & Noble, 2004). The 1996 IALS survey data from New Zealand is comparable with the much more recent IALS survey data from Scotland which found no significant gender differences in quantitative literacy scores (St Clair et al., 2010). However, the more recent New Zealand ALL survey (2006) shows small, but statistically significantly, higher numeracy scores for men than women (Satherley & Lawes, 2008a).

In New Zealand poor numeracy scores appear related to several socio-cultural factors: unemployment, semi and unskilled and manual jobs and low economic well-being (Dixon & Tuya, 2010; Smyth & Lane, 2009).

Educational attainment or qualifications are shown in the IALS survey as a strong predictor of adult numeracy scores (Culligan et al., 2004; St Clair et al., 2010) with poor numeracy scores for both men and women related to early exit from the compulsory education sector (Parsons & Bynner, 2005). Whether limited numeracy skills are a reason for non-participation in further education is uncertain, although the UK longitudinal study found people with the lowest levels of numeracy skills were least likely to receive work-related training (Parsons & Bynner, 2005).

Benn (1997) found that the common characteristic of adults learning basic mathematics was social background. Benn described most adults learning mathematics as belonging to the fringe of society and having weak or limited cultural capital. Cultural capital is the store of knowledge, attitudes and the disposition that resides within cultures. Cultural capital confers privileges to some, but not all, groups within that culture (Bourdieu, 1985). The importance of Bourdieu's idea is that it repositions education from being an individual attribute related to intelligence for example, to a form of capital which ensures a higher value is set upon scarcity. This emphasis on "scarcity" could result in an education structure which excludes, rather than includes people.

Harris (1997), like Benn (1997), views mathematics as having political, social and economic dimensions leading to mathematics discourses that are masculine and middle class. Mathematics as a subject serves a cultural capital purpose in that it has often been used to filter and fail people in terms of educational and professional advancement (Harris, 1997).

McMurchy-Pilkington (1996) found that the dominant mathematical paradigm rendered the Maori women's knowledge of numeracy relating to catering both silenced and invisible. McMurchy-Pilkington argued that school teachers need to link the mathematical knowledge they are teaching with the knowledge Maori girls are developing outside the school setting.

The arguments of Benn (1997) and Harris (1996) and those implied in McMurchy-Pilkington (1996), that mathematics learning and knowledge is overlaid with pedagogical, social, political and economic values which have effects on women, highlight the need for a careful examination of the test items used in the ALL survey in terms of the social, political and economic values that underlie the pen and paper test items. These authors also reinforce the importance of attitudes, feelings, identity and stereotype threat in relation to mathematical and numeracy skills.

Despite the purported poor numeracy skills of New Zealand women, attitudes and identity regarding mathematics may be changing. In 2000 around a third of New Zealand university graduates from mathematics, computer science, engineering, and manufacturing and construction faculties were women. In 2006 this proportion had unfortunately dropped to just fewer than 30%. This is, however, considerably better than the OECD average of around 25% for both years (OECD, 2008).

There is also international evidence of significant improvement in the participation of women in mathematics, engineering and science programmes (Kane & Mertz, 2012; OECD, 2008). This suggests that effective measures have been taken to change develop mathematical skills amongst women and girls. However, there is evidence that inequalities do continue to persist despite these improvements.

Whilst gender differences are found in mathematics and numeracy scores in test situations, few researchers ascribe the differences to differently gendered practices or to

the testing quality or methods. This raises the question of whether gender affects some facets of numeracy assessments rather than is a reflection of numeracy skills per se. The OECD sponsored IALS and ALL surveys appear to assume the latter. What does seem apparent from feminist and other researchers is that mathematics and numeracy are embedded not only in everyday social practices but within situations of social power and control.

## **2.7 Numeracy for social change**

Numeracy is often viewed as a skill required for good citizenship with better numeracy skills related to longer involvement in education and resulting qualifications, skills and income (Appleby & Bathmaker, 2006; Fenwick, 2006; OECD, 2007). One consequence of viewing numeracy in such a way is to make apparent the relationships between numeracy, power and domination (Belfiore, Defoe, Folinsbee, Hunter, & Jackson, 2004; Benn, 2001; Harris, 1997; Street, 2003).

Relations of power surrounding numeracy may be manifest in variable ways. For example, in New Zealand the mathematics curriculum in schools is determined by the state. Teaching of numeracy in the adult sector that is funded by the state, follows both the state mandated learning progressions and assessment (Tertiary Education Commission, 2008c).

From a different perspective of the exercise of power, ethnographic studies of workplace literacy practices in industrial or commercial businesses, found forms of passive resistance (Belfiore et al., 2004). This resistance often took the form of incorrect or non-completion of paperwork associated with quality management procedures, which were often ascribed by management to poor numeracy and literacy skills rather than acknowledged as political in nature.

Other studies suggest that resistance shown by women towards learning mathematics may be the outcome of relations of gendered power and dominance (Buerk, 1985; Fullerton, 1995; Walkerdine, 1998).

There is a suggestion that women engage less with mathematics and science tasks when pursuing everyday romantic goals (Park et al., 2011). This implies a dissonance between

romance and science or mathematics and could be part of role stereotypes discussed in the previous section.

However, perhaps the most significant question in regard to power and numeracy are the suggestions in the literature that cultural capital (in the form of literacy and numeracy skills) contributes to social inclusion. Social inclusion is seen in government policies as a benefit of adult numeracy education because of the statistical relationship shown between adult numeracy scores, education, employment and higher incomes (Appleby & Bathmaker, 2006; Benn, 1997; Dorgan, 2009; Ministry of Education, 2007). However, these findings are not causative and such assumptions must be questionable.

## **2.8 Summary**

This review has found mathematics and numeracy to be more than fixed universal truths but practices wherein knowers and users establish meanings that are appropriate personally and for the context within which they are being used. A distinction is made between mathematics as a vertical discourse and numeracy as a horizontal discourse (Bernstein, 1999).

The definitions of numeracy and numerate behaviour used in the ALL survey are presented. In light of the evidence that pen and paper tests of numeracy poorly reflect actual skills, the question of whether the ALL survey can accurately portray numeracy skills is raised.

There are competing views of what mathematics is and consequently what might constitute numeracy. These views have a strong impact on the underlying values that are incorporated in teaching and assessment processes. Evidence is provided that numeracy has both cultural and social dimensions with the possibility that the ALL survey may inadvertently value some forms of cultural or social content over alternative forms.

Underlying both the education sector and the ALL survey assessment framework is the assumption of transfer of learning which is found to be problematic. The literature suggests that adults may find “school maths” difficult rather than real-life numeracy tasks. Indeed, this study suggests that everyday tasks may change their nature when

they are transposed into the school classroom by, for example, adopting right and wrong answers. Implicit in this argument is that the ALL survey items may also change their nature when taken from real-life situations and transposed into pen and paper test items.

When people participate in mathematics and numeracy assessments both emotions and identities as knowers and users of mathematics and numeracy can affect engagement with the testing process. These effects, which may have social origins, cannot be treated as trivial. Emotions and identity may affect testing and assessment but not engagement with every-day numeracy tasks. Consequently, a distinction is made in this study between numeracy “scores” as measured in the ALL survey and numeracy “skills”.

International evidence is presented that suggests women do not engage as successfully with mathematics as men, and the possible reasons for this are discussed. Suggestions of cognitive differences are considered but, on balance, social factors are considered to be of greater importance.

This review reaches the conclusion that mathematics and numeracy knowledge are overlaid with pedagogical, cultural, social, political and economic values. The next chapter describes the ALL survey in detail and considers the values that that may underlie the survey.



## 3 THE ADULT LITERACY AND LIFE SKILLS (ALL) SURVEY

### 3.1 Introduction

The ALL survey findings have been highly influential in determining adult literacy (and numeracy) policy in New Zealand (Benseman, 2008; Ministry of Education, 2007; Tertiary Education Commission, 2008a, 2008b). The ALL survey findings reported over 50 % of New Zealand adults as having poor numeracy scores and women as having a lower level of scores than men – a finding that this literature review considers problematic (Satherley et al., 2008b; Tertiary Education Commission, 2008a).

Furthermore, this study finds a marked disparity between ALL survey numeracy scores for women and their self-perceptions of those skills. This chapter investigates the design, implementation and analysis of the ALL survey in capturing the range and quality of numeracy skills of adults. As the survey questions were the same, irrespective of gender, this chapter provides little information on women in particular. The major differences between the 1996 International Adult Literacy Survey and the 2006 Adult Literacy and Life Skills survey are outlined. The ALL survey questionnaire, the sampling method, the weighting processes, the balanced incomplete block (BIB) design and the use of item response theory (IRT) are explained. Some sample assessment items are presented and the self-assessment questions are discussed. Finally, in addition to outlining the ALL survey research process, this chapter also identifies the major current critiques of the IALS and ALL surveys.

Some key documents have been used in this study as authoritative references to make sense of the ALL survey. The framework for the survey is elucidated in *International Adult Literacy Survey, Measuring Adult Literacy and Life Skills: New Frameworks for Assessment* by the survey designers, Statistics Canada and the OECD (Murray, Clermont, & Binkley, 2005). The assessment question exemplars are detailed in T. S. Murray, et al. (2005). Following the examples of earlier researchers, these sources from Statistics Canada and the OECD have been used in references in the ALL survey (Henningsen, 2006; Statistics Canada, n.d.; Strafford, 2009; Thorn, 2009; Tout, 2008; Wister et al., 2010).

## 3.2 Background

The Organisation for Economic Co-operation and Development (OECD) has, in recent years, sponsored internationally comparative adult literacy research within a human capital agenda (Appleby & Bathmaker, 2006; Coulombe, Tremblay, & Marchand, 2004; OECD, 2007). The OECD argues that improvements in numeracy and literacy levels of the population will lead to improvements in both national productivity and national standards of living (Coulombe et al., 2004; OECD, 2007). In order to better understand the contribution of numeracy and literacy skills to human capital, the OECD promoted the IALS survey in the mid-1990s and the ALL survey in the mid-2000s (Murray, Clermont, et al., 2005; Murray, Owen, et al., 2005; Satherley et al., 2008b).

The International Adult Literacy Survey (IALS) was an internationally comparative adult literacy skills survey that assessed three dimensions of literacy: prose, document and quantitative literacy (Murray, Clermont, et al., 2005). The IALS survey provided “previously unavailable information on the distribution of adult literacy and numeracy skills and has provided tantalising insight into the causes and consequences of these skills for a range of countries” (Murray, Clermont, et al., 2005, p. 12). IALS was developed by Statistics Canada, the Educational Testing Service (ETS) and the United States Department of Education’s National Centre for Education Statistics (OECD & Statistics Canada, 2000).

There is a common belief in New Zealand in the economic power of both adult literacy and numeracy skills and education and this belief has provided a rationale for New Zealand’s engagement with both IALS and the ALL survey (Benseman & Sutton, 2008; Mason & Osborne, 2007; Ministry of Education, 2007; Skill New Zealand, 2002).

Prior to New Zealand taking part in IALS in 1996, information on the numeracy skills of New Zealanders was largely anecdotal, which resulted in limited official recognition of the sector (Benseman, 2008).

In 2006 New Zealand participated in the subsequent Adult Literacy and Life Skills (ALL) survey, which expanded on the IALS. The later survey incorporated some of the IALS assessment items and expanded the number and range of the test items (Murray, Clermont, et al., 2005; Strafford, 2009). The information gathered from the ALL

survey has been used as the foundation for new policy developments and further funding in adult education in New Zealand (Ministry of Education, 2007; Strafford, 2009; Tertiary Education Commission, 2008a; J. Walker, 2009).

The theoretical framework for the design of the ALL survey is based on the *Definition and Selection of Competencies: Theoretical and Conceptual Foundations* (DeSeCo) (Federal Statistical Office, Switzerland, 2005; Murray, Clermont, et al., 2005). DeSeCo is described as providing a common understanding of key adult competencies relevant for personal social and economic well-being (Murray, Clermont, et al., 2005). The key adult competencies identified by the DeSeCo project are defined as individually based competencies that:

- are instrumental for meeting important, complex demands in multiple areas of life
- contribute to highly valued outcomes at the individual and societal levels in terms of a successful life and a well-functioning society; and
- Are important to all individuals for coping successfully with complex challenges in multiple areas (Murray, Clermont, et al., 2005, p. 35).

The three broad categories of competence described by DeSeCo (Federal Statistical Office, Switzerland, 2005) are the ability to:

- Use tools interactively (e. g. language, technology)
- Interact in heterogeneous groups
- Act autonomously

A “competency” is described as “more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilising psychosocial resources (including skills and attitudes) in a particular context” (Federal Statistical Office, Switzerland, 2005). The DeSeCo project acknowledges the complexity of competencies which incorporate reflective thought and actions, moral and intellectual maturity and taking responsibility for learning and for actions (Federal Statistical Office, Switzerland, 2005). The DeSeCo project descriptions of adult competence have

influenced the development of test items in the ALL survey (Murray, Clermont, et al., 2005).

IALS (conducted in 1996 and pre-dated the DeSeCo competencies) incorporated three skill domains: prose, document and quantitative literacy, and a close correlation (approximately  $R = .90$ ) has been shown between each of the domains (Rock, 1998). Prose literacy was defined in both IALS and the ALL survey as “using printed and written information to function in society, to achieve one’s goals, and to develop one’s knowledge and potential” (Statistics Canada, 2002, p. 7). Prose literacy includes continuous texts or texts that are composed of sentences that are, in turn, organised into paragraphs (Murray, Clermont, et al., 2005). Prose literacy tasks included items such as finding information from the label on an aspirin packet, reading instructions on selecting the size of a bicycle frame or using one’s own words to describe, in writing, the difference between a job hiring panel and a group interview– information which was given in a piece of written text (Statistics Canada, 2002).

Document literacy differs from prose literacy in that document literacy uses non-continuous texts (Murray, Clermont, et al., 2005). Document literacy tasks included reading charts, graphs, or tasks such as a table that presented a consumer assessment of clock radios (Statistics Canada, 2002) (see Appendix C).

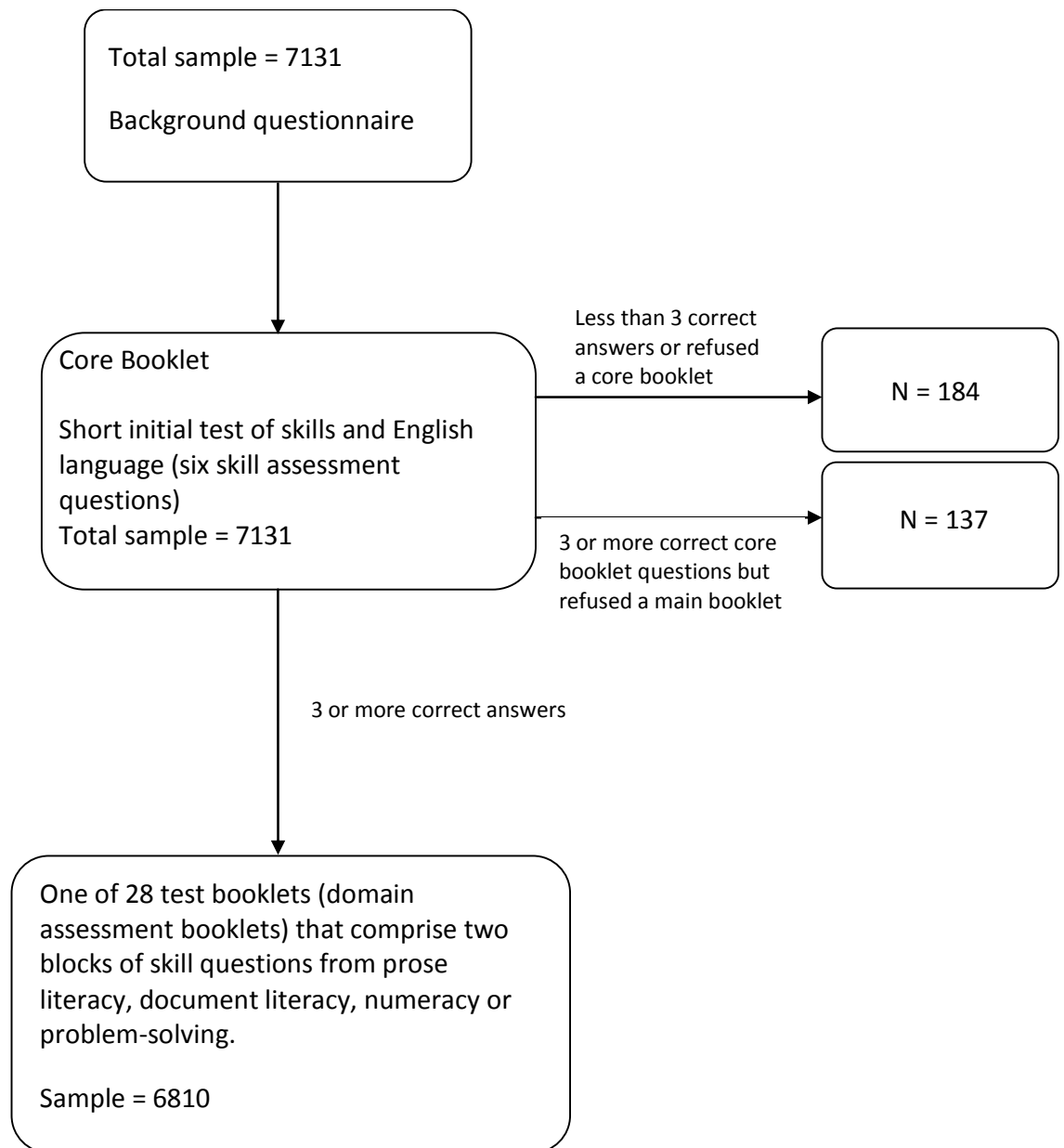
The numeracy and problem-solving domains were first used in the ALL survey (IALS used the term “quantitative literacy” rather than numeracy) and test items and exemplars were developed for each of these two newly developed domains (Murray, Owen, et al., 2005).

Efforts were made to develop and test measures for a teamwork domain, a practical cognition framework and an ICT literacy framework for inclusion in the ALL survey (Murray, Clermont, et al., 2005). The teamwork assessment framework sought to assess the skills needed for effective teamwork: group decision-making and planning, adaptability and flexibility and thirdly, interpersonal relations (Murray, Clermont, et al., 2005). The practical cognition framework distinguished “between academic cognition (or book smarts) and practical cognition (or street smarts or common sense)” (Murray, Clermont, et al., 2005, p. 278). The ICT framework proposed for the ALL survey maintained that ICT proficiency had two underlying dimensions: cognitive and

technical proficiency. Both cognitive and technical proficiency were seen as necessary to access, manage, integrate, evaluate and create information in a technology context (Murray, Clermont, et al., 2005). However, robust measurement assessments were not able to be developed for teamwork or for practical cognition. The assessment developers found that teamwork could only reliably be undertaken by observation (Murray, Clermont, et al., 2005). Despite the recognition of researchers' need to observe teamwork skills, the same recognition was not extended to observing numeracy skills used in context. Instead of observation of numeracy skills, a pen and paper test was adopted to measure numeracy skills. The ICT literacy domain was developed to acknowledge the changing nature of literacy but was not available in time to be included in the ALL survey (Murray, Clermont, et al., 2005). The practical cognition framework faced issues of validity, reliability, objective scoring, translation and culture (amongst other issues). As a consequence, the practical cognition and teamwork domains were discarded from the ALL survey, leaving the domains of prose and document literacy, numeracy and problem-solving (Murray, Clermont, et al., 2005). The discarding of the teamwork and practical cognition frameworks has resulted in an ALL survey which has diminished the scope of the value and the complexity of DeSeCo competencies.

The ALL survey gathered data using three research instruments. Firstly, the survey used an extensive background questionnaire which sought information on demographic, educational, employment and other social and economic parameters. The background survey was administered to all respondents. Secondly, a short initial test of performance of prose and document literacy, numeracy and problem-solving (the "core booklet") was used as a screening test of English language, numeracy and literacy skills (Strafford, 2009). Finally, if a particular standard was achieved in the screening test, a test booklet was used to gauge the skill levels in one or two of the four literacy domains (prose, document, numeracy or problem-solving). The survey used 28 different test booklets which were randomly assigned to the respondents (Statistics Canada, 2002; Strafford, 2009). This is described in more detail in the section describing balanced incomplete blocks (BIB). In New Zealand the background questionnaire was administered to 7131 people, and 184 people took no further part in the survey because of an inability to complete sufficient test items in the "core booklet" to meet the threshold to be given a test booklet (Strafford, 2009). A further 137 people

correctly completed three or more of the core skill questions but refused to undertake one of the skill booklets (Satherley, P., personal communication 12 September 2011).



**Figure 1. New Zealand ALL survey questionnaire completion**

### **3.2.1 The background questionnaire**

The New Zealand background questionnaire followed the international survey format (Statistics Canada, 2002; Strafford, 2009). The first section included age, gender, ethnicity, and the geographical region in which the respondent lived. Several questions were adapted to the New Zealand context. For example, the ethnicity questions included ethnicities relevant to New Zealand but which may be of little international significance (for example, Maori, Samoan, Tongan, Nuiean). In New Zealand respondents were able to indicate several ethnicities. About 6% described themselves

as having more than one ethnicity and these ethnicities were accorded equal value in the data analysis. Thus the total percentages in the extant ethnicity tables and charts exceeded 100% (Satherley & Lawes, 2008a).

The next sections of the background questionnaire enquired into education (adapted to a New Zealand context), immigration status, languages spoken, parental education, occupation and labour force information. The ALL survey included a number of questions relating to attitudes to numeracy and the self-reported uses of numeracy in job tasks. Some questions in the survey on numeracy practices and community involvement were taken to be measures of “social capital”. Other background questions included health and the use of information and communications technology. In all, the ALL survey *Background Questionnaire* contained around 400 questions (not all participants were asked all questions) in addition to the skill variables (Ministry of Education, n.d.; Ministry of Health, 2010; Murray, Clermont, et al., 2005; Strafford, 2009).

The volume and scope of the data collected by the ALL survey has been both wide ranging and substantial in its influence on government policy and funding (Benseman, 2008; Ministry of Education, 2007; Tertiary Education Commission, 2008a; J. Walker, 2009). It has resulted in a number of publications from the Ministry of Education: *Adult literacy and numeracy in New Zealand – A regional analysis* (Lane, 2010a); *Adult literacy and numeracy in New Zealand – key factors* (Lane, 2010b); *Literacy and life skills for Maori adults* (Satherley & Lawes, 2009a); *Literacy and life skills for Maori adult – further investigation* (Satherley & Lawes, 2009b); *Literacy and life skills for Pasifika adults* (Lawes, 2009a); *Literacy and life skills for Pasifika adults – further investigation* (Lawes, 2009b); *Skills and education: How well do educational qualifications measure skills?* (Smyth & Lane, 2009); *Skills, qualifications and wages: An analysis from the Adult Literacy and Life Skills survey* (Earle, 2009a); *The Adult Literacy and Life Skills (ALL) Survey: Age and literacy* (Satherley & Lawes, 2008b); *The Adult Literacy and Life Skills (ALL) Survey: An introduction* (Satherley & Lawes, 2007); *The Adult Literacy and Life Skills (ALL) Survey: Education, work and literacy* (Satherley et al., 2008a); *The Adult Literacy and Life Skills (ALL) Survey: Gender, ethnicity and literacy* (Satherley & Lawes, 2008a); *The Adult Literacy and Life Skills (ALL) Survey: Numeracy skills and education in New Zealand and Australia* (Satherley



& Lawes, 2009a); *The Adult Literacy and Life Skills (ALL) Survey: Overview and international comparisons* (Satherley et al., 2008b); and *The effect of first language and education on literacy, employment and income: An analysis from the Adult Literacy and Life Skills survey* (Earle, 2009b).

This section has briefly considered some of the information gathered by the background questionnaire. Critique of the background questionnaire is included in section 3.2.8.

The following section will describe the sampling process used for the data collection in New Zealand.

### **3.2.2 The ALL survey sampling**

The data gathering phase for the New Zealand ALL survey took place in 2006 and early 2007. The sample was drawn from a nationally representative sample of private households from which individual respondents were selected. The households were selected from a primary sampling unit of meshblocks. Meshblocks are the smallest geographic area used by Statistics New Zealand for census data collection and analysis (Statistics New Zealand, n.d.-a). Meshblocks vary in size ranging from about 60 to about 500 people (Statistics New Zealand, n.d.-b; Strafford, 2009). Those meshblocks containing fewer than nine dwellings and offshore islands (excluding Waiheke Island) were excluded, as were temporary dwellings, non-private dwellings (including prisons) and student halls of residence (Strafford, 2009).

The data was collected from 7,131 individuals aged from 16 – 65 years of age. The survey used an oversampling method to select more Maori and Pasifika people than their proportion in the total population in order to provide more accurate data on these smaller population groups (Strafford, 2009). The survey response rate achieved was 64% which is comparable with the response rates internationally but less than the target response rate of 70% (Power & Clermont, 2008; Statistics Canada, 2002).

In order to ensure the best representation of the population, the results from the sample were “weighted” using two separate processes: population weighting and the “jackknife” weightings. The population weighting factors included age, ethnicity and gender. This weighting value was then used, in part, to compensate for the non-response rate as well as population variations in the response rate (Statistics Canada, 2002; Strafford, 2009; Van de Kerckhove, Krenzke, & Mohadjer, 2009). The New

Zealand sample seems to be fairly representative of the target New Zealand population, although under-representing adults with low educational attainment and over-representing adults with high educational attainment (Dixon & Tuya, 2010). The guidelines for tabulation and analysis questionably specify that survey weightings must be used when analysing the ALL survey data (Statistics Canada, 2002). The “jackknife” weightings are used to derive the standard errors associated with the data analyses. For more information see Murray, Owen, et al., 2005, and Statistics Canada 2002.

The design of the survey, whereby the respondents were each allocated one of 28 different assessment task booklets, contributed to its complexity. Each of the test booklets was randomly allocated a range of test items within one or two of the four test domains (prose literacy, document literacy, numeracy or problem-solving). The process of allocating the domains and test items for the ALL survey uses a balanced incomplete block (BIB) assessment design. The intention of this methodology is to reduce “test-overload” by reducing the number of assessment tasks presented to each respondent (Murray, Owen, et al., 2005; Strafford, 2009). A good description of large scale assessment design including BIB techniques, albeit describing school assessments, is in Frey, Hartig and Rupp (2009).

### **3.2.3 Balanced incomplete blocks**

The ALL survey uses the balanced incomplete block (BIB) model to allocate one of the 28 different paper booklets to survey respondents who demonstrated adequate skills to advance to the assessment stage of the survey (Strafford, 2009). Each of the 28 booklets consisted of two “blocks” of test items – either two blocks from one domain or two blocks from different domains (Statistics Canada, 2002) (See Table 1).

The survey used eight different “blocks” of test items with different items in each block: four blocks had prose literacy and document literacy items, two blocks had numeracy items and two blocks had problem-solving items. The booklets were allocated to those people who successfully completed at least three of the six test items in the “core booklet”, which contained prose literacy, document literacy and numeracy items (Strafford, 2009).

**Table 1. Task Booklet and Sample Size**

Task Booklet No.	Task Booklet Content		Final Sample Size
	Block 1	Block 2	
1	L1	L2	180 (232)
2	L1	L3	180 (219)
3	L2	L3	180 (229)
4	L2	L4	180 (241)
5	L3	L1	180 (218)
6	L3	L4	180 (228)
7	L4	L1	180 (229)
8	L4	L2	180 (218)
9	L1	N1	180 (236)
10	L2	N2	180 (222)
11	L3	N2	180 (238)
12	L4	N1	180 (243)
13	N1	L2	180 (211)
14	N1	L3	180 (222)
15	N2	L1	180 (212)
16	N2	L4	180 (240)
17	N1	N2	270 (349)
18	N2	N1	270 (313)
19	L1	PS2	180 (228)
20	L2	PS1	180 (239)
21	L3	PS1	180 (216)
22	L4	PS2	180 (231)
23	PS1	L4	180 (233)
24	PS1	L4	180 (228)
25	PS2	L2	180 (220)
26	PS2	L3	180 (237)
27	PS1	PS2	270 (334)
28	PS2	PS1	270 (334)
Core Booklet Only			(321)
Total			5400 (7131)

*Note.* L = Literacy (no distinction is made between “prose” literacy and “document” literacy), N = Numeracy, PS = Problem-Solving.

(Satherley, personal communication 16 July, 2010).

The blocks were distributed according to Table 1 which shows the expected distribution of task booklets for a suggested sample size of 5400, which was the size recommended by the survey designers. The actual numbers in the New Zealand sample who completed each booklet is shown in brackets in the column labelled “Final Sample Size”.

Analysis of this table shows that around 35% of the respondents (2486) answered numeracy questions with just 662 of these people (around 9% of the total sample) answering numeracy questions only. The distribution of numeracy questions contrasts with the distribution of literacy questions. Literacy questions were presented to over 75% of the total sample and 25% of the total sample were given literacy questions exclusively.

The ALL survey then uses an imputation process to calculate the respondent’s test scores for the test domains that were not included in that particular test booklet (for example, if a test booklet contained two blocks of numeracy items, test scores would also be imputed for prose and document literacy as well as problem-solving). Thus the imputed numeracy values for 65% of the respondents are based on the scores and demographic characteristics of those 35 % of respondents who answered numeracy questions (Statistics Canada, 2002). The imputation process uses item response theory to calculate the imputed or “plausible values”.

### **3.2.4 Item response theory and plausible values**

The ALL test item design uses item response theory or models (IRT), which includes two parameters: the ability of a test item to discriminate (sensitivity to proficiency) and secondly, the test item’s difficulty (Goldstein & Wood, 1989; Murray, Clermont, et al., 2005). ITR is based “on the theory that someone at a given point on the scale is equally proficient in all tasks at that point on the scale” (Murray, Owen, et al., 2005, p. 278). “Plausible values” methodology is then used with the ALL survey data to estimate key population features and develop related score profiles. These profiles are then used to impute score values for those skill domains that were not assessed in the test booklets (which assessed only one or two of the skill domains)(Statistics Canada, 2002).

The processes used in relation to item response theory and the development of the subsequent plausible values for analysing the ALL survey data are publicly accessible in the ALL documentation (Statistics Canada, 2002). What the dataset shows is that despite survey respondents answering only one of the booklets covering one or two of the survey domains, the respondents have numerical values for all the survey domains. The dataset does not indicate which respondents actually answered questions in a particular test domain and which scores have imputed values that are the result of the item response theory calculations. There appears to be an assumption that the imputed values are of equal value to the actual test scores.

The result of these “calculations” is an estimation of proficiency based on the five plausible values for each of the skill domains. These five plausible values (for example, “num 1” through to “num 5” are used for the numeracy scale) accord to test scores. Level 1 is from 0 – 225, Level 2 is from 226 to 275, Level 3 is from 276 to 325, Level 4 is from 326 to 375 and Level 5 is for scores greater than 376 (Statistics Canada, 2002, p. 6). These levels are then used to describe the skill levels of the population both in New Zealand and internationally (Murray, Owen, et al., 2005; Satherley & Lawes, 2009a; Satherley et al., 2008b).

Proficiency of the population therefore rests on the actual scores of the survey individuals, the representativeness of the sample and the capacity of the test questions to capture or discover the range of skills in the sample and the reasonableness of this process for calculating the “plausible values”. Further assumptions underlie the survey processes and are discussed in section 3.2.8.3.

Having considered aspects of the design of ALL survey, the next section will discuss the numeracy assessment question exemplars that are currently available for examination. In total there are six numeracy exemplars available for scrutiny which are purported to be representative of the 40 numeracy questions (Murray, Owen, et al., 2005; Strafford, 2009). Whether these exemplars have been used in the numeracy component of the ALL survey is unknown. Uncertainty remains as to how well the numeracy questions capture the range of adults’ numeracy skills or any cultural or other values that may be implicit in the numeracy questions. Strong criticism was made of the cultural values embedded in the 1996 IALS quantitative literacy survey questions (Blum & Guerin-Pace, 2000; Hamilton & Barton, 2000; Sticht, 2001a).

### 3.2.5 Questions from the numeracy domain

The two blocks of numeracy questions used in the ALL survey each contained twenty questions which were selected to ensure a similar balance of both difficulty and content coverage (Murray, Clermont, et al., 2005).

The simplest numeracy question in the ALL survey numeracy questions asked the respondents to look at Figure 2 below and work out the total number of Coca Cola bottles in the two trays. The question required no reading of text and could be approached in a number of ways. The question assesses counting skills, possibly multiplication skills and also tests spatial awareness. Murray, Clermont, et al., (2005) acknowledge that the picture assumes that the trays contain identical numbers of bottles but say that this presented few problems for the respondents.

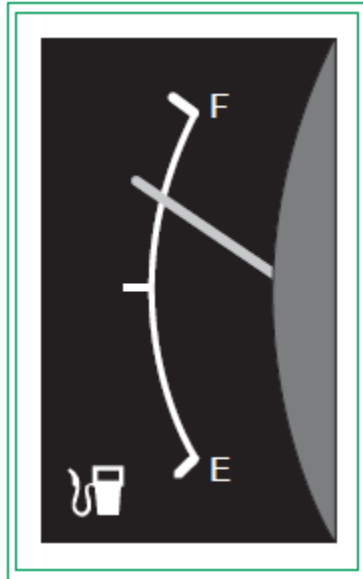


**Figure 2. Numeracy "Question 6"**

(Strafford, 2009, p. 61). Reprinted with permission.

The respondents who correctly answered the question in Figure 2 were given a score of 174 (Level 1 scores ranged from 0-225) (Murray, Owen, et al., 2005, p. 298).

Another numeracy task (scoring 248 with a Level 2 range of scores from 226 to 275) required the respondents to read a vehicle fuel gauge.

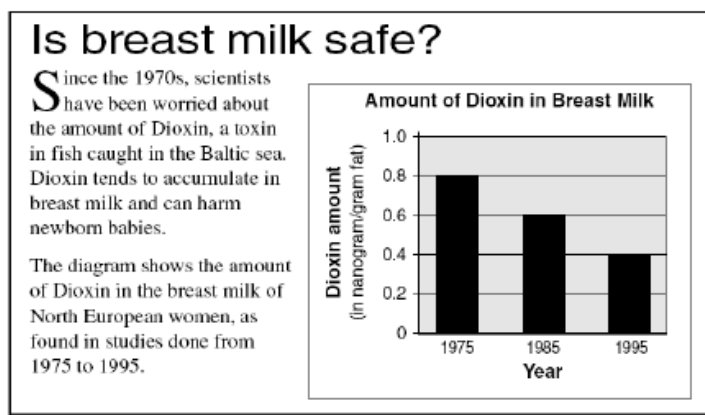


**Figure 3. Numeracy "Question 5"**

(Strafford, 2009, p. 64). Reprinted with permission.

The New Zealand question tells the respondent that the car fuel tank holds 48 litres and then asks how many litres remain in the tank, assuming the gauge is accurate. The correct answer is any answer that falls in the range of 33 to 39 litres (Murray, Owen, et al., 2005; Strafford, 2009). Adults may, however, be more likely to calculate fuel levels in tanks that are nearly empty rather than nearly full. Furthermore, fuel gauge displays are not normally symmetrical, leading to this question being criticised for its simple representation of a far more complex real life problem (Henningsen, 2006).

A more difficult question presented a graph of the amount of dioxin in breast milk.



**Questions 18 - 19. Refer to the article titled 'Is breast milk safe?' on the opposite page to answer questions 18 and 19.**

18. Describe how the amount of Dioxin changed from 1975 to 1995.

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**Figure 4. Numeracy “Questions 18-19”**

(Strafford, 2009, pp. 65–66). Reprinted with permission.

Question 18 (Describe how the amount of Dioxin changed from 1975 to 1995) was given a score of 280, at the lower end of Level 3 (which ranged from 276-325).

A further question asked respondents to compare the *percent* of change in the dioxin level from 1975 to 1985 (a decrease of 25%) with the *percent* of change from 1985 to 1995 (a decrease 33.3%) and to explain their answer (Strafford, 2009). This part of the Dioxin question was scored at 377 (or at Level 5, which ranged from 376 to 500). Completing this question accurately required changing the percentage calculation base from 1975 for the first comparison, to 1985 for the second comparison. Percentages however, may be a somewhat artificial representation of the data presented in this graph – the *rate of decrease* in dioxin levels has remained the same in each of the ten year



time periods. Why adults would want to calculate these percentages in interpreting this graph is puzzling.

The most difficult numeracy item:

receiving a difficulty value of 380 (Level 5), presented adults with an advertisement claiming that it is possible for an investor to double an amount invested in seven years, based on a 10 per cent fixed interest rate each year. Adults were asked if it is possible to double \$1000 invested at this rate after seven years and had to support their answer with their calculations. A range of responses was accepted as correct as long as a reasonable justification was provided, with relevant computations.

Respondents were free to perform the calculation any way they wanted, but could also use a “financial hint” which accompanied the advertisement and presented a formula for estimating the worth of an investment after any number of years.

Those who used the formula had to enter information stated in the text into variables in the formula (principal, interest rate and time period) and then perform the needed computations and compare the result to the expected amount if \$1000 is doubled (Murray, Owen, et al., 2005, p. 301).

This question does not seem to be a question from a real life context. In a computer age adults are quite unlikely to calculate (or check) compound interest but may possibly use an online interest calculator rather than carry out the process required to answer this question.

In addition to the skill assessment items, the ALL survey also asked questions about the frequency with which adults used numeracy activities at work.

### **3.2.6 Self-assessment of literacy and numeracy skills**

The ALL survey asked a series of questions of people in work relating to their skills and the respondent's beliefs about the adequacy of those skills for the jobs they currently hold (Ministry of Education, n.d.). The question numbers are shown in brackets.

For example:

- How often do you read or use information from each of the following as part of your main job? Letters, memos or e-mails; reports, articles, magazines or journals; manuals or reference books including catalogues; diagrams or schematics; directions or

instructions; and bills, invoices, spreadsheets or budget tables. (Variable numbers E1A, E1B, E1C, E1D, E1E, E1F).

- How often do you write or fill out each of the following as part of your main job? Letters, memos or e-mails; reports, articles, magazines or journals; manuals or reference books including catalogues; directions or instructions; and bills, invoices, spreadsheets or budget tables. (Variable numbers E2A, E2B, E2C, E2D, E2E).
- How often do you do each of the following as part of your main job? Measure or estimate the size or weight of objects; calculate prices, costs or budgets; count or read numbers to keep track of things; manage time or prepare timetables; give or follow directions or use maps or street directories; and use statistical data to reach conclusions. (Variable numbers E3A, E3B, E3C, E3D, E3E, E3F).

The options respondents were given in answering these questions were: at least once a week, less than once a week, rarely and never (Strafford, 2009).

The New Zealand findings from these questions have not been widely analysed or reported although there is a suggestion that many workers with low numeracy skills may hold jobs that have little requirement for such skills (Dixon & Tuya, 2010). Alternatively, these questions may not capture the very diverse, complex and embedded range of numeracy skills that these workers actually use.

The self-assessment numeracy skills question may provide more insight into *whether* adults see themselves as users of numeracy – or their “identity”.

### **3.2.7 Numeracy identity**

A small number of questions in the ALL survey potentially provide insight into respondents’ attitudes, feelings and anxiety in relation to numeracy skills and knowledge. These questions are:

Think about learning maths and how you were taught maths while a student at secondary school. Please tell me whether you strongly agree, agree, disagree, or strongly disagree with the following statements:

- I enjoyed maths at school (A9A).

- I got good grades in maths (A9B).
- The teachers went too fast and I often got lost (A9C) (which is actually two questions in one).
- I usually understood what was going on in maths classes (A9D).

Further relevant questions include:

- I have the maths skills I need to do my main job well (E4C).
- I am good with numbers and calculations (G7A) (again two questions in one).
- I feel anxious when figuring such amounts as discounts, sales tax or tips (G7B) (multiple questions in one).

(Ministry of Education, n.d.)

The importance given to the pen and paper test numeracy scores in the reports of the ALL survey in contrast to women's self-perceived competence with everyday tasks presents a recurring theme in this study and is a criticism that can be levelled at the ALL survey.

### **3.2.8 IALS and the ALL survey critiques**

There are several major critiques of the earlier IALS research, although there are fewer critiques yet of the later ALL survey. The critiques of the IALS research are with respect to many aspects of the survey including methodology, analytical procedures, assumptions that underlie the survey and the test items themselves. Critiques range from the construct of numeracy used in the IALS and ALL surveys to the likelihood of improvement in literacy or numeracy levels having an impact on the New Zealand economy.

Numeracy is acknowledged by the ALL survey numeracy designers to be numerate behaviour used in real contexts; however, a testing process such as the ALL survey does not appear to assess this (Murray, Owen, et al., 2005). The ALL survey numeracy

questions seem to be a proxy for behaviour in real contexts. Consequently, the questions may serve to underestimate the real numeracy skills of adults.

Understanding the IALS and ALL survey critiques assists in understanding the limitations to the survey and the conclusions that can be drawn from the survey reports. Each of these aspects is now considered.

### **3.2.8.1 Methodology of the ALL survey**

The methodology critiques include sampling and participation rates, the response rates and the reasonableness of cross-cultural comparisons of literacy surveys (Blum & Guerin-Pace, 2001; Carey, 2000; Sussman, 2003; Van de Kerckhove et al., 2009).

There are distinct differences in sampling frames for different countries. Some countries used census-gathering frames. Canada used a census-gathering frame but excluded people living on Indian Reserves. Other countries used electoral rolls and Switzerland used a register of private telephone numbers (Murray, Owen, et al., 2005). Each of these processes potentially has different forms of statistical bias. For instance, samples based on electoral rolls may not include illegal residents. The use of a telephone register in Switzerland excludes households without a private telephone. In New Zealand the sample is based on the census “meshblocks”, a sampling frame which excluded the most isolated rural areas (Statistics New Zealand, n.d.-a). Carey (2000) found that the sampling frames and processes varied markedly in different European countries and to such an extent that the quality of between-country comparisons of skill scores was problematic.

There is a large difference between the ALL survey response rates in New Zealand (64%) and Australia (81%) although in Australia some form of compulsion may have been used to gain this level of response (NSW Council for Civil Liberties, 2004). When the IALS survey was conducted in New Zealand there was criticism levelled at the 74% response rate (Elley, 1999). Possible bias because of non-response from sample targets that had the poorest score levels was at the centre of Elley’s concerns. Culligan et al. (2004) used responses of only 58% of the New Zealand IALS sample in their analysis (see 6.6). The New Zealand ALL survey sample and the New Zealand Household Labour Force Survey (HLFS) samples have been compared. This comparison found the

ALL survey sample under-represented adults with low educational attainment and over-represented adults with high educational attainment, although the sample was still believed to fairly represent the target population on most criteria (Dixon & Tuya, 2010).

In the United States a report was produced on the effects of non-response on the United States ALL survey data. This is a routine requirement for any data collection conducted by the U.S. National Center for Educational Statistics where the response rate falls below 85%. This report found that the non-response adjustments (or weighting) were highly effective at reducing non-response bias and that the non-response bias on the United States ALL survey data was likely to be negligible (Van de Kerckhove et al., 2009).

What can be concluded is that internationally the response rates were often below the targeted 70% rate (Switzerland and Italy had response rates between 40 and 45%), but the agencies who sponsored the surveys were satisfied that the weighting process adequately compensated for the non-response bias (Murray, Owen, et al., 2005; Power & Clermont, 2008; Van de Kerckhove et al., 2009).

In New Zealand, the weighting process used four variables: probability weight, non-response rate, benchmark adjustment and total weight, which was the product of the three preceding weights. The “benchmark” adjustment related to gender, ethnicity (three groups) and age (five groups). The 2006 New Zealand Census data was used as the comparison statistics for calculating the benchmark adjustments (Strafford, 2009).

There seems to have been relatively little criticism of the response rates for the ALL survey in New Zealand but because of the circular nature of this survey, using imputed score values based on the responses of other respondents, the non-response bias should not be overlooked. The response rate of the IALS survey was criticised and the IALS response rate was much greater than the subsequent ALL survey response rate (Culligan et al., 2004; Elley, 1999).

Critique of the response rates and methodology is only one facet of the survey; the analysis, underlying assumptions and test items should also be scrutinized.

### **3.2.8.2 Analysis**

The use of imputed data which is the outcome of the balanced incomplete block (BIB) design and the use of item response theory (IRT) to derive plausible values, is a process that has been critically questioned by statisticians (Blum, Goldstein, & Guerin-Pace, 2001; Carey, 2000; Goldstein & Wood, 1989). The process does not appear to have been widely critiqued by literacy researchers, although Hamilton & Barton (2000) describe the IALS research as the product of testers and statisticians rather than the product of the adult literacy field and this criticism could continue to apply to the ALL survey. The OECD sponsored adult literacy surveys have evolved from school-based surveys such as PISA and TIMSS (Murray, Clermont, et al., 2005), which may or may not be an appropriate model for adult literacy surveys, particularly because of the evidence that adults may demonstrate “spiky” or highly uneven skill profiles (Bynner & Parsons, 2006; Coben et al., 2003; Hamilton, 2001; St Clair et al., 2010; Sticht, 2005).

Reder & Bynner (2009), based on research by Purcell-Gates et al., (2004), question measurement stability on literacy surveys that use IRT models. They suggest that different constructs are being measured when the test is re-administered with the same respondents at different times. For example: the first item in the previously discussed numeracy exemplars (Coca Cola bottles) could be measuring numeracy or spatial awareness.

The close correlation between the three IALS domains correlation (approximately  $R = .90$ ) suggests the justification for the use of three domains is rather weak (Blum et al., 2001; Rock, 1998). Furthermore, that the process of selecting and excluding items in the skill tests may actually hide further or underlying dimensions of literacy (Blum et al., 2001).

With the ALL survey in New Zealand, a similarly close correlation is evident between the domains, ranging from an  $r = .83$  correlation (between problem-solving and numeracy) and  $r = .93$  (between prose and document literacy) (Lane, 2010b). These close correlations between the ALL survey domains blur distinctions between the domains and could suggest a circular process, whereby the findings on one domain are used to predict scores in other domains, when the survey may be measuring underlying

(or unidentified) literacy dimensions. This could point to unsoundness in the use of plausible values for adult literacy surveys.

The use of imputed values, the stability of adult literacy measurement, the questions around skill dimension and the evidence for “spiky” profiles call into question the conclusions that may reasonably be drawn on skill levels from the IALS and ALL survey findings. There are, however, a range of further assumptions that have been used in the IALS and ALL surveys that should not be overlooked.

### **3.2.8.3 Assumptions**

Adult numeracy is a complex field for investigation and the ALL survey has used assumptions that have already been questioned by researchers investigating the IALS research. These questions include the literacy domains used, the use of discrete levels in reporting the survey results and, finally, the relationship between the ALL survey score levels and commonly understood skill levels.

Whether four domains (prose literacy, document literacy, numeracy and problem-solving) are sufficient to describe the entirety of “literacy” is a matter for conjecture. Equally, numeracy is constantly at risk of being subsumed into “literacy” when the evidence points to numeracy having features, such as mathematics anxiety, that indicate a different imperative for teaching and learning is often necessary. Often the term ‘LLN’ (literacy, language and numeracy) is used to encompass the entirety of literacy. However, discourse analysts argue that the use of such nominalisations serves to diminish the complexity of skills and knowledge required to successfully operate in each of the domains encompassed in such nominalisations (Blommaert, 2005). This current study has, therefore, avoided using LLN but has used “literacy” as a wide term that often incorporates numeracy, although “numeracy” is also used exclusively.

The initial framework for the ALL survey included a further “literacy” – a skill domain for ICT (Information and Communications Technology) but this was not ready for inclusion when the survey was finalised. Questions relating to ICT use were included in the background questionnaire, as were questions relating to health and wellbeing. The ALL survey designers attempted to develop “teamwork” and “practical cognition” domains for the survey (Murray, Clermont, et al., 2005). That these domains were

investigated for inclusion in the ALL survey suggests an acknowledgement that the three original domains in IALS were insufficient to fully describe the range of adult competencies as described in the DeSeCo report (Federal Statistical Office, Switzerland, 2005). Some questions relating to financial literacy seem to have been included under the numeracy domain, although the extent of this and the cogency of the questions are uncertain, given the lack of access to these questions.

The ALL survey (like the IALS) reported on skills using a series of levels. Doubt has been raised in the literature about dividing the continuum of scores into levels that have clear-cut off points (Blum et al., 2001; Hamilton & Barton, 2000a). The difference in scores between a person with 225 and 226 is negligible, but a score of 225 equates with Level 1 and 226 with Level 2 (Blum et al., 2001). A further question has been raised about the reasonableness of an arbitrary threshold of 80% success for reaching the next level on the scale. In order to, for instance, be regarded as having Level 3 skills, a respondent had to score at or above that level with an 80% probability. This means that the respondent needed to score four out of five questions correctly at Level 3 or above to achieve a score at Level 3. At any one level an individual may be just above the minimum level or scoring higher than that, but not at achieving the 80% probability required for scoring at the next level (Blum et al., 2001; Statistics Canada, 2002).

A further assumption has been that using Level Three, which is described as “college entry level”, as a reasonable level of adult numeracy for the entire New Zealand population may be unjustifiable (G. Johnston, 2004). Given that New Zealand had compulsory schooling to age 15 (around Year 10) until 1993 when the age was increased to 16 (Year 11), it is not surprising that a substantial number of survey respondents in 2006 did not demonstrate levels of numeracy at the equivalent of Year 13 or college entry level.

Any major quantitative research has key statistical assumptions that underlie the research design. This applies to the IALS and ALL survey. Assumptions in quantitative studies of adult numeracy skills research may also be cultural, which might be reflected in the test items (Blum & Guerin-Pace, 2000; Hamilton & Barton, 2000). The numeracy test items and their relevance to adult respondents are addressed in the next section.



#### **3.2.8.4 Test items**

The skills measured in the ALL survey are dependent on the questions used in the skills assessment booklets. The key issue is how well those questions capture and display the range of skills adults have and use in situ in their daily lives. Inevitably, there must be questions surrounding the test items used in the numeracy test and their cultural and social relevance for adults.

Clearly, criticisms have arisen as to the cultural context of questions used in the IALS survey that could likewise be levelled at the ALL survey (Blum & Guerin-Pace, 2000; Blum et al., 2001; Carey, 2000; Hamilton & Barton, 2000a). Some numeracy questions require significant reading skill including the use of specialised vocabulary.

These exemplar questions that have been published seem to be measuring a particular form of school-based numeracy which may not capture the actual practices of many adults using numeracy skills in their unique social and cultural situations (Ginsburg et al., 2006; McMurchy-Pilkington, 1996; Rawiri, 2006; St Clair et al., 2010).

Research on the real mathematical demands of the workplace or home life show how little school mathematics may resemble out-of-school mathematics. Furthermore, context is a significant part of understanding the mathematical skills, knowledge and practices of adults (Ginsburg et al., 2006; McMurchy-Pilkington, 1996). Unfortunately the test items are not available for inspection. Consequently we must assume the criticisms that can be levelled at the numeracy exemplars are likely to apply to most other questions in the assessment.

There are, however, besides methodology, analysis, assumptions and test items, a number of additional critiques of the IALS, and by implication the ALL surveys. One of these critiques relates to the argument that national economic advantages may result from improvement in adults' numeracy skills – a pertinent point for women after research suggesting that poor numeracy skills have a greater economic impact on women than men (Parsons & Bynner, 2005).

### **3.2.8.5 *Economic benefits of numeracy and literacy skills***

Much of the rationale for investigating adult numeracy and literacy skills and developing programmes to increase these skills is economic and has arisen from the purported link between such skills and economic development (Appleby & Bathmaker, 2006; Brine, 2006; G. Johnston, 2004; Mason & Osborne, 2007). In New Zealand, as in other OECD countries, adult literacy policy is often justified in terms of the findings of the IALS and ALL survey (Ministry of Education, 2001, 2007). However, Johnston (2004) expresses doubts that major improvements in the literacy, and presumably numeracy, skill levels of the New Zealand population are feasible or would have a noticeable impact on this country's Gross Domestic Product (GDP). A relationship between higher numeracy scores and higher incomes is evident in IALS and the ALL survey. Whether higher skills *result* in higher incomes or whether higher paying work *develops* numeracy scores is problematic. Certainly, much of government policy in New Zealand and throughout the OECD seems predicated on the belief that were the numeracy scores of a population increased, higher incomes would result (Brine, 2006; Coulombe et al., 2004; Ministry of Education, 2001, 2007; OECD, 2005, 2007). In the United Kingdom, a clear relationship is evident for women with competent numeracy markedly more likely to be employed, with subsequent economic advantages over those with poor numeracy skills (Parsons & Bynner, 2005).

### **3.2.8.6 *Additional critiques of the IALS and ALL surveys***

France withdrew from the IALS survey and did not participate in the ALL survey after the results suggested that three-quarters of the French adult population had literacy scores at Levels One and Two in the survey as distinct from 52% of British, 49% of Dutch, 47% of Americans and 28% of Swedes. Blum et al. (2001) argue that cultural and language translation effects have produced this outcome. The criticisms of IALS are not, however, limited to language and culture.

Questions arise with both the IALS and ALL survey in relation to the model of numeracy that has been used with both surveys. Numeracy seems to be viewed as a series of autonomous, transferable skills, independent of culture which can easily be transferred from one setting or context to another – a proposition that was discussed in Chapter 3. By including the test items developed for the IALS study in the ALL survey

there is an underlying assumption about a national model of numeracy which is static or only changing slowly. In this regard, the document literacy sample questions are of interest (Murray, Owen, et al., 2005; Strafford, 2009). These questions show graphical representations of data which were often seen in newspapers and similar publications, but are now rarely seen in New Zealand newspapers (See Appendix 3). The ALL survey does acknowledge the changing nature of literacy with the inclusion of the problem-solving domain and the development of ICT measures and questions investigating ICT uses.

Only five exemplars of the numeracy test items have been made available and researchers largely remain unsure of what, exactly, these test items measure. The exemplars suggest they may represent a classroom-based approach to numeracy. Access to the 40 numeracy test items was sought for this research. However, contractual arrangements between the New Zealand Ministry of Education and Statistics Canada means this access could only be granted by Statistics Canada, which declined this request (Satherley, P., personal communication, September 16, 2010).

In addition to questions about the skill test items, a variety of critiques may be levelled at the Background Questionnaire, which has collected a very wide array of data.

Some questions in the ALL survey background questionnaire provide data on numeracy practices people use in their work, but not whether the skills are part of a repertoire that a worker may have but not use frequently. In addition, the questions only explore frequency of use rather than quality of use insofar as the complexity of the tasks may vary widely. The numeracy questions in the background questionnaire may seem so ordinary that respondents may not acknowledge how often they actually perform these tasks. For example, around one third of the New Zealand sample said they “never” estimate the size or weight of objects at work, which seems a high proportion when lifting heavy objects is so frequently emphasised in New Zealand health and safety programmes.

The published ALL survey findings do not explore self-reported workplace numeracy use in depth although there is evidence that a greater proportion workers with the lowest scores, compared with those who had higher scores, reported they rarely or never performed specified mathematics tasks at work. Despite this finding, more than half of

workers with Level 1 scores are regularly performing work-related numeracy tasks (Dixon & Tuya, 2010).

Another aspect of numeracy practices relate to computer use. The ALL survey reported on home computer use (around 55% of older adults were using a home computer five or more hours per month and around 65% of younger adults, with little difference between men and women) (Lane, 2010b). More recent research indicates that internet use has increased markedly since the completion of the ALL survey, with over 80% of New Zealanders now using the internet (Smith et al., 2010). It is reasonable to think that home computer access and usage may provide skills that women could acquire at home and transfer to the workplace. Thus, if skills transfer from home to work, the ALL survey findings may possibly undervalue the self-reported numeracy skills of women.

Henningsen (2006) argues that many of the results from the ALL survey should have been analysed controlling for confounding variables. A “confounding variable is an extraneous variable whose presence affects the variables being studied so that the results do not reflect the actual relationship between the variables under investigation” (AlleyDog.com, n.d.). Henningsen (2006) explains that literacy and numeracy skills are highly correlated with education, despite the evidence of the existence of adults with high levels of numeracy skills and low levels of education (Parsons & Bynner, 2007; Satherley et al., 2008a). Gender differences in numeracy scores may be the result of different education or educational experiences rather than the result of gender as such. In this case, education would be a confounding variable. One confounding variable that could have explained some of the difference in numeracy scores between men and women might be the number of years of mathematics study, particularly given the classroom-based nature of the assessment questions. A further confounding variable which could have been influential might have been attendance at boys or girls secondary schools. Confounding variables may also influence judgement about one’s self-reported skills.

Undervaluing self-reported skills is one of the many criticisms that apply to the ALL survey (Henningsen, 2006). There appear to have been relatively few publications critical of the ALL survey itself. There are, however, substantive critiques of the earlier IALS research. The lack of critique of the ALL survey may be because the later survey has drawn so substantially on the methodology and assessment material of the earlier

survey that the critiques of the previous survey are applicable to the both surveys. However, uncertainty remains around the numeracy test items and whether these items adequately capture the range of numeracy skills of New Zealand women.

The uncertainty surrounding the numeracy test items used in the ALL survey suggests that replication of the ALL survey research would be almost impossible and research which is not potentially replicable is generally regarded as poor research (Bryman, 2004; Sarantakos, 2005).

### **3.3 Influence of the literature review on the design of this study**

This study used an existing dataset (the ALL survey) to describe some of the characteristics of the numeracy skills of New Zealand women. Using this data necessitated developing an understanding of the design, methodology and analysis processes of this survey in order to evaluate the findings that can be drawn from this data – both the findings of other researchers and the findings of this study.

The ALL survey critiques have raised further questions about the reliance that can be put on the data (Reder & Bynner, 2009); the nature of the concepts of numeracy that are measured (Hamilton, 2001; Hamilton & Barton, 2000a); the sampling frame, response rates and statistical assumptions (Blum et al., 2001; Carey, 2000; Goldstein & Wood, 1989; Sussman, 2003); the use of IRT and BIB designs (Carey, 2000; Goldstein & Wood, 1989) and the reasonableness of the standard of skill expected of the population (Isaacs, 2005; G. Johnston, 2004; Sussman, 2003).

This chapter has described the origins of the International Adult Literacy Survey (IALS) and the subsequent Adult Literacy and Life Skills survey whilst situating these surveys in a human capital model of economic growth. The key competencies identified by the DeSeCo project, which provided one of the foundations for the ALL survey, have been briefly described. The design of assessment items, particularly the numeracy test item exemplars, and the research methodology used in the ALL survey are outlined. The background questionnaire is described, as are the sampling methods, the use of balanced incomplete blocks (BIB) and item response theory (IRT) and plausible values. The

questions that address self-assessment of skills are outlined. Finally, some of the critiques of the IALS and ALL surveys are discussed.

The next section will cover the methodology used for this study.

## **4 Research methodology**

### **4.1 Introduction**

Given that this study uses an existing dataset (the ALL survey dataset) to examine both the extant findings on women and numeracy skills and then uses the same dataset for further analysis, the methodology is quantitative. However, existing qualitative research on women and numeracy has been used to provide insights into the extant findings and the further analysis which has principally focused on affective factors and identities of women as knowers and users of mathematics.

Using an existing data set has both advantages and drawbacks. The advantages include the capacity to move quickly to the stage of analysis and to draw on the findings of other researchers using the same data set. The disadvantages include having no control over the design of the background survey or the numeracy assessment methodology. One further drawback of using the ALL survey data set is the difficulty of manipulating the data set. The approach taken to overcome the drawbacks and conduct the analysis is described.

### **4.2 Methodology**

Mixed methods research methodology incorporates both quantitative and qualitative dimensions (Bryman, 2004; Johnson & Onwuegbuzie, 2004). Drawing on both quantitative research and qualitative research methods enables interpretation of the quantitative data beyond population generalisations which are the usual product of such research. The extent of the qualitative research in this study is limited to drawing on the qualitative research literature; however, the findings could be used as the foundation of further qualitative inquiry.

Analysing the ALL data set is a most challenging undertaking, from developing a familiarity with the hundreds of variables gathered, the different population subsets used for the many extant findings to manipulating the plausible values. The analysis in this study has been conducted using the original data, but analysed using different software from the original Ministry of Education (MoE) software. The MoE used SAS

software to analyse the ALL survey results, whereas this study has used SPSS. The use of SPSS has presented particular difficulties using the programming macros.

Two different weighting processes are used with the ALL survey data set. Firstly, a variable called “POPWT” is used to adjust the sample size to more accurately represent the demographic profile of the New Zealand adult population. Secondly, Statistics Canada supplies four SPSS programming macros which estimate the sampling variance of the difference between subgroups (Statistics Canada, 2002). Two of the macros are for computing linear regression coefficients. One further macro is for calculating weighted percentages of respondents and their mean values on continuous variables. The final macro is for calculating weighted percentages of respondents and their mean achievement scores. This final macro is necessary when using multiple plausible values (Statistics Canada, 2002).

Statistics Canada (2002) describe the use of the data set thus:

There is little doubt that the ALL data set is difficult to manipulate. The 5 Plausible values for the 5 domains (if you include health literacy) along with the 30 replicate weights make the procedures for accurate assessment of standard errors a convoluted affair .... For this reason it is recommended that preliminary research use only one of the Plausible values rather than all five.... Once the research is ready for publication, the replicate weights and 5 plausible values should be used to produce the final estimates with accurate standard errors (p. 111).

The extant findings from the New Zealand ALL survey on either “numeracy” or “women” or both “numeracy and women” were initially identified, although some of this data was duplicated in more than one publication. These totalled over 120 figures or tables with only a very small number of tables including both women and numeracy. Some of the extant figures were of such complexity drawing meaning from the data was difficult. For example, one such figure incorporated prose literacy, numeracy, income decile and gender, Satherley & Lawes, (2008, p. 18). The extant findings data are presented as in the original documents which reported data using percentages rather than weighted numbers. All the findings are reported using weighted data and thus representing the adult New Zealand population.

A “preliminary analysis” using one of the plausible values was then undertaken on those test questions that were suggested in the international literature as possibly having



relevance for the research questions. As a result of using the preliminary analysis process the standard errors are not available for the tables that are the outcome of this analysis.

Additionally, correlations and regression analyses have been used with the variables that indicate attitudes, feelings and confidence using mathematics and numeracy. The Pearson “ $r$ ” correlation coefficient has been employed. Whilst Spearman Rank was the correlation test of choice, the analyses were unable to be performed because of the size of the data set. Subsequently, the Pearson product-moment correlation squared ( $r^2$ ) was used to further examine relationships between and among variables.

The data analysis followed several steps. Firstly, a subset of women from the original data set was created for easier data management. Variables such as employment classifications, labour force information and income were excluded, partly because of the relevance of these variables for the research questions, the complexity of analysing these variables and the extant findings. A bivariate correlation was compiled. The statistically significant data where  $p < .01$  (2-tailed) and  $r > .3$  or  $r < -.3$  were noted. Those correlations that were both statistically significant and with  $r > .3$  or  $r < -.3$  were then subject to cross-tabulations.

These cross-tabulations investigated patterns of response of New Zealand women to the questions that involve feelings, confidence and attitudes in more detail than the extant findings. The variables that have been selected for further analysis in this study have also been influenced by the literature review. One variable (born in New Zealand) was statistically significant but, when correlated with other variables, had values of  $r < .3$ . This variable was cross-tabulated and showed a consistent pattern for women across the affective numeracy variables and has thus been reported.

New Zealand Ministry of Education officials have kindly supplied answers to specific questions in relation to the survey, including supplying the unpublished balanced incomplete block (BIB) data.

### **4.3 Summary and conclusion**

The methodology of much of this study has been determined by the ALL survey designers (Statistics Canada), who have provided the background questionnaire,

assessment tasks, implementation processes and the analysis processes to the New Zealand Ministry of Education. The correlations investigated here provide some insights into women and their attitudes towards numeracy, school experiences, learning mathematics, and numeracy skills.

## **5 FINDINGS**

### **5.1 Introduction**

Factors which may affect women and their numeracy skills include gender differences, age, ethnicity and language skills, disabilities, education, further education and training, employment and computer usage. Payne (2006) argues that demographic analysis based on the OECD adult literacy surveys can provide worthwhile insights into factors contributing to higher levels of adult numeracy scores. The first part of this section sheds some light on demographic characteristics relating to women and numeracy skills. Findings on education, employment and computer use are delineated. The feelings and attitudes of New Zealand women towards numeracy, the principle findings of this study, are elucidated.

The findings in Section 5.2 to Section 5.4 are mostly drawn from New Zealand government publications of the ALL survey findings (Dixon & Tuya, 2010; Earle, 2009a, 2009b; Lane, 2010b; Satherley & Lawes, 2008a, 2008b, 2009a; Satherley et al., 2008a; Smyth & Lane, 2009).

The major findings are the lower levels of educational participation for women, the disproportionately high number of New Zealand European women with a Level 1 numeracy score and the association between being New Zealand-born and failing to enjoy mathematics in school.

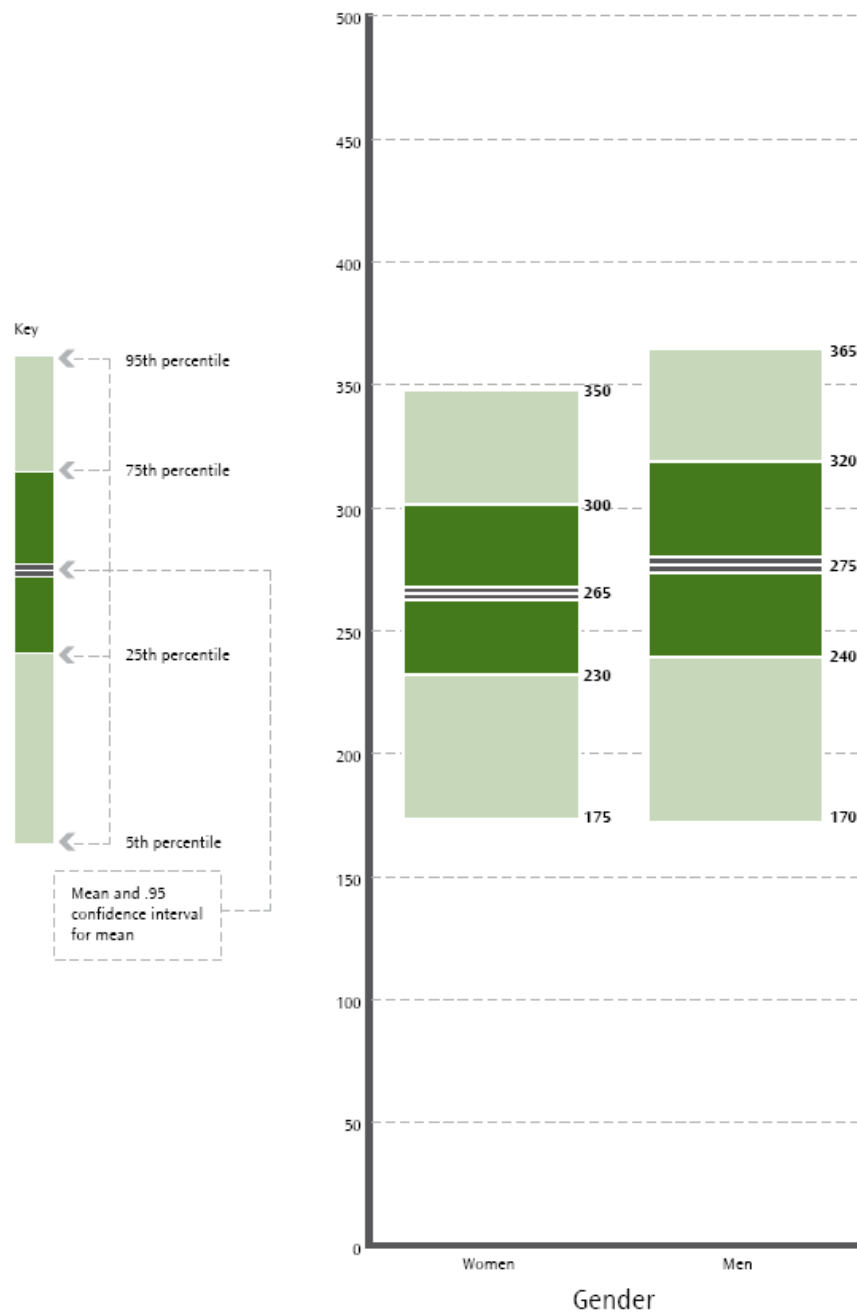
### **5.2 Demographic characteristics and numeracy**

The ALL survey extant findings provide a significant data source in terms of the characteristics of adults with higher numeracy scores. These characteristics include gender age, ethnicity and language. There is a small amount of data from the ALL survey available on adults with self-described disabilities.

#### **5.2.1 Gender differences**

The ALL survey extant findings show a significant difference exists in mean numeracy scores for men and women. Men tended to have ALL survey numeracy scores 10 points higher (or 2%) than for women. A higher proportion of men have higher

numeracy scores. The range of scores is greater for men than for women with the numeracy scores on the 5<sup>th</sup> and 95<sup>th</sup> percentiles, ranging from 175 to 350 for women and 170 to 365 for men.



**Figure 5. Numeracy and gender**

(Satherley & Lawes, 2008a, p. 12). Crown copyright 2008. Reprinted with permission.

Figure 5 could suggest that women have greater lower level numeracy scores and lesser high level numeracy scores.

Gender is only one of a number of demographic characteristics that may influence numeracy scores. Age, irrespective of gender, shows distinctive relationship with numeracy scores in the survey (Satherley & Lawes, 2008b).

### **5.2.2 Age**

A relationship between age groups and numeracy scores is evident, with younger women (25 – 44) significantly more likely to have higher numeracy scores than older women (45 – 65) (Lane, 2010b). Lane suggests that part of the explanation for the relationship between age and numeracy scores is that older adults have had differing educational histories and opportunities from younger adults, who have been required to remain in education for longer than older adults.

The incidence of participation in further education has grown markedly since the 1950s when the older survey respondents completed their schooling. The age trends, however, seem to be more complex than this dichotomy suggests. Numeracy scores are lower for the youngest and oldest age groups for both men and women, supporting suggestions that numeracy skills may develop or continue to develop after compulsory schooling is completed (Carpentieri, Litster, & Frumkin, 2010; Parsons & Bynner, 2005, 2007; Satherley & Lawes, 2008b). With respect to age, other factors may be confounding variables, for example, education level. Other such factors might be attitudes towards mathematics or numeracy or, for women, time in the labour force (Henningsen, 2006). We shall now see that, in addition to age, other factors influence numeracy score, including ethnicity and language.

### **5.2.3 Ethnicity and language**

It appears that the respondent's first language (a key variable in the survey) shows that women who speak a language other than English appear to have substantially poorer numeracy scores. In an unpublished study of workers with both literacy and numeracy skills at Level 1, Sutton (2009) described 38% of workers with Level 1 numeracy skills as born outside New Zealand. A similar percentage (38%) of people with Level 1 numeracy skills spoke a language other than English as their first language (as cited in Dixon & Tuya, 2010). These findings could be partly the outcome of numeracy test items that contain language features and complexity that may relate to language skills

rather than numeracy skills alone. This issue has been discussed in Section 3.2.5, which found some of the numeracy test items are visual representations of numeracy concepts. Other items (see Figure 4) are embedded in written English language.

The extant findings show that around 90% of the total adult population aged 25 to 65 in the ALL survey was found to have English as a first language and a further 5% had a first language other than English, but used English as their main home language (Lane, 2010b). The variable “first language” was found by Lane to be a better guide to English literacy and numeracy skills than the variable “main language spoken at home” (Lane, 2010b). Over half of those who had a first language and main home language that was other than English, had arrived in New Zealand within the last 10 years (Earle, 2009b). The survey findings show a strong relationship between language and higher numeracy skills (Lane, 2010b), although this finding should be viewed with caution as there are only a small proportion of speakers of languages other than English.

Another possible characteristic of women who may have difficulties with numeracy could be the incidence of disabilities.

#### **5.2.4 Disabilities**

A Scottish study (St Clair et al., 2010) found that of those people at Level 1 on all of the three domains of the IALS study, 17% had problems with eyesight, hearing, speech or a learning disability. Information on the nature of disabilities has not been reported for the New Zealand ALL survey, but around 22% of New Zealander women identified as having a disability or handicap that is long-term, lasting six months or more. Thus, we do not know if these disabilities could affect numeracy scores. There may be relationships between disabilities and educational participation, but more precise information on the nature of the disabilities is needed to demonstrate such relationships.

### **5.3 Education**

The ALL survey findings demonstrate a relationship between levels of education and numeracy scores (Lane, 2010b; Satherley et al., 2008a). However, many questions remain unanswered, such as the effect of mathematics skills on decisions about further education.

Educational participation was found, in the extant findings, to be a key factor in numeracy scores in the ALL survey (Lane, 2010b; Smyth & Lane, 2009). “Educational participation” refers to the self-reported highest level of schooling completed. However, a conundrum surrounds this finding – do higher levels of numeracy score lead to higher levels of educational participation or does higher education result in higher levels of numeracy score?

The ALL survey contains over 400 variables, which have been given unique alphanumeric code numbers. In examining the extant findings the variable used has not always been explicit. Consequently, the alphanumeric variable code has been added in brackets throughout this thesis for clarification.

Several variables have been used in the ALL survey to describe educational participation. One variable (A4) has been used in the extant findings for international comparisons and for educational participation comparisons between the IALS and ALL surveys. Variable A4 showed striking changes in educational participation in the 10 years between IALS and the ALL survey, particularly for the “lower secondary or less” group, who had completed secondary schooling before completing Year 10 or School Certificate or NCEA Level 1. By 2006, this group was estimated to comprise only 10% of the adult population age 16 – 65. The current study has instead used variable A4CZ for educational participation, which is a variable that has been adapted for the New Zealand schooling system. The variable A4CZ has included those adults who completed Year 10 or School Certificate or NCEA Level 1 as “lower secondary”. This has been done because variable A4CZ demonstrates a more equitable distribution of the sample across three categories than variable A4. The outcome of this process is that the extant findings from the Ministry of Education ALL survey report findings on educational participation are not directly comparable with the findings in this study.

**Table 2. Educational participation IALS and ALL**

	Lower secondary or less	Higher secondary	Tertiary
IALS (1996)	49%	25%	25%
ALL (2006)	10%	46%	44%

*Note.* This data is for both men and women. Source: (Satherley et al., 2008a)

Gender differences in educational participation are small.

**Table 3. Educational participation (ALL survey only)**

	Year 11 or less	Upper Secondary	Tertiary	Totals
Women	26%	32%	43%	100%
Men	24%	31%	45%	100%

*Note.* Variable A4CZ Source

A similar percentage of women born in New Zealand or born overseas participated in tertiary education (42.5%).

Whether the findings on the relationship between numeracy levels and educational participation are the result of differing amounts of mathematics learning at school is not a question on which the survey can inform researchers. Respondents were asked about years of schooling and qualifications but not the subject content of that schooling. The ALL survey may have an underlying assumption that full mathematics is an integral component of the entire school curriculum, whereas in New Zealand secondary schools, particularly in the senior years, full mathematics has been an optional subject. Furthermore, there is the suggestion that in the 1940s and 1950s boys had to opt out of mathematics at secondary school, whereas girls had to opt into study mathematics (Openshaw, 1993). This could be a relevant finding in relation to numeracy scores of older women. The omission of a question in the ALL survey questionnaire on the level or extent of mathematics learning in secondary school means that a relationship was unable to be determined between studying mathematics, or years of studying mathematics at school, and numeracy scores.



### **5.3.1 Further Education and Training**

Workers with poor numeracy scores may participate less in further education than workers with better numeracy scores, with women more likely than men to participate in courses not linked to a qualification (Dixon & Tuya, 2010). The effect of women having poorer numeracy scores as measured by the ALL survey, as well as undertaking courses that do not lead to a qualification, could be confirmation of the research from the United Kingdom which suggests the effect on women of poor numeracy skills is greater than the effect of poor numeracy skills for men (Parsons & Bynner, 2007). Low skills and a greater likelihood of training without resulting qualifications could lead to small benefits to workers who take part in such training. Small benefits from undertaking training may result in less training being undertaken than if significant rewards were probable. Older adults seemed somewhat less likely to have engaged in studying, whether for a qualification or not, than younger adults (Dixon & Tuya, 2010).

Adults who were 60-65 for the ALL survey in 2006 would have been at secondary school in the 1950s when the New Zealand economy and education system were in the middle of the post-World War Two baby boom. Consequently, numeracy scores for women over 50 are likely to be a reflection of the educational, social and economic realities of that era. Employment patterns of women have also changed markedly since the 1950s (Hillcoat-Nalletamby & Baxendine, 2004).

For women, paid or unpaid work has often provided difficulties for researchers, partly because of child-care tasks and responsibilities where women with skills ranging from low to very high may choose to spend significant periods of time caring for children. The most detailed ALL survey report on workplace literacy or numeracy skills analysed only those adults in work (Dixon & Tuya, 2010).

### **5.3.2 Employment**

The measurement of employment as a variable in surveys such as the ALL survey is complex because of the range of possible categories: full and part time work, work for part of the year, casual work, retirement, disability or illness, the status of homemakers and so on. The findings of the ALL survey in relation to employment and numeracy scores are thus limited. However, around 55% of employed adults or students age 25 –

65 had numeracy scores at Levels 3 – 5. Of the unemployed, retired, homemakers or “other” adults 25 – 65 between 25% and 35% had numeracy scores in the range of Levels 3 – 5 (Lane, 2010b).

With women, there is not a consistent relationship between working or not working and answers to the questions investigating attitudes towards numeracy. However, women working tended to believe they were “good with numbers and calculations” (79%) compared with non-working women (71%). Women who were working were less likely to “feel anxious when figuring amounts of discounts, etc.” (23%) compared with their non-working counterparts (44%).

Clearly, the majority of women, irrespective of whether they are in employment, are confident that their numeracy skills meet their everyday needs. This is despite suggestions based on the ALL survey that around half of women have numeracy scores that indicate “pressing needs” (Tertiary Education Commission, 2008b, p. 4). However, there remains a minority, which is higher amongst the non-employed, who are dissatisfied with their numeracy skill levels.

Irrespective of gender, workers with poorer numeracy scores are less likely to be regularly undertaking numeracy tasks in the workplace than their more skilled colleagues (Dixon & Tuya, 2010). These workers are also less likely to be using a computer at home or at work than their more skilled counterparts (Lane, 2010b; Parsons & Bynner, 2007).

## **5.4 Women with Level 1 numeracy scores**

Table 4 shows higher numbers of NZ European women than NZ European men with Level 1 numeracy scores, whilst the gender difference in scores for the other ethnicity groups is smaller. The Asian, Maori, Pasifika and Other groups collectively, have a higher number of respondents with low level numeracy scores, despite making up smaller percentages of the New Zealand population (see Appendix A).

**Table 4. Level 1 Numeracy scores, gender and first ethnicity**

Gender	New Zealand European	Maori	Pasifika	Asian	Other	Totals
Male	101,427 43%	48,074 20%	40,409 17%	37,268 16%	8,173 4%	235,351 100%
Female	148,172 54%	50,213 18%	37,857 14%	30,699 11%	5,896 2%	272,837 100%
Totals	249,599	98,287	78,266	67,967	14,069	508,188
% of total ethnicity	13%	38%	56%	30%	20%	

*Note.* The “% of total ethnicity” is the percentage of adults in each ethnicity group with Level 1 numeracy scores. Source: Drawn from the New Zealand results of the Adult Literacy and Life Skills survey and Satherley & Lawes (2008).

The New Zealand European population with Level 1 numeracy scores shown in Table 4 represents 13% of the 16 – 65 age population. Adults with Level 1 numeracy scores comprise a much higher percentage of each of the non-New Zealand European ethnicity groups, although they represent a much smaller proportion of the total adult population.

This table suggests that New Zealand European women may have a disproportionate difficulty with numeracy.

## **5.5 Women, attitudes and emotions towards numeracy**

The literature review has discussed women as knowers and users of numeracy and the importance of such an identity. Furthermore, literature on women’s confidence at using numeracy skills in every-day life suggests that women may have numeracy skills which are greater than the ALL survey indicates.

The ALL survey collected information on adults’ self-assessment and a series of attitude questions. The answers to these questions have not, in the main, been published.

### 5.5.1 Women's self-perceived skills

A series of questions were asked about self-assessed numeracy skills. One such question asked "Please tell me whether you strongly agree, agree, disagree, or strongly disagree with the following statements: I am good with numbers and calculations" (G7A) (Ministry of Education, n.d.).

**Table 5. *Born in New Zealand and "I'm good with numbers and calculations"***

	I'm good with numbers and calculations			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	23%	51%	21%	4%
Not born in NZ	26%	56%	14%	4%

*Note.* Women only.

Table 5 reveals that around 80% of women believe they are competent at carrying out the calculations and understanding and using numbers in their lives. The ALL survey, however, finds that around half of New Zealand adults have scores that are regarded by the survey as "low".

**Table 6. *Measured numeracy skills and self-assessed numeracy skills.***

		Self-assessed numeracy skills		
		Higher	Lower	Total
Measured numeracy skills	Higher	44%	5%	49%
	Lower	37%	14%	51%
	Total	81%	19%	100%

Source: Satherley & Lawes (2009a, p. 14).

An issue to be considered with self-assessed numeracy skills is the standard involved in "higher" or "lower" skills. The ALL survey standard differentiation between "higher" and "lower" scores is approximately related to an American college entry standard (OECD & Statistics Canada, 2000). This standard may be higher than the standard respondents used to self-evaluate whether they are "good with numbers and calculations". Furthermore, as Satherley & Lawes (2009a, p. 15) suggest, "this may not

mean that a lot of people are wrong about what they can do, but rather it may mean their skills are relatively well-matched to their numerical activity”.

In a recent report from Scotland using IALS<sup>1</sup>, St Clair et al. (2010) argued that adults have spiky profiles with some areas of strength and other areas of weakness, as well as an ability to use texts in some contexts more effectively than in other contexts. These authors find “it is likely that the skills measured in the individual test (IALS) are an underestimation of what people can do in real-world settings” (St Clair et al., 2010, p. 12). They found spiky profiles between the three literacy domains (prose, document and quantitative). The ALL survey data cannot provide clarity on the presence or absence of spiky profiles within domains such as numeracy, although it is reasonable to question whether adults might have strength in numbers or measurement, for example, but not statistics. In self-assessing numeracy skills, adults may recognise that they have stronger skills in some aspects of numeracy than in other aspects. As a consequence of a self-recognised spiky profile, some adults may be uncertain as how to accurately answer these questions. The ALL survey provides no answer options other than the “strongly agree”, “agree”, “disagree” and “strongly disagree” which may be appropriate for analysis but not necessarily for accurately describing skill mixtures.

Self-assessment is also overlaid with social and cultural values relating to modesty, social mores and peer influences – factors which may also relate to personal feelings of affect towards numeracy.

### **5.5.2 Affective issues**

The extant ALL survey findings in New Zealand have paid only cursory attention to the background questionnaire questions on attitudes and emotions towards numeracy.

The questions in the ALL survey on affective issues relating to mathematics were only asked of people who had had some secondary education (Ministry of Education, n.d.). Question A9A asked “Think about learning mathematics and how you were taught mathematics while a student at secondary school, please tell me whether you strongly agree, agree, disagree, or strongly disagree with the following statement(s): I enjoyed

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<sup>1</sup>The report does not make clear the reasons for undertaking the IALS instead of the ALL survey, but this may have been done so that skills data was comparable with previous surveys.

maths in school” (Ministry of Education, n.d., p. 16). For women, the distribution of agreement and disagreement with enjoying maths shows a negative correlation ( $r=-.159$ ) with being born in New Zealand ( $p<.01$ ).

**Table 7. Born in New Zealand and “Enjoyed maths at school”**

	Enjoyed maths at school			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	15%	33%	33%	18%
Not born in NZ	24%	42%	26%	7%

*Note.* Women only.

For women, getting “good grades in math” was highly correlated ( $r=.702$ ,  $p<.01$ ) with “enjoying maths in school”.

**Table 8. Born in New Zealand and “I got good grades in maths”**

	I got good grades in maths			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	13%	42%	30%	12%
Not born in NZ	19%	49%	25%	5%

*Note.* Women only.

The data on “I enjoyed maths in school” and “age” suggest a weak relationship between these variables, with older women tending to have stronger negative views and younger women more positive views (see Appendix B, Table 16). Understanding the classroom material and lessons in maths class is also likely to influence attitudes towards mathematics and numeracy.

When women were asked if they “usually understood what was going on in maths class” (A9D) a noticeably smaller percentage of women born in New Zealand strongly agreed with this statement, contrasting with women born overseas

**Table 9. Born in New Zealand and “I understood maths classes”**

	I understood maths classes			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	11%	52%	29%	7%
Not born in NZ	18%	59%	20%	2%

*Note.* Women only.

Tertiary educated women, irrespective of whether they were born in New Zealand or not, were less likely to get “lost in maths” than women who had only completed secondary education.

**Table 10. Born in New Zealand and “I often got lost in maths”**

	I often got lost in maths			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	11%	31%	45%	10%
Not born in NZ	4%	30%	52%	13%

*Note.* Women only.

A smaller proportion of New Zealand-born Asian women strongly agreed or agreed that they enjoyed maths at secondary school (38%) than overseas-born Asian women (76%), although the numbers of New Zealand-born Asian women are not large.

The strong relationship between being born in New Zealand or not, does not show up to the same extent with the statements “I’m good with numbers and calculations”, “I have the maths skills to do my job well” or “I feel anxious when figuring amounts of discounts or tax”. All the New Zealand-born Asian women agreed or strongly agreed that they were “good with numbers and calculations” compared with 86% of their overseas born counterparts. Around 75% of New Zealand-born women agreed they were “good with numbers and calculations” compared with more than 80% of overseas-born women.

**Table 11. Born in New Zealand and “I’m good with numbers and calculations”**

	I’m good with numbers and calculations			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	23%	51%	21%	4%
Not born in NZ	26%	56%	14%	4%

*Note.* Women only.

Despite the negative beliefs shown by New Zealand-born women relating to mathematics in secondary school, significant concerns about mathematics skills are not evident in the self-assessments in the workplace. Only a small percentage of women, either born in New Zealand or born overseas, disagreed or strongly disagreed with the statement “I have the maths skills to do my job well”.

**Table 12. Born in New Zealand and “I have the maths skills to do my job well”**

	I have the maths skills to do my job well			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	52%	41%	5%	1%
Not born in NZ	49%	44%	5%	1%

*Note.* Women only. Only respondents in work were asked this question.

However, we have no knowledge of the mathematics skills involved in those jobs. It is possible that women are competent at workplace numeracy skills or the numeracy content may be taken out of jobs where the workers lack the skills to complete those tasks (Benseman & Sutton, 2007; Dixon & Tuya, 2010; Kell, 2009). As well as numeracy being removed from job tasks, the numeracy content involved in the job may be small, which means that a respondent who confidently replies that they strongly agree in their ability to complete the numeracy tasks in their work may be completely truthful and objective (Dixon & Tuya, 2010). Alternatively, workers may have learned specific skills to be able to undertake specific numeracy tasks in the workplace. Perhaps the question used in the survey could have been better worded, or follow-up questions asked or a factor analysis performed on the numeracy tasks done at work (variables E1A to E3F) and related to the self-performance rating.



Some of these affective issues questions are, however, negative (for example, “got lost in maths” or “feel anxious”) and tend to focus on what respondents cannot do rather than on what they can do. There may be consequences in the negativity of these questions. Firstly, some women may feel uncomfortable about admitting difficulty with school learning. Secondly, women may relate numeracy competence to mathematics learning at school, whereas the literature review in this study has suggested that numeracy skills continue to develop well into adulthood (Parsons & Bynner, 1998). Thirdly, people may understand mathematics in class but not be able to relate their understanding to real life or transfer the learning into other contexts.

Affective issues can influence identity as knowers and users of numeracy.

### **5.5.3 Identity and numeracy**

The affective questions from the ALL survey (see section 5.5.2) can also provide some insight into women respondents’ identities as knowers and users of numeracy.

These variables were correlated with each other using a Pearson correlation coefficient.

**Table 13.** *Correlations for affective and self-evaluation ALL survey questions*

	Enjoyed maths (A9A)	Good grades (A9B)	Got lost in maths (A9C)	Understood maths in class (A9D)	Good with numbers & calculations (G7A)	Have maths skills to do my job well (E4C)
Enjoyed maths (A9A)						
Good grades (A9B)	.702					
Got lost in maths (A9C)	-.347	-.327				
Understood maths in class (A9D)	.637	.634	-.398			
Good with numbers & calculations (G7A)	.488	.496	-.275	.430		
Have maths skills to do my job well (E4C)	.218	.267	-.153	.221	.415	
Feel anxious (G7B)	-.236	-.255	.213	-.223	-.352	-.221

*Note.* Women only. Pearson *r* correlations using weighted data. Each of these correlations is significant at the 0.01 level (2-tailed) using the weighted data.

Table 13 shows a matrix of correlations. The strongest correlations are “enjoyed maths in school” (A9A), “got good grades in maths” (A9B) and “understood maths in class” (A9D). A further two variables show strong correlations: “I’m good with numbers and calculations” (G7A), “enjoyed maths” (A9A) and “got good grades in maths” (A9B). These correlations indicate positive feelings and attitudes towards mathematics and numbers. Getting lost in mathematics correlated with a lack of enjoyment, poor results and lack of understanding mathematics and could suggest a lack of identity as users and knowers of numeracy.

A key finding from the crosstabulations is that for women, being born in New Zealand seems to have resulted in consistently higher levels of anxiety and negative feelings relating to mathematics and numeracy than being born outside of New Zealand.

Lane (2010a) found a relationship between being born in New Zealand and numeracy scores as distinct from numeracy skills. However, analysis of this variable by gender and comparing it across the affective issues as well as a selection of demographic variables has raised interesting questions, such as whether this factor correlates with ethnicity, first language, age, mother’s schooling and mother being born in New Zealand. Other relevant factors may include whether the respondent completed years 12/13 at secondary school or had been educated outside of New Zealand.

**Table 14. *First language (English or other) and enjoyed maths at school***

First language	Enjoyed maths at school			
	Strongly agree	Agree	Disagree	Strongly disagree
English	15%	33%	33%	17%
Other language	24%	46%	22%	6%

*Note.* Women only.

Women whose first language was a language other than English enjoyed mathematics at school noticeably more than those whose first language was English. However, the relationship between “first language spoken” and the remaining affective questions (“got lost in maths”, “understood maths in class”, “have the maths skills to do my job well”, “feel anxious when figuring out discounts” and “good with numbers and calculations”) are not as strongly correlated as “enjoyed maths in school” for the “born

in New Zealand” variable. The “first language spoken” variable could be seen as a proxy variable for culture or ethnicity insofar as English was learned as an additional language by 17% of the adult population in 2006. More than half these people had arrived in New Zealand between 1996 and 2006 (Earle, 2009b). In view of the discussion included in the literature review on the cultural and social situatedness of numeracy, it is evident that affect and identity are also socially and culturally situated. This, in turn, suggests that, particularly for New Zealand women, learning numeracy is intimately bound up with issues of both affect and identity.

## **5.6 Summary and conclusion**

Profound concern surrounds the soundness of the ALL survey methodology with its use of imputed values which are then equated with actual test scores, and the circular nature of their calculation (Culligan et al., 2004). Furthermore, the reporting of the ALL survey continuum of scores as discrete skill levels is a questionable practice.

The ALL survey numeracy scores show that numeracy skills continue to develop into middle age. However, although the ALL survey scores reflect age trends they do not reflect the confidence women have in their capacity to perform numeracy tasks both at work or in their everyday lives. The pen and paper nature of the ALL survey skill assessment exemplars, which are reminiscent of school arithmetic assessments, suggest that the ALL survey numeracy assessment probably captured only a small portion of tasks women frequently perform. Furthermore, to relate everyday numeracy competence to mathematics learning at school is a manifestly false conception.

The ALL survey extant findings do not differentiate between scores measured by the ALL survey assessments and skills. Instead, the extant findings equate “scores” with “skills”. Furthermore, the extant findings imply “skills in situ” despite the evidence to the contrary of numeracy skills beyond the scope of the ALL survey questions.

Being born in New Zealand detrimentally affects the attitudes of women towards mathematics compared with their overseas-born counterparts. However, when in work, women are overwhelmingly confident they have the maths skills to do their jobs well. For women, numeracy self-assessments are overlaid with social and cultural values as well as emotions and attitudes towards numeracy or mathematics.

The disparity shown for women between self-assessed numeracy skills and the ALL survey scores suggests the need to examine how well the ALL survey numeracy test items relate to current uses of everyday numeracy for women. Alternatively, the standards women use to self-assess their skills may relate to their everyday lives, in which they feel overwhelmingly competent, rather than a decontextualised English language test of “college entry” numeracy.

## 6 DISCUSSION

### 6.1 Introduction

This chapter discusses the research findings from Chapter 5 in relation to both the research questions and the literature review.

The first section investigates the characteristics of New Zealand women that are described by the ALL survey as having inadequate numeracy skills. A distinction is made between *scores* achieved in the ALL survey assessment tasks and numeracy *skills* used in everyday life. This section considers the reasonableness of ascribing poor numeracy skills to women when the difficulties may lie with the ALL survey questions and assumptions, or their numeracy scores.

The second section considers New Zealand women's perceptions of their numeracy skills, how women feel about learning mathematics in school and their identities as users and knowers of numeracy. In particular, this section considers the finding from this analysis that being born in New Zealand is an important factor in how women enjoy and feel about their numeracy skills. Possible reasons for this finding are examined.

The third section explores the confidence women have in their numeracy skills to meet their needs in real life and work compared with the ALL survey findings.

The final section appraises the key issues surrounding the ALL survey design.

### 6.2 Women with low level numeracy

The first research question investigated New Zealand women described by the ALL survey as having inadequate numeracy skills bearing in mind that the ALL survey described ALL survey "scores" as "skills". This question could now be restated as: to investigate New Zealand women described as having inadequate numeracy "scores". The 21% of New Zealand women with Level 1 numeracy scores included respondents who could perform none of the tasks with those who were able to complete Level 2 or higher tasks on some of the items, but not with an 80% probability of completing Level 2 tasks. This factor alone suggests that 'people with Level 1' scores includes many

respondents who are likely to perform at a higher level than the ALL survey reports suggest.

There are a disproportionate number of New Zealand European women with Level 1 numeracy scores compared with New Zealand European men. Around 60% of New Zealand Europeans with Level 1 numeracy scores are women. However, of the total numbers of women with Level 1 numeracy scores nearly half are Maori, Pasifika or from other non-New Zealand European ethnic groups. In addition, there is a disproportionately higher proportion (29%) of older women (56 – 65) and younger women (22% of women age 16 – 25) with Level 1 numeracy scores (Appendix B, Table 24). The international ALL survey results for the numeracy domain show a consistent score difference between men and women across the entire range of countries which participated in the first tranche of the ALL survey (Murray, Owen, et al., 2005). This score difference is attributed to occupational choices, course enrolment and training programmes undertaken (Lane, 2010b; Murray, Owen, et al., 2005). If higher levels of educational participation result in higher numeracy scores, the large increases in educational participation rates in New Zealand between IALS (1996) and the ALL survey (2006) could indicate possible increases in numeracy scores in future such surveys (See Table 2 and Table). However, higher levels of education may not result in higher numeracy scores. The ALL survey may be measuring a numeracy which is a vertically or hierarchically organised schema of knowledge as opposed to a numeracy learned in situ for a specific purpose in a horizontal context (Bernstein, 1999). If the numeracy learned in higher education is horizontally, or context oriented, and the ALL survey is measuring vertical numeracy, then higher rates of educational participation may not result in higher numeracy scores.

The international ALL survey report discusses the possible effects of aging on numeracy score levels (Murray, Owen, et al., 2005). They describe four effects influencing adult numeracy performance: aging, practice, cohort and period effects. Aging effects are the declines in cognitive mechanics associated with age; practice effects are the outcome of life experiences and opportunities; cohort effects can be seen in extended periods of education for young people compared with older cohorts, and period effects are the effects of, for example, teaching methods (Murray, Owen, et al., 2005). Aging effects could explain the decline in numeracy skill levels in the older age

groups (Drolet, Schwartz, & Yoon, 2010; Murray, 2009; Reder & Bynner, 2009; Wagner, 1994). Correspondingly, the younger age groups may not have had opportunities to transfer some of their classroom-based numeracy knowledge into practice or to develop in situ numeracy skills.

The effects of ethnicity and first language on numeracy scores for women are complex and seem likely to be embedded in culture, education and social experiences as well as language. The ALL survey has a theoretical framework that required test assessment items to be “equivalent for population sub-groups within countries”(Murray, Owen, et al., 2005, p. 21), although exactly what “population sub-groups” are is not specified. At the same time, the assessment items had to “be culturally diverse, representing a broad range of cultures, languages and geographic regions” (Murray, Clermont, et al., 2005). One could question both the cultural representativeness and the logic of a process that is based on gender-neutrality. Assessment items were excluded if they were not answered in “roughly the same way” (Gal et al., 2005, p. 170) by men and women in the pilot study. The gender difference on numeracy scores is consistent both in New Zealand and internationally (Murray, Owen, et al., 2005; Satherley & Lawes, 2008a). It may be possible that the inclusion of only gender neutral assessment items, when numeracy itself may not be gender neutral, has contributed to the findings of the small but significant differences between New Zealand men and women in numeracy score levels. Furthermore, as is now apparent, we cannot equate ALL survey “scores” with actual skills.

### **6.3 Women’s perceptions of inadequacy**

The second research question investigated the characteristics of New Zealand women who perceive their numeracy skills to be inadequate. This section will discuss the findings into women and their identities as users and knowers of mathematics and numeracy.

This research question has used data from two questions to frame the research question: “I feel anxious when figuring such amounts as discounts, sales tax or tips” and “I have the maths skills to do my job well”. The ALL survey asked whether respondents felt “anxious when figuring such amounts as discounts, sales tax or tips”, women with



poorer scores indicated a higher level of anxiety carrying out these proportional or percentage calculations (see Table 22).

The second self-perception question was “I have the maths skills to do my job well”. This question could be problematic for a range of cultural and social reasons, including questions of identity as knowers and users of numeracy (Boaler et al., 2000; Lerman, 2001; Van De Mierop, 2005).

This study investigated a range of affective and self-evaluation variables included in the ALL survey that might offer insight into the “maths identity” of women respondents. These variables were A9A, A9B, A9C, A9D, E4C, G7A and G7B. For women, the variable “born in New Zealand” provided consistent findings across the above range of affective variables. The argument that women’s identities and attitudes to mathematics are learned in the home or socially derived (Burkley et al., 2010; Ingleton & O’Regan, 2002; Mendick, 2005b) could suggest that the women whose mothers were born overseas might show different attitudes from women whose mothers were born in New Zealand, but the data did not support this suggestion. Being “born in New Zealand” suggests that attitudes towards numeracy are learned early in life, but the lack of an intergenerational relationship suggests that these attitudes may be learned outside the home environment.

Early educational experience is one possible explanation for the possible relationship between being New Zealand-born as distinct from overseas-born and the affective questions in the ALL survey.

A study conducted in the United States found that female primary school teachers with mathematics anxiety transmit negative beliefs to their female pupils about mathematics skills (Beilock et al., 2010). The study investigated the attitudes of girls entering the classes of mathematics anxious teachers and found the higher the teacher’s anxiety, the lower the girls’, but not the boys’ mathematics achievement. Furthermore, at the end of a year of learning mathematics with mathematics anxious teachers, the greater the teacher’s anxiety levels the more likely the girls were to endorse the idea that boys’ are better at mathematics and girls are better at reading. This belief, in turn, resulted in girls demonstrating lower mathematics achievement. Forthcoming research into third year teacher trainees and mathematics anxiety may provide insight into the extent of

mathematics anxiety among New Zealand teachers (G. Frankcom-Burgess, personal communication, October 4, 2011).

However, the disturbing question remains as to what is occurring in the New Zealand education system that results in girls acquiring negative attitudes towards mathematics.

One concern arising from negative attitudes towards numeracy and mathematics is the commonly held belief that mathematics ability is somehow related to “intelligence” (Jones, 2010; Solar, 1995). This belief could lead to an association between mathematics skills and educational participation, insofar as women perceived as having higher intelligence (because of demonstrably good mathematics skills) may be encouraged to pursue further education. This belief may also have negative connotations for highly able women who do not excel at mathematics insofar as the ability of these women may not be recognised or encouraged to the extent of their mathematically able peers.

Educational participation was a significant indicator of higher numeracy scores levels in the ALL survey. Whether an individual participates in further education can be influenced by social contexts, peer groups or family; economic or employment imperatives; or a sense of self-worth as a potentially successful learner (Ingleton & O’Regan, 2002; Mendick, 2005b; Swain, 2005). If educational participation is viewed as a process of socialisation rather than learning, learners may reject the teaching as a conscious choice in retaining their personal social capital. This may, in part explain the lower educational participation rates amongst Maori who may see education as having little relevance to their lives (Rawiri, 2006). It is possible that numeracy skill and knowledge embedded in Maori cultural capital have not been captured in the ALL survey questions because of the universal and American origin of the questions (McMurchy-Pilkington, 1996; Ohia, 2002). As a result of a lack of access to the assessment questions, we remain unsure about any cultural orientation, but the background questions display such a bias. For example, one question asked about anxiety when figuring out amounts of “discounts, sales tax or tips”. In New Zealand, only “discounts” has any relevance at all insofar as sales tax is never calculated in real life. Goods and Services Tax (GST) is applied to prior to every purchase, and tips, if provided, are rarely, if ever, a percentage of an account.

A finding from international comparisons of the ALL surveys has shown that different immigration policies tend to affect national ALL survey levels (Murray, Owen, et al., 2005). New Zealand Immigration policy patterns and their effect on the ALL survey findings are beyond the scope of this current study, but the international ALL survey findings suggest that such patterns could be usefully explored. For instance, recent New Zealand research has found that migrants from 2005 – 2010 are “overeducated” compared with earlier migrants who tended to be “undereducated” (Hodgson & Poot, 2010). This could, in turn, suggest that ALL survey scores for both the immigrant population and the total population might, in future, be higher than in 2006.

Almost 90% of women with the lowest level of numeracy scores believed they had the numeracy skills to do their jobs well, although use of the tag “well” in the question requires a comparison with an unknowable standard. This is in stark contrast to the extant findings of the ALL survey which describe half of all New Zealand women as lacking the numeracy skills to fully participate in the knowledge society and economy (Satherley & Lawes, 2009a).

## **6.4 Women’s numeracy skills usually meet their needs**

The fourth research question investigated why New Zealand women perceive their numeracy skills to be much better than their actual scores in the ALL survey.

Many factors may affect women’s perceptions of their numeracy skills in their daily lives. However, the self-perception relates to use of real-life numeracy practices used in situ which the ALL survey could not assess, instead using a standardised pen and paper test. The women were not asked how they felt they had performed in the pen and paper test but how they managed the numeracy tasks they carried out in every-day life. The self-evaluations were then compared with an arbitrary and decontextualized assessment standard – college entry level numeracy – and many women were described as having poor “skills”. This must raise questions about the relevance of the questions in capturing the numeracy skills of New Zealand women.

The self-evaluation questions in the ALL survey point to the identities of women as knowers and users of mathematics. There are suggestions in the literature that women see numeracy and mathematics as being mathematical tasks that they cannot do,

whereas the tasks they can easily perform they describe as “common sense” (Harris, 1997; McMurchy-Pilkington, 1996). This suggests that some women may develop identities as *not* being knowers or users of mathematics and numeracy, because of the difference between “academic” numeracy and real life practice in which the mathematics and numeracy are often invisible and thus not acknowledged as such.

Identity could be influencing the findings of the ALL survey, insofar as women may not recognise or value their numerical knowledge and skills. Alternatively, as the self-evaluation questions find, women may often see and recognise their skills, but these skills may be unrecognised by the survey as the skills may be embedded in social practices.

## **6.5 The ALL survey**

The third research question considered the reliance that can be placed on the ALL survey findings on New Zealand women and their numeracy skills. Answering this question has resulted in systematically evaluating the theoretical foundations, design and implementation of the ALL survey and its New Zealand findings.

The ALL survey research methodology with such frequent use of imputed scores is disturbing; particularly in light of the spiky profile evidence (St Clair et al., 2010). The powerful political sponsorship of the ALL survey by the OECD and national governments may be the reason the methodology has not been widely questioned. However, in excluding the New Zealand IALS respondents with totally imputed scores from their analysis, Culligan, Sligo, Arnold, & Noble, (2004) have shown sufficient concern as to the statistical implications of the circular nature of this process to deviate from the standard IALS analytical protocols.

The BIB process, whereby one domain of the three domains had imputed skill scores, is also questionable. The ALL survey used four domains rather than the three domains used by the IALS survey, and therefore, survey respondents had a greater proportion of imputed skill scores than the IALS survey, increasing the questionability of using imputed skill scores. A significant proportion of the total sample would have had three out of four ALL survey domains scored with imputed values.

The use of item response theory (IRT) and balanced incomplete blocks (BIB) raises several issues. Firstly, whether the ALL survey process is a valid and reliable process for the adult sector where researchers and practitioners are aware of the unusual skill mixes and levels displayed by adults (spiky profiles). Secondly, because of the reliance on school-like pen and paper tests, the design of the ALL survey may fail to capture the ability of adults to have, show or use different skills in different contexts. Finally, the complexity of both understanding and analysing the ALL survey data appears to have repositioned numeracy from adult numeracy practice to the field of computer analysts and statisticians, who may not see nor recognise the complexity of skills and knowledge that comprise the use of adult numeracy skills (Hamilton & Barton, 2000a). The Scottish IALS report, which has had numeracy and literacy practitioners closely involved in interpreting their IALS findings, is noticeably cautious in the interpretations of the data, including finding 3.6% of Scottish adults to have serious challenges with literacy practices (St Clair et al., 2010). This 3.6% of Scottish adults with “serious challenges” demonstrated IALS Level 1 scores on each of the three domains, as compared with 12.3% who scored at Level 1 on at least one scale (St Clair et al., 2010). The interpretation placed on the literacy findings in the Scottish study contrasts with the discourse in New Zealand surrounding the ALL survey results, which states uncritically that, for example “51% of Aucklanders have low numeracy making it hard for them to work out simple calculations needed for daily life and work” (Sutton & Vester, 2010, p. 8) or that “a significant number of working-age adults are without the literacy, numeracy and language competencies necessary for sustained employment and active participation in society” (Ministry of Education, 2007, p. 33). The latter two claims appear problematic (although “a significant number” is vague) in terms of interpretation placed on the survey findings. To describe people as unable to meet the demands of everyday life seems to undervalue the situated skills and knowledge of many people (Sticht, 2001b).

The IALS and ALL surveys have developed alongside measures of reading, mathematics and science studies in the compulsory school sector such as Trends in International Mathematics and Science Study (TIMSS: 1999, 2003 and 2007) and the Programme for International Student Assessment (PISA: 2000, 2003, 2006, 2009). The Educational Testing Service (ETS) in the United States has been closely involved in each of these skill surveys. However, whether the processes suitable for the school

sector (such as BIB and IRT) are appropriately transferred to the adult sector has not been closely investigated, except from a statistical analysis perspective (Blum et al., 2001). Possibly, access to the information needed for such an investigation is both difficult and requires a unique blend of statistical modelling, as well as adult literacy sector knowledge. Few researchers may be in a position to undertake such an examination.

## **6.6 Conclusion**

The relationship between affective issues and being born in New Zealand raises the possibility that New Zealand girls may have been influenced to see themselves as less likely to enjoy or be successful at mathematics. Combined with the common view that success in mathematics is related to intelligence, this may in the past have led to an early departure from education. Early departure from education could compound the effect of low formal education levels and poorer mathematics skills. This could then lead to lower skilled and paid work. However, educational participation patterns appear to be changing over time and this may begin to address the small ALL survey numeracy score differences between men and women.

More research is needed into the significance for women of being born in New Zealand and associated negative attitudes and feelings about mathematics. Early education experiences, as well as anxiety among women teachers in primary schools, may be contributors to women's attitudes towards mathematics.

These suggestions are, however, overlaid with concerns about original data collected by the ALL survey. The design, measurement and analysis processes of the ALL survey use processes that cast doubt on the usefulness of the survey findings.

Questions remain about the appropriateness of the numeracy assessment items and the ALL survey methodology. The overriding emphasis on the survey's assessment of "skills" equated with "scores" rather than the respondent's self-assessment of their skill and the assessment of numeracy only in an English language context, is questionable. This in turn, points to the possible disconnect between the ALL survey pen and paper test assessment and real life skills. Furthermore, this supports the suggestion that the ALL survey may be measuring a "vertical" discourse when numeracy may be a

“horizontal” discourse (Bernstein, 1999). Thus, the ALL survey numeracy assessment may not actually measure numeracy. Each of these concerns has contributed to reservations about the findings relating to the first research question.

The difficulties in using the ALL survey data set during this research have highlighted the sheer complexity of the research and analysis processes. Engaging with the data has also highlighted the many assumptions that underlie the survey design and the consequential limitations in the data interpretation.

This study has carefully considered the reasonableness of interpretations relating to New Zealand women and numeracy that have been based on the data from the ALL survey. The definition of numeracy (see 2.2), which is ostensibly the foundation of the numeracy test items (Kirsch, 2003), suggests that understanding what the test items try to measure is critical to evaluating the findings of the survey. This research has produced some evidence that schooled numeracy may have very complex relationships to the numeracy practices of everyday life (McMurchy-Pilkington, 1996). The test items in the ALL survey may be seen by respondents as assessing “school” numeracy rather than what respondents perceive to be common sense which may, in turn, affect the findings of the survey. The survey seems to assess a particular valued form of school-based numeracy and numerical behaviour that is embedded in certain social values that are apparent in the background questionnaire. If the numeracy exemplars indicate the nature of all the test items, then serious concerns are raised when the test items are not available for scrutiny by researchers (Hamilton & Barton, 2000a; St Clair et al., 2010; Sticht, 2001a).

There are multiple dangers when few people have access to the ALL survey data and even fewer people look carefully at the numbers and critically consider the interpretations (Sussman, 2003).

## **6.7 The contribution made by this research**

This research has investigated the overlooked self-evaluative and affective ALL survey question responses of women as providing insight into identity as knowers and users of numeracy. Interpretation of these findings may be confounded by both the questions used in the survey and underlying social and cultural values. Some of the self-

evaluation questions are poorly worded; for example, using two or more questions in one. Other questions ask adults to compare their skills to an unknowable standard. Furthermore, the ALL survey questions ask people to rate their skills, which may raise issues of modesty or self-deprecation.

One finding from this study may be the effect of being “born in New Zealand” on feelings about numeracy, particularly school experiences. This study has positioned that finding alongside research which describes the influence of women teachers’ mathematics anxiety on girls. Furthermore, it questions whether women teachers’ mathematics anxiety has contributed to negative views about learning mathematics in school and confidence in mathematics skills.

A counterbalance has been provided here to the interpretation of the ALL survey findings on women and numeracy in New Zealand. Some of the critiques in the international literature of the OECD sponsored international adult literacy surveys (IALS and the ALL survey) have been highlighted.

Many questions have been identified as either not being answered or not able to be answered, for example, questions relating to transfer of learning from one context to another, could be answered by alternative research methodologies, such as longitudinal or ethnographic research. In addition, the inclusion of sociological and ethnomathematical perspectives could provide some other unforeseen interpretations of the ALL survey findings, which may show that the numeracy skills of women as an ethnos (or cultural entity) are not as poor as the ALL survey suggests.

## **6.8 Summary and conclusion**

There are significant methodological limitations to the ALL survey which should be considered when interpreting the survey findings. The construction of the ALL survey, based on defined skill competencies, is probably a political activity which involves valued forms of numeracy. Interpreting the findings of the IALS and ALL surveys incorporates aspects of community and political values as well as survey design (Druine & Wildemeersch, 2000). For example, workplace literacies are only one of the many literacies adults use and yet labour market outcomes and productivity are a primary



focus for OECD-sponsored adult literacy surveys in New Zealand (Dixon & Tuya, 2010; G. Johnston, 2004; Ministry of Education, 2007; Satherley et al., 2008a).

Women have overwhelmingly reported that they have developed numeracy skills to meet their needs in everyday life. These are likely to be the “horizontal” skills, specialised skills for meeting specific needs, rather than the “vertical” pen and paper test skills measured by the ALL survey. Consequently, the ALL survey findings undervalue the numeracy skills and knowledge of many New Zealand women. However, the negative attitude of many New Zealand women towards numeracy and mathematics is a significant question for further research.

## **7 CONCLUSION**

### **7.1 Introduction**

Overwhelmingly, women are satisfied that their numeracy skills meet their everyday needs, although there remains a small group of women who are dissatisfied. This confidence is shown despite this self-perception being overlaid with social and cultural values of modesty, social mores and peer influences. Furthermore, this self-perception is against an unknown standard. The striking contrast between self-perceived real life numeracy activities and the findings of the ALL survey suggests that the ALL survey may be measuring a construct of “numeracy” that differs from real life skills, and hence, may be a construct other than numeracy.

### **7.2 Summary of the key findings**

The vast majority of New Zealand women are satisfied that their numeracy skills meet their everyday numeracy needs. Self-perception of numeracy skills is confused by judgment against unknown standards and a lack of information on the amount or level of mathematics achievement in formal schooling, as well as poorly worded self-evaluation questions.

However, there is a distinguishing variable for New Zealand-born women, who express markedly less enjoyment and success with mathematics learning in school than women born overseas. Furthermore, New Zealand-born women indicate less confidence in their mathematics skills than their overseas-born counterparts. That being New Zealand-born appears such an important variable for women could suggest that early education or school experiences may have detrimentally influenced their attitudes towards mathematics.

The sharp contrast between the confidence New Zealand women have in their in situ numeracy skills and the findings of the ALL survey, which suggest that the majority of women have difficulty with numeracy tasks, calls for a deeper questioning of the design and analysis of the ALL survey itself.

The DeSeCo project described a rich array of skills and attributes believed to be necessary for working in a modern economy. However, the survey designers were

unable to successfully design assessment frameworks for “teamwork” or “practical cognition”, despite recognising the importance of these attributes. In attempting to develop these competencies into an assessment framework, the survey designers seem to be acknowledging that the literacy and numeracy skills measured by the ALL survey are not a sufficient condition in themselves for participation in the “knowledge economy”. The designers concluded that the only way to effectively assess teamwork skills is through observation (Murray, Clermont, et al., 2005). However, in measuring numeracy skills, the ALL survey designers used a decontextualized pen and paper test as a de facto measure of skills. This was despite the overwhelming evidence that numeracy is more than skills measured in school-like pen and paper tests, but is embedded in everyday life tasks and culture. In turn, this suggests that numeracy, if it can be measured, should also be measured in situ.

Disappointingly, the reports based on the ALL survey findings have repeatedly reported ALL survey “scores” as “skills” without drawing attention to this distinction. Furthermore, the “skills” continuum has been separated into discrete levels despite the questionable nature of such a process.

The ALL survey contains some questionable assumptions, including the use of balanced incomplete blocks and plausible values that critics find problematic (Blum et al., 2001; Culligan et al., 2004). The process of creating plausible values from limited demographic characteristics overlooks the importance of other demographic factors (Payne, 2006). The evidence for spiky profiles or uneven skill levels makes the extrapolation of skills, as occurs with the imputed (or plausible) values, problematic (Hamilton & Barton, 2000; St Clair et al., 2010). However, the IALS (with three skill domains) has evolved into the ALL survey (with four skill domains) and the ALL survey in turn has expanded into PIAAC (with the addition of problem-solving in technology-rich environments). The more domains included in the international adult literacy surveys, the greater the extent of use of this circular imputed score process. The greater the use of imputed scores, the more questionable the findings from adult literacy surveys in light of the “spiky” profile evidence.

The ALL survey background questionnaire collected copious amounts of information but the wording of questions, and indeed the social or cultural assumptions behind some questions, suggests values that may relate to middle class affluence as much as to

literacy or numeracy practices. Furthermore, some of the background questions on affective attitudes were worded as two or even three questions in one, creating potential difficulty with answers. Other questions were pointedly positive or negative in orientation, possibly implying biased responses.

The extant findings have mainly overlooked the affective questions included in the ALL survey background questionnaire, almost as though attitudes towards numeracy are unimportant or too difficult to change. This is despite the research that describes the importance of women having identities as knowers and users of mathematics. The findings from this study, with respect to the importance of being born in New Zealand and attitudes towards numeracy, suggests that overseas-born women have more secure identities as knowers and users of mathematics and numeracy. The reasons for this finding are uncertain and suggest this as an important issue for further research.

Numeracy skills (and ALL survey scores) continue to develop with age and after the completion of formal education, which suggests that numeracy is an accumulation of skills acquired in situ rather than the use of a hierarchy of transferable skills.

### **7.3 Limits and usefulness of international surveys**

The usefulness of the ALL survey depends upon the perspective of the users. For adult literacy programme supporters, the low literacy scores provide justification for funding adult literacy programmes. The IALS data has been used in New Zealand to suggest a change to reading instructional approaches used in schools (Chapman, Tunmer, & Allen, 2003). The Ministry of Education have conducted extensive research using the ALL survey data (Earle, 2009a, 2009b; Lane, 2010a, 2010b; Satherley & Lawes, 2007, 2008a, 2008b, 2009a, 2009b; Satherley et al., 2008a, 2008b; Smyth & Lane, 2009) finding that education, first language and computer use are important indicators of higher levels of numeracy scores. However, their research is unable to explain whether, for example, numeracy scores are enhanced by computer use, or whether higher numeracy scores are needed to engage with computers in the first instance.

International research has emphasised the relationships between social deprivation and numeracy skills (Parsons & Bynner, 2007; Payne, 2006; St Clair et al., 2010) with limited success at finding solutions. Possibly this is because of the complexity of interrelated factors impacting on the lives of the socially deprived and the lives of adult

literacy learners. Furthermore, the numeracy skills of the “socially deprived” are not well measured by pen and paper tests. These are all factors beyond the capacity of survey research to investigate.

The ALL survey, being entirely English-language based in New Zealand, is limited in its capacity to identify the numeracy skills of non or low English language speakers. The numeracy test items often require subtle or specialised understanding of language embedded in particular cultural contexts, although the extant findings have usually taken such results to indicate poor skills.

Lack of response limits the validity of any survey, and the response rate for the ALL survey was 64% (Strafford, 2009). However, this response rate included data that would have been excluded by Culligan et al., (2004) in the IALS analysis because of concern that imputed skill scores did not represent independent information. The limited number of population weighting factors used (gender, age and ethnicity) (Strafford, 2009) and the circular nature of the imputing process are problematic in light of the evidence of both spiky profiles and the evidence that numeracy skills are social practices acquired by adults to meet specific needs.

In the process of investigating the ALL survey data on women and numeracy, substantial engagement was necessary with the design and research methodology. This has resulted in identification of some of the inadequacies of the ALL survey. The ALL survey numeracy assessment (and researchers have been prevented from accessing more than a handful of exemplars) appears to measure a hierarchical construct of numeracy with a scale of operations, whereas in real life it appears women usually acquire the numeracy skills they want, at a time and in a situation of choice, to meet a particular need.

The evidence points to women as likely to have and use numeracy skills that are better than the ALL survey finds.

## **7.4 Limitations of this research**

This research is limited by the design, assumptions, methodology and implementation of the original ALL survey. The questions posed in the background survey and the

omitted questions have limited the range of questions this research was able to investigate. Furthermore, the findings on women and numeracy are limited by the concept of numeracy and the quality of the assessment.

Whilst the OECD documents acknowledge the complexity of skills involved in adult numeracy, the question remains as to how well the assessment items in the ALL survey represent both the complexity of the skills and the relevance of the unknown questions to the widely varying personal circumstances of the respondents. The ability to learn new skills when and if required is a critical skill, but not a skill that is assessed by the ALL survey (Federal Statistical Office, Switzerland, 2005; Levy, 2010).

One finding from the literature review for this research has been uncertainty about whether the numeracy test questions capture a sufficient range of numeracy skills in culturally relevant contexts for women (Blum & Guerin-Pace, 2001; Hamilton & Barton, 2000a; Harris, 1996). Consequently, access has been sought, without success, to examine the numeracy questions. As a result of the inability to examine the numeracy assessment items, doubt remains as to exactly what the assessment items measure.

Analysing the ALL survey data is a very complex task, particularly using the plausible values and replicate weights to calculate the sampling errors. This is a necessary step to fully using the domain skill levels (Statistics Canada, 2002). The complexity of this task has limited the scope of this research.

There is also, to date, a lack of substantive research critical of the ALL survey, which has resulted in a greater than desirable reliance on literature relating to the earlier IALS survey. However, with the similarities between these two surveys, many critiques of the IALS apply equally to the ALL survey.

## **7.5 Summary and conclusion**

This study has produced evidence that schooled numeracy (and the ALL survey exemplar assessment items appear similar to schooled numeracy tests) is viewed as largely irrelevant to the everyday numeracy tasks of many New Zealand women (McMurchy-Pilkington, 1996; Rawiri, 2006). Several international researchers have

argued that the IALS survey is likely to underestimate the numeracy skills of adults (Blum et al., 2001; Hamilton & Barton, 2000; St Clair et al., 2010).

This research suggests that the ALL survey findings should be examined critically, despite the complexity and difficulty of the task. Such examination brings into question sweeping statements that describe over 50% of the adult New Zealand population as having low numeracy skills (Tertiary Education Commission, 2008b). Such statements serve to undervalue the skills and knowledge of many people (Sticht, 2001b).

The ALL survey measures a particular form of adult numeracy which is analysed in a questionable manner. The survey provides only limited information on the numeracy skills of New Zealand women and is likely to significantly underestimate those skills.

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## 8 Appendices

### Appendix A

New Zealand Ethnic distribution of the population 1991-2006								
Ethnic group	1991	%	1996	%	2001	%	2006	%
European	2,783,028	83.2	2,879,085	83.1	2,871,432	80.1	2,997,051	77.6
Maori	434,847	13	523,374	15.1	526,281	14.7	565,329	14.6
Pacific peoples	167,070	5	202,233	5.8	231,798	6.5	265,974	6.9
Asian	99,759	3	173,502	5	238,176	6.6	354,549	9.2
Other	6,597	0.2	15,804	0.5	24,885	0.7	36,237	0.9
Total people with ethnicity specified	3,345,741		3,466,515		3,586,641		3,860,163	

[www. socialreport. msd. govt. nz/people/ethnic-composition-population. html](http://www.socialreport.msd.govt.nz/people/ethnic-composition-population.html)

## Appendix B

### Further ALL survey tables

**Table 15. Numeracy and Age Groups**

	Age				
	16 - 24	25 – 34	35 – 44	45 - 54	55 - 65
Level 1	23%	19%	16%	19%	23%
Level 2	35%	28%	29%	30%	34%
Level 3	30%	32%	35%	34%	31%
Level 4/5	13%	21%	20%	17%	12%

*Note.* All adults. Source: Satherley & Lawes, 2008b, p. 12

**Table 16. “Enjoyed maths at school” and age group**

Age group	I enjoyed maths in school				Totals
	Strongly agree	Agree	Disagree	Strongly disagree	
16-25	37,344	121,403	84,972	32,138	275,857
	13%	44%	30%	12%	100%
26-35	46,425	103,158	90,771	38,109	278,463
	17%	37%	33%	14%	100%
36-45	64,476	113,166	85,110	49,081	311,833
	21%	36%	27%	16%	100%
46-55	48,494	78,657	92,960	54,574	274,685
	18%	29%	34%	20%	100%
56-65	33,539	56,530	60,525	32,591	183,185
	18%	31%	25%	13%	100%
Totals	230,278	472,914	414,338	206,493	1,324,023
	17%	36%	31%	16%	100%

*Note.* Women only

**Table 17. All adults with higher (Levels 3,4& 5) numeracy by age and gender**

	Age	
	25-44	45-65
Female	50%	40%
Male	55%	58%

*Note.* Estimated percentages only. Source: Lane, 2010a, p. 72

**Table 18. Numeracy skills and educational participation (ALL only)**

	Lower secondary or less	Higher secondary	Tertiary	All levels
Level 1	51%	23%	9%	20%
Level 2	36%	36%	25%	31%
Levels 3 - 5	13%	41%	66%	49%

*Note.* Estimated percentages only, total population. Source: Satherley et al., (2008a, p. 11)

**Table 19. Education participation of workers aged 25 years plus and numeracy score**

	Participation rates (%)		
	Study towards a qualification	Other courses	Study and courses
Level 1 numeracy	18%	16%	32%
Level 2 numeracy	23%	34%	50%
Level 3 numeracy	18%	42%	54%
Level 4/5 numeracy	18%	52%	63%

Source: Dixon & Tuya, (2010, p. 33)

**Table 20. Born in New Zealand and “I got good grades in maths”**

	I got good grades in maths			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	130,082 13. 1%	425,789 42%	304,394 30%	115,836 12%
Not born in NZ	66,032 19%	171,106 49%	87,780 25%	16,979 5%
Totals	196,114	596,895	392,174	132,815

*Note.* Women only.

**Table 21. Born in New Zealand and “I understood maths classes”**

	I understood maths classes			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	105,776 11%	517,046 52%	285,799 29%	70,636 7%
Not born in NZ	60,849 18%	205,363 59%	68,751 20%	7,789 2%
Totals	166,625	722,409	354,550	78,425

*Note.* Women only.

**Table 22. Born in New Zealand and “I feel anxious”**

	I feel anxious when figuring amounts of discounts/tax etc.			
	Strongly agree	Agree	Disagree	Strongly disagree
Born in NZ	65,201 7%	288,115 29%	460,109 46%	169,684 17%
Not born in NZ	20,367 6%	93,747 27%	177,697 50%	53,718 15%



Totals	85,568	381,862	637,806	223,402
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*Note.* Women only.

**Table 23. Proportions of 16-65 year olds at combinations of levels 1, 2, 3 or 4/5 across all four skill domains: prose literacy, document literacy, numeracy, problem-solving**

Level 1 on all four domains	9.5%
Level 1 and Level 2, no Level 3 or more	24.5%
Level 3 on one or two domains and Level 1 or 2 on two or three domains	20.4%
Level 3 on all four domains or all other ranges	24.5%
Level 4/5 on one domain and Level 3 on 3 domains	5.7%
Level 4/5 on two or three domains and Level 3 for one or two domains	11.4%
Level 4/5 on all four domains	4.0%
Total	100%

Source: Adult Literacy and Life Skills Survey, 2006, (P. Satherley, personal communication, March 8, 2011).

**Table 24. Age of women with Level 1 numeracy skills and percentage of all women in the age group**

	Age					Totals
	16-25	26-35	36-45	46-55	56-65	
Level 1 skills	61,145	53,585	53,424	64,001	55,082	287,237
% of all women	22%	19%	17%	23%	29%	21%
All women	278,368	281,812	317,828	282,162	189,882	1,350,052

*Note.* Women only.



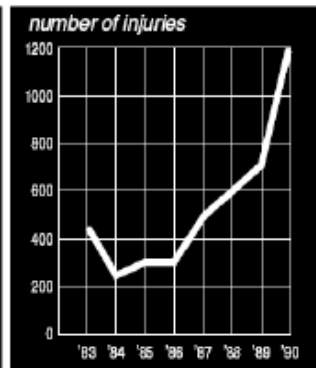
## Appendix C

### Examples of Document Literacy Test Items

Fireworks In the Netherlands



Victims of fireworks



BLOCK -2

Questions 12 - 14. Use the charts on the opposite page to answer questions 12 through 14.

12. In what year were the fewest number of people in the Netherlands injured by fireworks?

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13. According to the charts, what was the value, in New Zealand dollars, of fireworks sold in the Netherlands in 1991?

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14. Describe the relationship between sales of fireworks and injuries due to fireworks.

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Qn 12: Level 2 (242)

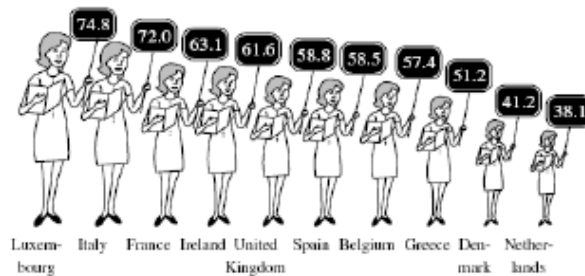
Qn 13: Level 3 (291)

Qn 14: Level 3 (295)

(Strafford, n. d. p. 57)

### FEW DUTCH WOMEN AT THE BLACKBOARD

There is a low percentage of women teachers in the Netherlands compared to other European countries. In most of the other countries, the majority of teachers are women. However, if we include the figures for inspectors and school principals, the proportion shrinks considerably and women are in a minority everywhere.



Percentage of women teachers (kindergarten, elementary, and secondary).

**Questions 1 - 3. Use the chart about women teachers in Europe on the opposite page to answer questions 1 through 3.**

- What is the percentage of women in the teaching profession in Greece?  
\_\_\_\_\_
- List all the countries where the percentage of women teachers is between 60% and 75%.  
\_\_\_\_\_  
\_\_\_\_\_
- In which country, other than the Netherlands, are women in the teaching profession in the minority?  
\_\_\_\_\_  
\_\_\_\_\_

**Qn 1: Level 1 (188)**

**Qn 2: Level 3 (266)**

**Qn 3: Level 2 (234)**

(Strafford, n. d. p 59)