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ADULTS RETURNING TO STUDY MATHEMATICS

This chapter focuses on adults learning mathematics in two distinct sections; adults learning mathematics in the workplace and community; and adults engaged in further studies (e.g. university or vocational studies) including bridging mathematics. In this review, research available on adults in basic numeracy education through to those gaining access to or supported at university study involving mathematics in a variety of forms is investigated. Consideration is also given to relevant definitions of adult, mathematics and numeracy, and to the relationship between research into learning and research into teaching practices or curriculum design. It is concluded that the area of adults learning mathematics is still under-theorised and under- researched at a time when 21st century needs demand a population with increasing numeracy-based skills and knowledge.

INTRODUCTION[i]

This overview of adults returning to study mathematics by necessity involves the intersection of two research domains; adult learning and mathematics education. This intersection leads to the distinct regime of adults learning mathematics, a young and growing domain which has been described as under-theorised (FitzSimons & Godden, 2001) and research scant. In 2001 the Australian Council for Adult Literacy (ACAL), wrote:

> Ten years ago Australia was at the forefront of adult literacy and numeracy teaching, learning and research. Now, we do not even have a national policy and we are going backwards (ACAL, 2001, cited in Coben, 2006).

So it is not surprising that no previous MERGA review of adults learning mathematics has specifically been conducted, although components have been incorporated into other sections of previous reviews. However, since 2002 there has been a resurgence in research, especially within the vocational education sector, often under that banner of literacy research.

With these developments in mind, in this review mathematics will be viewed within a broad conception, not limited to specialised mathematics (FitzSimons, Coben, & O'Donoghue, 2003). It will incorporate research available on adults in basic numeracy education through to those gaining access to, or studying at, university level. Consideration will be given to definitions associated with mathematics, numeracy, and adult which will help define the parameters of the chapter. In the body of the chapter, the focus is on research on adults learning and

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using mathematics in the workplace and community, in further studies, such as the Vocational and Training (VET) sector or bridging or enabling mathematics programs at the university level. Within this literature there is a strong relationship between research into learning and research into teaching practice or curriculum design. Hence, research into the pedagogies for adults returning to study mathematics in all its forms will be included.

DEFINITIONS

Adult

In commencing this review it became apparent that there was some confusion about what constituted *an adult*. A precise definition has proved elusive and has been described as "nebulus and revolves around the student rather than the level of mathematics" (FitzSimons & Godden, 2001, p. 14). Even using the legal definition of all persons over 18 years of age is problematic. Thus for the purpose of this review we will focus on adults who are returning to study mathematics or those who have never studied mathematics. So that means that a 16 year old who left school at 15 years and is now in the work force will be classified as an adult learner, while a 17 or 18 year old who has entered university directly from school will not be so classified.

Mathematics and Numeracy

In this chapter we focus on the definition of adults returning to mathematics as clarified above and the notion of numeracy that surrounds them. We are aware of various terms often used synonymously with numeracy (critical numeracy, quantitative literacy, financial literacy, document literacy, mathematical literacy, democratic numeracy, functional mathematics) but will not attempt to define them here.

The nature of numeracy has been touched on in previous MERGA reviews. In a chapter on language factors in the 1996-1999 review, Ellerton, Clarkson and Clements (2000) devoted some time to the definition of numeracy. At the time it appeared that too little was known about how mathematics was used in aspects of life. In the years between 2000 and 2003 the MERGA literature was silent about numeracy, while in other arenas its definition was hotly debated. This debate was dominated by concerns about numeracy being politicised and subsumed by literacy. In recent years, the debate has reduced with the National Centre for Vocational Educational Research NCVER (2003) concluding that:

> Attempts to propose any single definition of literacy and numeracy are relatively futile when social, cultural and technological changes shape our understandings and alter the way we think about literacy and numeracy. As

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> our concepts change with the times, so do approaches to developing these skills. (p. 1)

This is reflected in FitzSimons (2006a) who quoted van Groenstijn (2002) to emphasise that numeracy is essentially "dynamic and contextually bound to time and place" (para. 4). In a suite of research-based reports on literacy and numeracy from the NCVER (see section on workplace and community), *literacy* was used as a *catch-all* term for "English language, numeracy and information technology literacy" (Wickert & McGuick, 2005, p. 11). Hence in this review, literature which used the term literacy was only included if, upon closer inspection, some aspect of numeracy was found.

In recent literature a change in the concept of numeracy has been chronicled (Kemp, 2005; Miller-Reilly, 2006). Between 2004 and 2007 there appeared to be a group of core definitions with a number of common characteristics. An international group of mathematics educators (Adults Learning Maths: A Research Forum), with a substantial Australian and New Zealand membership, has extensively debated the topic with Johnston and McGuire (2005) indicating that numeracy involved:

> managing a situation of solving a problem in a real context by responding to information about mathematical ideas that is represented in a range of ways and requires activation of a range of enabling knowledge, behaviours and processes. (p. 128)

FitzSimons (2004) used Coben's (2003) definition which expands the Johnston-McGuire definition to include a sense of confidence when describing numerate behaviour on the job.

> To be numerate means to be competent, confident, and comfortable with one's own 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 (FitzSimons, 2004, p. 10)

The most recently used definitions include mathematics, its context, and the notion of being able to use the mathematics for decision making or problem solving. This is reflected in a definition developed by the Australian Association of Mathematics Teachers (AAMT). Here numeracy is defined as the ability "to use mathematics effectively to meet the demands of life at home, in paid work, and for participation in community and civic life" (AAMT, 1998). In a review by Hartley and Horne (2005) it was noted that:

> …many Citizens Advice Bureau (CAB) enquirers have well developed numeracy and literacy skills but are unable to identify the optimum financial decision or strategy based on the information available to them. (p. 22)

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The CAB enquirers, in fact, do not have well developed numeracy skills, according to the recent numeracy definitions, as they could not solve the problem of finding the optimal financial decision.

The term academic numeracy, modified from Yatsukawa and Johnston (1994), was used by Galligan and Taylor (2005) to clarify the skills necessary for success in the university context as:

> a critical awareness which allows the student to situate, interpret, critique, use and perhaps even create mathematics in context, in this case the academic context. It is more than being able to manipulate numbers or being able to succeed at mathematics. (p. 87)

Neil (2001), attempting to clarify the notion of numeracy, suggested that there were two threads running through many of the forty definitions he examined*:* *location* (home, work, society etc) and *context* (specific problems or situations). At the time few definitions included both of these components. It should be noted that the three definitions quoted in the review (Johnson & McGuire, 2005; FitzSimons, 2004; Galligan & Taylor, 2006) all have the concepts of *location* and *context.*

FitzSimons (2005d) brought a new dimension to the numeracy debate situating it in an international setting and focusing on Bernstein's concepts of vertical and horizontal discourse. While vertical discourse centres mainly on school mathematics, horizontal discourse is closely linked to numeracy as it is related to on-going practices, is affective, has specific immediate goals, and is highly relevant. She emphasised that these discourses are different with different practices, and that vertical discourses will not guarantee numerate activity.

FitzSimons and Coben (in press) referred to Maguire and O'Donoghue's 2002 framework of adult numeracy as a continuum from formative (phase 1: basic skills) to mathematical (phase 2: mathematics in the context of everyday life) to integrative (phase 3: mathematics integrated with the cultural, social, personal, and emotional). At phase 3, they argue, adults can become *knowledge producers* as well as *knowledge consumers* (Maguire & O'Donoghue, 2002). Thus adults become "technologically, socially, personally, and/or democratically numerate" (American Institutes for Research, 2002, p.7)

Finally, Zevenbergen (2004) placed the concept of numeracy in the context of the workforce. She defined numeracy as "the application of, and disposition towards using contextually appropriate mathematics to solve everyday problems" (2004, p.100) and visited the notion of multiple numeracies. While there has been debate over multi-literacies in these *new times*, until then no such debate had emerged in mathematics and numeracy. She poses the question of whether there are different forms of numeracy in these changing times and concluded that we may need to re-theorise knowledge, skills and dispositions, to re-conceptualise definitions of numeracy relevant to workforce needs.

The next section is divided into three parts: Reviews pertaining to adult numeracy; a series of studies commissioned by the National Council of Vocational

Educational Research (NCVER); and other research focussing on workplace and community. In the final section adults in further studies will be reported on.

WORKPLACE, COMMUNITY AND THE ADULT LEARNER OF MATHEMATICS

Reviews of Adult Numeracy

Five contributions were found in which Australasian research on aspects of adult literacy that included numeracy was reviewed. The first of these was from New Zealand, three were from Australia and one jointly researched with an Irish author.

Benseman, Sutton, & Lander's (2005a) review, commissioned by The New Zealand Ministry of Education, located 300 studies (world wide) in which the effectiveness of adult literacy, numeracy and language teaching was investigated. Within the 105-page report, only six pages were devoted to numeracy, reinforcing the notion of the under-researched nature of adult numeracy. The authors were led to conclude:

> …the research evidence on numeracy does not provide guidance on the time and the nature and extent of teaching required for adults to make significant progress…our understanding of adult numeracy is so limited that at this point rather than evaluating the impact of what does take place it may be more appropriate to undertake insight studies that consider that range and nature of adult mathematical understandings, how that understanding develops and what interventions might be effective. (Benseman, Sutton, & Lander, 2005a, p. 84)

Hartley and Horne (2005) reported on an Australian NCVER project in which the social and economic benefits of improved adult literacy was investigated. The report focussed on business, health and financial literacy (including research projects by the ANZ bank in 2003 and the Commonwealth Bank in 2005), family literacy and crime, together with brief reviews of research related to two specific population groups (older people and Australian Aborigines). Some useful frameworks for measuring numeracy directly were also discussed (Hartley & Horne, 2005, 2006).

McKenna and Fitzpatrick (2004) conducted an extensive audit of policies and practices of adult literacy and adult basic skills in Canada, Ireland, New Zealand, USA, UK and Australia. Their report focussed on four areas of literacy; "'basic', 'new basics', 'elite literacies and foreign language literacy'" (p. 10). Numeracy was implicitly embedded in three of the areas. While the authors concluded that Australia was successful in integrating literacy within Vocational Education and Training (VET), national policies in that sector had not been renewed since 1996. Outside of VET sector there appeared to be a lack of understanding of the literacy provision.

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Perkins (2005) reported on the national reporting system which sets level of language, literacy and numeracy in Australia. The author concluded from their research that although this system was generally accepted by practitioners, it needed to be updated.

Johnston and McGuire (2005) aimed ambitiously to 'provide a snapshot of international adult numeracy policy, pedagogy and provision over the last 20 years with case studies of interesting and significant initiatives' (p. 8). The seven chapters included policy, financial and lifelong numeracy, and international comparisons. Chapters on research, professional development and implications were not available at the time of this review.

Workplace and Community Projects

In New Zealand a *Learning for Living* project, has produced a number of general research based-reports commissioned by the Ministry of Education into aspects of adult literacy. This includes research into assessment practices (New Zealand Council for Educational Research 2006) and observational study on adult literacy, numeracy and language teachers (Benseman, Sutton & Lander, 2005b). These reports, while having an overall focus on literacy, numeracy and language, had little specific numeracy research. However a research project on the development of a community of practice for numeracy teachers has been completed by Gill Thomas but not available in time for this publication.

In 2002, 2003 and 2004 the NCVER in Australia managed adult literacy projects producing 20 publications between 2004 and 2006, (Foster & Beddie, 2005). Of these one general (Wickert & McGuirk, 2005) and five specific reports included research on numeracy.

The Wickert and McGuirk study (2005) was a preliminary investigation into building literacy capabilities in communities and the workplace. They used the term 'literacy' as a general term including English language, numeracy and IT literacy and interviewed coordinators of initiatives from five worksites and four community sites. Only in one example (a women's community health centre) were numerate activities identified. These involved using street directories and timetables (p. 33). While acknowledging this as a small study, the authors concluded that there was potential to engage agencies outside education and the training sector (e.g. industry partnerships) to improve literacy competencies.

Numerous studies have reported on the numeracy demands of the chemical spraying industry. FitzSimons and others examined the numeracy in this industry (FitzSimons, 2004; FitzSimons, Mlcek, Hull & Wright, 2005; FitzSimons, 2005b; FitzSimons, 2005c) using work shadowing, observation, semi-structured interviews and the collection of artefacts. They concluded that all the workplaces investigated required a wide variety of mathematical skills based on Mayer's key competencies (as cited in FitzSimons et al. 2005, p 20): collecting, analysing and organising information; communicating ideas and information; planning and organising activities; working with others and in teams; using mathematical ideas and

techniques; solving problems; using technology collecting. FitzSimons also identified Bishop's 'pan-cultural' activities (counting, designing, explaining, locating, measuring and playing), plus underlying skills of algebra (spreadsheets) calculations, estimations, geometric thinking, storage, retrieval display and interpretation of data (as cited in FitzSimons, 2005b, p.35). This research importantly recognised the complexity of the workplace, where workers require a strong general mathematics education. In was purported that the research should assist vocational teachers to address the broad range of concepts beyond 'simplistic rational number and measurement skills' (2005, p. 38). Following this work and underpinned by Activity Theory was FitzSimons (2005c) project on 'An evaluative framework for new learning technologies. Together in these numerous works she argues that while learning numeracy in the workforce is informal, it is filled with meaning and the relation between such things as rules of the community, the division of labour and knowledge is important.

Cumming and Wilson (2005) investigated the literacy and numeracy demands of alternative dispute resolution processes in Australia. After surveying six alternative dispute resolution organisations, 51 individual dispute resolution practitioners (response rate of 22%) and analysing numerous documents, they suggested that dispute resolution required a high level of numeracy (level 5 National Reporting System (NRS)). The numeracy skills identified included financial, map reading (for property settlement), interpreting data and calculating percentages. In one instance the poor numeracy skills of lawyers were noted. The results indicated that this level of numeracy demand may prevent Australians from participating in the effective dispute resolution processes and suggested a need for specific training of practitioners. This research appeared to be the first of its kind as even though dispute resolution involved a 'considerable range of financial considerations and mathematical procedures involved in legal cases', no previous international research had involved numeracy considerations. The authors expressed a concern that limited literacy and numeracy skills could act as a barrier to participation in the justice system in Australia' (p. 17).

Hayes, Golding and Harvey (2006) investigated the literacy and numeracy skills of public safety volunteers. In this study of over 300 participants from twenty fire brigades and SES units in small and remote Australian communities, the authors described the numeracy demands of the profession and the participants' perceptions of their personal competencies. Questions on skills produced the following results on the importance of a skills to the brigade and particpant's personal rating on certain skills: reading a map (50% rated their personal skills as high and 82% rated this as highly important to the brigade); reading dials on equipment (51% personal skills high and 79% highly important to the brigade); doing basic calculations (44% high personal skills high and 43% highly important to the brigade). The authors concluded that the development of skills is best embedded into training that is of direct interest to the volunteers. The providers should have strong links with the volunteer organisations. Informal training was also concluded to be significant for the development of numeracy skills and should

not overlook the importance of the volunteer with local knowledge. They recommended the use of mentors to deal with the wide range of learners.

A project by Gleeson (2005) sought to explore the benefits of further training for adults with low levels of numeracy. The research applied statistical modelling to the 1975 cohort of the Longitudinal Survey of Australian Youth (LSAY) and the 1979 cohort of the American National Longitudinal Survey of Youth (NLSY79). Analysis of the Longitudinal Survey of Australian Youth indicates that individuals with low numeracy skills are less likely to receive further education, but gain positive and significant economic returns when they do. Continuing with formal schooling is positive and significant for individuals with very low numeracy skills.

A study by Balatti, Black and Falk (2005) was concerned with the changes in students' connections with people and examined the social capital outcomes experienced by students undertaking numeracy or literacy courses. This qualitative study involved interviews with 57 students and 18 teachers in Northern Territory, Queensland and New South Wales. Data were coded for the presence of social capital based on the Australian Bureau Statistics framework (2004), and evidence of course participation exerting socio-cultural impacts. The study showed that the outcomes were highly valued by students and teachers. Almost 80% gained social capital i.e. they found changes in network structures and transactions. The course impacted on their lives not by improved literacy and numeracy but social capital outcomes.

Marr and Hagston (2007) investigated how numeracy skills are learned in the workplace and how these skills are related to the workers' school learning experiences. They conducted semi-structured interviews with ten key stakeholders and in three worksites (an aged care facility, an automative engineering manufacturer and a sheetmetal engineering factory). They confirmed the necessity for numeracy skills now and in the future; found workers competent but under-confident in numeracy related skills; found workers had a lack of understanding of the link between school mathematics and their paid work; and suggested training be developed and delivered by a team with adult numeracy expertise and local industry knowledge. They also found the term "numeracy" is problematic as it "conveys a narrow picture of basic number calculations" (p. 8) and suggested it be extracted from the LLN (language, literacy and numeracy) acronym at the policy level and unpack the term to explicitly extend the scope and breadth of numeracy from policy statements down to training packages.

Zevenbergen (2004, 2005; Zevenbergen & Zevenbergen, 2004) reported on the results of a three year project which examined numeracy practices of young people in the Australian workplace. She suggested there is little research on 'multi-numeracies' and posed the question: 'are there new ways of working mathematically brought about by the use of technology?' (2004, p. 99). The study examined the ways young people (22 years or less) perceive and work mathematically in the workplace compared to more senior people (older than 40). Workers involved included: a bricklayer, boat-builder, hairdresser, motor mechanic, retail assistant, baker, builder, signwriter, painter, printer, room service,

laundry attendant, lab technician, receptionist, short order cook, and chief. In total 880 participants were surveyed, work-shadowed or interviewed using stimulus recall. Results suggested younger and older people have a 'different orientation to mathematics in the workforce'. Senior people see the value of mental calculations whereas younger people see this is undertaken using technology and their task is problem solving and estimation. Zevenbergen (2005) suggested there was evidence of demathatiziation of the workplace in many sites.

In a large Australian study the Commonwealth Bank Foundation (2005) investigated the links between financial literacy and individual outcomes. This study initially included a telephone survey of 5000 individuals (16 - 65 years), which asked questions about such things as how to choose the best way to reduce your credit card interest (82% correct) or understand how to control mobile phone bills (18% correct). Follow-up stages investigated the micro and macro economic effects of improving financial literacy using hypothetical scenarios and modelling. The authors concluded that if the financial literacy of the 10% of the Australian population with the lowest scores was increased over a ten-year period, Australia's GDP would increase by $6 billion per year and 16,000 new jobs would be created (p.7).

In a case study of the numeracy skills of adults with Downs Syndrome, Faragher and Brown (2005) attempted to identify links between numeracy and the quality of life model (personal contexts, variability, life-span perspectives, values, choices and personal control, perception and self image). Results demonstrated numeracy competencies in six areas of the quality of life model. Questions as to whether Downs Syndrome adults should learn the mathematics (e.g., knowing the bowling score and then knowing they lost); how to prepare for numeracy and how to tailor it, were posed.

While there were a number of conference papers and journal articles on adult numeracy in the period 2004 to 2007, many of them did not report on actual research, or the research was framed loosely. In particular, Inglis (2005), in a plenary in the Adults Learning Maths Conference in Goteburg, highlighted numeracy demands in plumbing. Research however was not the focus of this paper. Similarly, Lee (2006) investigated numeracy in hairdressing and beauty therapy in New Zealand through workshops in a learning centre at an institute of technology. Feedback from the workshops indicated improved student attitudes towards mathematics, and confidence with numeracy associated with pricing guns, tills, and diluting solutions. In other papers only descriptions of numeracy in particular contexts were provided; for example, Faine (2006) on saving house water, and Porter (2006) on statistics in marine studies.

In 1996 Australia and New Zealand were part of an international survey of aspects of literacy. In the second half of 2006 this was followed by a second wave of data collection under the auspices of the Adult Literacy and Life Skills Survey (ALLS). This survey, of about 9000 persons in Australia and 7000 in New Zealand, targeted more aspects of numeracy than did the 1996 survey. One of the objectives was to assess the skills of adults in four areas: prose, document literacy,

numeracy, problem solving and analytical reasoning. It also aimed to identify students at risk with low level skills, and evaluate assistance programs. The results of the survey will be published in 2008 (ABS, 2007; Ministry of Education 2008).

The studies reported in this section on workplace and community suggest a surge in Australian and New Zealand government-led research. In particular the research by NCVER to 2007 indicated increased interest in the area. Whether this research will have an impact on teaching practices and curriculum design is unclear. However, funding for the adult literacy and numeracy research through NCVER ceased from March 2007 and the impact of such cuts on further research are as yet uncertain.

ADULTS IN FURTHER STUDIES

Adults in further studies can be enrolled in a range of different types of courses. Although we acknowledge that overlap exists between the contents of this chapter and the review of students in university level mathematics (Chapter **), we have restricted the review to students enrolled in two types of programs.

The first type refers to courses that lead to university entrance of some form. These are routinely called bridging, enabling, or occasionally developmental courses. In this review this will primarily involve students who can be called 2nd chance students. This means that they are adults returning to study at the tertiary level of education with limited backgrounds in mathematics (Miller-Reilly, 2006).

The second type includes courses, programs and strategies that are designed to support students whilst enrolled in University studies. These can take the form of consultations in learning centres or interventions embedded within traditional university courses.

Care is taken within these two categories not to intersect with research available on traditional learning and teaching of mathematics in undergraduate courses and is thus focussed on mature students in university study rather than recent school leavers.

Although there are a significant number of courses across Australasia within the VET or TAFE sector, the paucity of research on learning and teaching within these programs precludes their inclusion in this section, with the exception of one article. In this, Cooper et al. (2007) used an action-research methodology to investigate how mathematically-underachieving Torres Straight Islander students could meet the requirements of a block-laying course.

Learning and Teaching within Bridging Mathematics

Bridging mathematics has been a focus within mathematics education since the early 1990s. Wood (2003), in the previous MERGA 4-yearly review, included a brief section on research in this area. In a recent review of research, Taylor and Galligan (2006b) indicated that there have been four broad areas of research within the bridging mathematics community, namely: evaluation of specific courses, tests

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and other methods of establishing student needs, ways of overcoming maths anxiety, and what are the important cognitive differences between bridging mathematics and traditional mathematics teaching. In the years of this review, the types of research undertaken within the bridging mathematics sector have changed little.

Miller-Reilly (2006), in a significant long term analysis of two large bridging courses and one individual bridging program in New Zealand, used quantitative and qualitative measures to compare students' reactions. These multiple strands of evidence provided a complex overall picture of three largely successful teaching approaches. A one-to-one supervised course focused on understanding fear of mathematics and early mathematics experiences. The course empowered the student who came to believe that mathematics was a creative and enjoyable process. A second course (100 students) focused on the mathematization of realistic situations. Here, students came to regard mathematics as useful, interesting and relevant to real life. The third course (100 students) was a carefully structured re-introduction of mathematics. The students appreciated the course and were pleased they could now do mathematics that they could not do in school. Students in all programs were highly motivated, mature, and had not seen formal mathematics for some years. One surprising result from the study was that if students were unsuccessful they were, in fact, worse off than before, and often confused. A significant component of the study was the focus placed on dealing with students' mathematics anxiety or fear. Quantitative measures and qualitative descriptors indicated a decrease in mathematics anxiety throughout the three programs and in the larger courses correlated with achievement. Beliefs about mathematics in general, however, did not necessarily change, although students in the larger course did see the practical nature of mathematics.

The importance of attitudes and beliefs about mathematics was taken up by a number of other researchers within the bridging mathematics community. In an analysis of the written reflections of mature students within a preparatory course, Viskic and Petocz (2006) found that although their students' mathematical abilities varied, many showed a maturing understanding of mathematics and its place in their own self development and in various aspects of their lives, including their working life, intellectual life, and civic life. In particular, they could categorise students' beliefs into 'component', 'models', 'life' and 'techniques' previously defined by Reid, Petocz, Smith, Wood and Dortins, (2003). Overall the students' reflections on projects they had to complete indicated that although initially surprised by the project's connection with mathematics, there was growth in their awareness of the usefulness of mathematics.

In a more quantitative approach, Klinger (2006) investigated attitudes, self-efficacy beliefs, and math-anxiety of a diverse group of pre-tertiary adult learners using a self-designed survey and pre- and post-testing. He found that although students initially shared the negative views reported in the wider population, these views changed significantly by the conclusion of the topic(s). He concluded that adults' perceptions of, and capacity to engage with, mathematical content was

strongly influenced by early learning experiences, but like authors before, confirmed that these could be changed. In a later study, Klinger (in press) repeated the analysis with commencing arts, humanities, and science students and found the arts/humanities students to have significantly lower mathematical self-efficacy and poorer attitudes than the science students. The results were strongly linked with gender, with females scoring lower than males. He concluded that such results indicated that undergraduate support programs would have to address such poor attitudes to enable students to succeed and develop mathematical literacy necessary for their discipline.

In two similar quantitative studies underpinned by Bandura's social cognitive theory (Carmichael & Taylor, 2005; Carmichael, Dunne & Taylor, 2006), motivation (particularly self-efficacy) and other factors such as prior knowledge were examined as measures of prediction of success in a university preparatory mathematics course. Results suggested that students' assessment of their confidence was based, in part, on their current levels of knowledge and skills, and that this assessment influenced their current performance. Females and those who had been away from study for a long period of time had lower entering levels of confidence and self-efficacy than males and recent school leavers, but final performance in the course was not significantly different.

Taylor and Galligan (2006a) used conversation theory framework to design a multimedia package to simultaneously develop students' mathematical skills while improving mathematics confidence. The evaluation of this program indicated the effectiveness of this approach. It is apparent through the work discussed above that although attitudes and beliefs about mathematics are of significant importance to students enrolled in bridging programs, these programs can change students' attitudes and beliefs about mathematics as well as their achievement. An alternative to the above is to design programs that can assist in self-selection. Egea (2004) has designed and evaluated an online self assessment tool, which assists students to choose the appropriate level of bridging mathematics program. It has been specifically designed with the mathematics anxious students in mind, and participating students indicated that the test was 'enjoyable', 'fun', 'easy', even 'relaxing', confirming that its design had addressed both cognitive and affective domains.

Bridging or foundation programs are widely available across Australasia along with similar programs for indigenous students. However, few research studies have been published on the learning and teaching within these programs. Galligan (2004a) described one such program for on-campus International students, highlighting the added difficulties for students whose 1st language is not English. Significant difficulties are associated with English language proficiency and the role that language plays in bi-lingual students' processing of mathematics (Galligan, 2004b). Galligan (2005, 2007) reported further on the difficulties associated with extending such programs to offshore delivery. Using an ethnographic approach, she investigated potential conflicts in a mathematics foundation classroom in Hong Kong, and analysed the data using Valsiner's Zone

theory. Although the emerging themes of teaching, student, curriculum issues, outside influences, and use of English, would not be surprising to anyone working in the field, the methodology used in the study allowed for greater understanding to be developed between teacher, student and program provider. Birney (2006) briefly described what works with Melanesian adults living in Papua New Guinea and involved numeracy based activities. One such activity was learning the decimal place system. Here the students learn by building on their traditional language and the concept of number embedded in that language.

Mathematics Support within the University Sector

For some years, universities across Australia have supported the mathematical learning and development of undergraduate students. They do this through a variety of methods and strategies. This type of support is often offered to all students, not just students who are enrolled in traditional mathematics courses. Traditionally the support is distinct from the teaching of such courses, but increasingly such support is integrated into the teaching (e.g., Taylor & Mander, 2004). The research on the teaching and learning within this integrated support is rare, but growing. This section will focus on research on support courses rather than studies associated with the teaching of undergraduate mathematics courses, which are reviewed in Chapter ****. In most instances research on support courses focuses on mature aged university students rather than recent school leavers. Leder and Forgasz (2004), in their research on the daily challenges of mature students of mathematics, recommended that identification of required prerequisite skills early in students' studies may bridge perceived deficiencies. Research in that area is growing, as typified by the work of Egea, Dekkers and Flanders (2004) and Wilson and MacGillivray (2007). Carmody and Wood (2006) describe a peer-tutoring system that uses third year students to support the development of the mathematics and statistics skills of first year students. They reported benefits not only to the first year students but also to the peer tutors in terms of increasing their own understanding of mathematics.

Although support programs focus on a range of disciplines, current research is apparent only within Nursing. Two studies were identified in the area of drug calculations. Behrend, Clark, Hall and Hill (2006) designed a pencil and paper test to diagnose numeracy skills and used the results to develop and evaluate a comprehensive one-stop shop to manage the safe administration of drugs. Gillies (2004) compared two methods of teaching drug calculation: traditional formula method, and building on students' existing mathematical problem solving skills. Using a pre-test/post test model, performance in drug calculations was better when using the application of formulas than when allowing students to employ a problem solving strategy of their choice from a suite of strategies explored in classes. However, the groups who were taught a variety of problems solving strategies demonstrated increased confidence, and better long-term recall and transfer of skills.

GALLIGAN, L. & TAYLOR, J.A. (2008). Adults Returning to Study Mathematics. in "*Research in Mathematics Education in Australasia 2004-2007*" (Eds. H. Forgasz, A. Barkatsas, A. Bishop, B, Clarke, S. Keast, W. Seah & P. Sullivan), Sense Publishers Rotterdam. pp. 99 -118.

More general learning skills were researched in two other instances. Taylor and McDonald (2007) investigated the use of writing to improve non-routine problem solving and mathematical communication among students enrolled in a service mathematical course enhanced by mathematics support staff. Results indicated that both communication and problem solving improved after introducing a writing heuristic into group problem solving sessions. Kemp (2005), in an extensive study of critical numeracy at the tertiary level, initially developed a qualitative instrument to measure the ability of students to read and interpret tables of data, and then used the instrument to diagnose and thus address students' table reading behaviour. Through a workshop-based intervention, she investigated the efficacy of teaching table reading and interpreting skills. Overall Kemp (2005) concluded that table reading and interpreting skills can be taught and learned, and that students should not be assumed to be able to perform these tasks without instruction. Finally Winn and Keuskamp (2007) lean heavily on the work of Kemp (2005) and a pattern-based approach to provide a strategy for developing problem solving skills for university students requiring support for the development of academic numeracy skills. Their "getting started" strategy should provide a useful device for staff to support such students.

CONCLUSION

Adults studying in formal or informal numeracy programs are involved in learning more that mathematics. They encounter rich embedded numeracy tasks, whether there are involved in spraying chemicals, analysing options to buying a mobile phone, or studying/preparing for university courses with embedded mathematics (e.g., drug calculations).

Research on numeracy in the workplace suggests that as the workforce is becoming dematematized, numeracy is becoming more hidden in complex tasks. Teachers, it appears, are ill equipped to deal with these complexities and have few resources at their disposal. Strong themes related to pedagogy emerged from this section of the review. For example, there are consistent, strong calls for the development of initial training and professional development of teachers in numeracy (Benseman et al. 2005a). Another example is that no mechanism currently exists to accurately quantify the language, literacy, and numeracy teaching workforce in Australia (Mackay et al. 2006). Also, there is an urgent need for mandatory specialised preparation and/or professional development of teachers and trainers involved in adult numeracy, even if this is not their principal role. (FitzSimons, 2005a). Although there does appear to be a move in the direction of "improving the skills and strategies of foundation skills tutors" (Benseman & Sutton, 2007, p.26).

In an NCVER report on the professional development needs of the literacies workforce (Mackay et al., 2006), it was found that the sector had high levels of casualization, with limited access to resources and learning materials. FitzSimons (2004) says that such numeracy teaching requires a "fundamentally different

curriculum and pedagogy from that of school mathematics" (p. 39), a sentiment reflected by McKenna and Fitzpatrick (2004). Marr (2006) described a model of cooperative collaboration between herself, a researcher and a group of seven practicing adult numeracy teachers which appeared effective in developing a holistic adult numeracy assessment resource.

Research on adults returning to study mathematics in the tertiary sector has some similarities to those occurring in the workplace and community, although there is little to no discussion of teaching practice. The focus is often on the students and what they bring with them, rather than the pedagogical practice they experience, although there is a growing number of such studies. Taylor and Galligan (2006) list four key unanswered questions within bridging or enabling mathematics, including:

- "How is success defined in bridging mathematics activities?
- What are the numeracy demands on entry to 'non-mathematical' university study?
- Are successful bridging mathematics students, successful university students?
- Is there more than mathematics?" (For example language and learning skills) (p.18)

With the exception of some key research projects, most of research explored in this review primarily focused on the descriptive. Only in some recent cases in adult numeracy literature for the workforce and the community has the research adopted more sophisticated methodologies (e.g., work-shadowing, stimulated recall). In only a few papers was the discussion framed within theoretical concepts, such as Bernstein's horizontal and vertical discourse, activity theory, conversation theory or Valsiner zone theory. This is probably a result of the high teaching demands placed on many of the authors highlighted in this review. The demands of teaching leave little room for research and publication. The resurgence of government funding for workplace and community research associated with literacy may assist in the development of numeracy research. However, similar funding is not easily accessible in the tertiary sector and this has resulted in the stagnation of research in this area, after a flurry of activity in the early 1990s. Clearly, adults returning to study mathematics is still an under-theorized research domain, with little activity in recent years to move the domain to the next level of research. Zevenbergen (2004) takes this criticism even further in her calls to re-theorize our understandings of knowledge, skills, and dispositions to apply to 21st century needs.

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