Adult Numeracy and New Technologies of Learning

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In an era of globalisation, post-compulsory education is becoming *technologise*d, as adults study at diverse locations and times, oftentimes outside of recognised institutions (EU, 2000). As noted by the EU, there is a burgeoning interest in the production of distance education materials, especially electronically distributed forms, and the Commission stresses the importance of quality learning experiences to support the great potential offered by information technologies. However, while much is known about principles of andragogy and of exemplary practice in mathematics education, in Australia there appears to be little heed paid to research-based knowledge concerning the transformation of these into high-quality technologised educational products appropriate to the particular needs of adults wishing to develop numeracy skills or of vocational learners in mathematics. This paper will draw upon Engeström's *expansive learning* framework to interrogate potential sites for fruitful research and development in this area.

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Introduction

The Australian government has policy commitments to lifelong learning, new learning technologies (NLTs), and adult numeracy, but these are being realised under discrete research and funding arrangements. In this paper I will address the relationships between adult numeracy and lifelong learning, and between adult numeracy and NLTs. I then describe a research project designed to meld these disparate policies, to synthesise the diverse literatures in order to inform the key Activity groups of potential users (students and teachers) and producers.

Numeracy and Lifelong Learning

The changing nature of work is a multifaceted issue of enormous concern and relevance as globalisation and new technologies impact on the individual and collective lives of adults. These require "increased competences, the development of new skills and the capacity to adapt productively to the continuously changing demands of employment throughout working life" (UNESCO, 1997, p 8). In Australia there have been concerted efforts at encouraging lifelong education among the adult population. These have largely been focused upon a social marketing strategy (e.g., ANTA, 1999, 2000a) — an important subject for research at the macro level of policy and planning, but the strategy ignores the meso- and micro-level issues of recontextualising knowledge and 'transmitting' it to students (Bernstein 1996).

Key international theoretical debates about the nature and function of generic skills have been influential in Australia (e.g. Kearns 2001). There is a swell of voices calling for Australia to become a knowledge economy, to make the most of its human capital. One significant area to emerge in recent years is research into literacy and numeracy practices in restructuring workplaces, especially in relation to automation, emerging communications technologies, and new approaches to workplace organisation and management (FitzSimons 2000). Accordingly, the Federal Government is committed to a policy of encouraging adult numeracy, as well as technological and other literacies, in adult and vocational education. However, the concept of numeracy is contested.

In recent reviews of numeracy published by ANTA's research arm, the National Centre for Vocational Education Research [NCVER], there are no clear definitions of what is meant by numeracy, except as a subset of literacy skills: "literacy includes the recognition of numbers and basic mathematical signs and symbols within text" (Falk and Millar 2001, p 9). Watson, Nicholson, and Sharplin (2001) declare that attempts at a single definition are relatively futile, and ANTA is quoted to define numeracy merely as calculations needed in the workplace (Sanguinetti and Hartley 2000). In the Kearns review, which stresses an increasing demand for generic skills, the word *numeracy* occurs several times, but the concept is neither defined nor problematised. Numeracy, in relation to basic skills, is assumed to be an important pre-requisite for employability. However it may be defined, it cannot be assumed that (potential) workers enrolled in VET courses have high levels of numeracy — often due to reasons beyond their control.

The fact that these ANTA review documents are premised upon literacy and numeracy being taught together and integrated into workplace training results in them being treated as a single entity throughout these reviews of research, and in a related guide for practitioners (ANTA 2000b). Even the Falk and Millar (2000) review treats numeracy as an appendix to literacy; neither author has an established reputation in the inter/national mathematics education research community. Sanguinetti and Hartley (2000) have identified a range of problems which arise from this situation, including:

- Implicit numeracy competencies in industry standards require a high degree of analytical sophistication and educational expertise … not all Enterprise-Based trainers nor workplace trainers have such expertise. Often buried in training packages, literacy and numeracy competencies need to be made more explicit. (p 33).
- The assessment-driven model minimises need for teaching or support; there are limited opportunities for development of underpinning skills. More holistic and structured approaches are required (p 34).

By contrast, this view of numeracy as imbricated with literacy, where the word 'mathematics' is *never* used at all, is not supported by the international mathematics education research community which distinguishes between mathematics and numeracy, yet maintains that numeracy must be underpinned by mathematical knowledge of an appropriate kind (e.g. Evans 2000; Steen (ed) 2001). The OECD *Programme for International Student Assessment* (PISA) [http://www.pisa.oecd.org/math/mathm.htm] is firmly committed to mathematical literacy as a scale independent of reading literacy and scientific literacy for school students; the international *Adult Literacy and Lifeskills* [ALL] project's numeracy document [available from http://www.alm-online.org/], likewise. In these studies, numeracy is taken to be much broader than facility with numbers or basic arithmetic, and includes spatial and quantitative (statistical) literacy. (See FitzSimons, in press, for further discussion of the contested nature of numeracy.)

Klein (2000) considers numeracy not as a thing to be possessed, but as a capacity for action. Thus, in relation to numeracy, democratic power depends upon access to mathematical knowledge — information selectively derived from a range of possibilities and which is capable of being interpreted and understood — access to which is also unequally distributed. Klein argues that "numerate behaviour reflects a certain agency with mathematics and comprises intellectual and social aspects of knowing mathematics" (Klein 2000, p 76). Throughout the Kearns (2000) report, there was a stress on problem solving, systems thinking, and analytic skills (generic numeracies, according to Buckingham, 1997). These are essentially mathematical cognitive skills and, I assert, cannot develop into agentic behaviours unless there is strong underpinning disciplinary knowledge to support them (FitzSimons 2000, 2001).

Technology and Adult Numeracy Education

In an era of globalisation, education is becoming *technologised*, as adults study at diverse locations and times, often outside recognised institutions (EU 2000). As noted by the EU, there is a burgeoning interest in the production of distance education materials, especially electronically distributed forms, and the Commission stresses the importance of quality learning experiences to support the great potential offered by information technologies. However, while much is known

about principles of andragogy and of exemplary practice in mathematics education, in Australia there is a dearth of research-based knowledge about how to transform these into high-quality technologised educational products.

In Australia, as internationally, there is a burgeoning research into technologies of education (e.g. Brennan, McFadden and Law 2001; Felix 2001, Harper, Hedberg, Bennett, and Lockyer 2000), but little of the literature is specifically related to mathematics education. (A case study in Alexander and McKenzie 1998, is one exception.) On the other hand, research into mathematics education and technology is mostly located within the mathematics classroom (e.g. Galbraith and Haines, 1998; Lagrange 2000; Trouche 2000; TWIN 1999). Few researchers (e.g. Pickard and Cock 1997; Vanhille and D'Halluin 1997) have considered the impact of new teaching technologies as a medium for teaching mathematics in situations comparable to distance education, where the learner is (or may be) remote from the teacher in space and/or time. Australian adult and vocational education students may be working with a numeracy tutor who is qualified only as a literacy tutor or a workplace trainer with no post-school mathematics or mathematics education qualification. Lifelong education in mathematics needs to consider relationships with the affective domain of adults as well as the cognitive domain (FitzSimons, Coben, and O'Donoghue, in press; FitzSimons and Godden 2000).

The Kearns (2000) report stressed the need for workers to be competent in working with new technologies. Internationally, there is a burgeoning interest in the integration of technology as a tool for mathematics learning; much has been written about the use of scientific and graphic calculators; computer graph and geometry programs, and so forth. However, while much is known about principles of pedagogy and exemplary practice in mathematics education, it is unlikely to be enacted in classrooms or training sites where the teacher or trainer has little or no competence or confidence in using, or teaching with, these tools.

Clearly the issues of lifelong education, adult and vocational numeracy, and the use of new learning technologies (NLTs) — as an innovative means of reaching learners who previously lacked access to institutional forms of adult education — all have serious and important political, economic, and social implications. For example, poor quality teaching and resources may result in (further) alienation from mathematics in learners (young and old) who lack self-confidence, raising barriers to further study and employment. One of the major recommendations in the Kearns report was to foster a willingness and a capacity to learn. This can only take place where teachers are well-prepared and supported by high quality pedagogical resources.

Potential Sites of Research and Development

In order for adult numeracy teaching in Australia to be comparable to world standards the concept needs to problematised. There needs to be a clear definition based upon international research into mathematics in the workplace (e.g. Bessot and Ridgway 2000; Noss, Hoyles, and Pozzi 1998), validated under Australian conditions, complementing the work of Buckingham (1997). Such a definition would extend numeracy beyond its current historical status in Australia as a subset of literacy skills. In addition, use must be made of research into teaching adults (e.g. Coben, O'Donoghue and FitzSimons (eds) 2000; FitzSimons, O'Donoghue and Coben (eds) 2001). Only then can world class pedagogical resources be developed to support adult numeracy teachers,

trainers and students in their attempts to develop a knowledge-based economy in Australia. Much is at stake in terms of financial and opportunity costs to industry and the Australian community generally.

Building on the work of Bickmore-Brand (2001), a new methodologically sound framework needs to be developed to enable assessment of any learning package for adult and vocational numeracy — whether electronic or print-based — along several dimensions. For example, it would enable determination of whether the learning package (print-based, CD-ROM, video, online, etc.):

- is sufficiently broad in *mathematics/numeracy content* and appropriate to the needs of the prospective learner in social, cultural, economic, and political terms;
- is appropriate in type and of suitable quality in terms of appropriate *pedagogies* along cognitive and affective dimensions; and
- uses *technology* appropriately as both tool for learning and means of delivery.

Engeström (1999) outlined a framework for *expansive learning* — working towards a reconceptualisation of Activity theory. He elaborated five principles to summarise Activity theory and cross-tabulated these with four questions central to any theory of learning (Table 1). In this context the concept of learner is taken broadly, to include *all* participants in the dynamic process — not just the students. The five principles are: (a) Activity system as a unit of analysis — interconnected activity systems; (b) Multi-voicedness — multiple views, traditions and interests, voices; (c) Historicity — historical appreciation, pressures; (d) Contradictions — historically accumulated structural tensions within and between Activity systems, struggles; and (e) Expansive cycles — qualitative transformations; questioning and deviation from established norms; in full a collaborative journey through ZPD.

Table 1: Expansive Learning Model

	Activity system as a unit of analysis	***Multi-voicedness***	***Historicity***	***Contradictions***	***Expansive cycles***
Who are learning?					
Why do they learn?					
What do they learn?					
How do they learn					

Source: (Engeström 1999, p 6)

The cells in Engeström's model which are most pertinent to adult numeracy and new learning technologies are as follows. The *Activity groups* include as stakeholders: students, teachers, industry, curriculum developers, technology developers, and policy makers. Each of these groups is *multi-voiced* — that is, their lived experiences go far beyond these simple categorisations, and may overlap, with expertise of various forms distributed non-hierarchically. In other words, no adult is 'just a student'. The *historicity* dimension acknowledges that there are diverse reasons for adults

needing to return to study in mathematics/numeracy, that not all numeracy teachers or trainers have a strong background in post-school mathematics (or indeed any), and that knowledge of international research in mathematics education may be lacking in those groups producing or using the technological artefacts. *Contradictions* abound in the discrepancies between policy and practice: for example in the rhetoric of lifelong learning vs. the practice of 'User pays'; or in the exhortations to raise numeracy standards in the face of chronic lack of discipline-based professional development for tutors and trainers (especially those without recognised entry-level qualifications in mathematics and mathematics education); or in the tensions between new and old curriculum and pedagogical practices in mathematics education. These are exacerbated by the superimposition of NLTs, founded upon minimal research in general (Harper et al., 2000); more particularly, in the field of mathematics education there is a burgeoning literature into the use of technology as a tool for learning as well as means of delivery, and it is this literature which is virtually ignored in the Australian VET sector at present.

A post-doctoral research project currently underway at Monash University aims to identify factors which contribute to the effective and efficient utilisation of technologies in mathematics education, primarily from the perspective of technology as an alternative means of delivery. However, the use of technology as a tool for enhancing understanding of concepts, hypothetical thinking, and interpretation of data is an integral part of this research. Accordingly, the project will synthesise research in mathematics education (including adult numeracy) and NLTs grounded in the literature of lifelong education. It will iteratively research, design, and trial a framework for the evaluation of NLTs intended as a means of distribution of mathematical knowledge to support mathematics, statistics and numeracy education for learners located in (semi)autonomous situations in relation to time and place of learning. This project will take account of Engeström's (1999) Activity groups, their multi-voicedness, historicity, and contradictions, to inform both the developers (commercial and academic) of these materials and the potential users (lecturers, teachers, tutors, industry trainers, and students). It will also take account of Engeström's four central educational questions, and work done by Brennan (2000). Based upon the dimensions of appropriateness of content, pedagogy/andragogy, and use of technology, the objectives of this project are to:

- Identify international examples of high quality mathematics education using technology as a tool and as a medium of delivery
- Identify the strategies used by the developers of these programmes which contribute towards their success (or otherwise)
- Research, design, and trial a framework for the evaluation of NLTs employed in adult and vocational numeracy education for learners in (semi)autonomous learning situations.

Conclusion

This paper addresses an issue of concern to many adult students, their teachers, and learning organisations who are the potential purchasers or funders of technological artefacts: How to evaluate the quality of NLTs with regard to adult numeracy? On the other hand, curriculum developers together with technological developers might also be expected to set a priority on producing high-quality materials that will give them a market advantage, intellectually and/or financially. Research-based knowledge is of the essence in understanding the mathematics/numeracy needs of the learners, their teachers, and Australian society in general. This knowledge production and synthesis arises

from (a) deep understandings of the discipline of mathematics and its related set of numeracy skills; (b) integration of the partially overlapping fields of mathematics education and technology education; (c) knowledge of the diverse, particular groups of adult learners in relation to their past experiences of mathematics together with their foregrounds; and (d) analysis of the critical feedback that emanates from practical use of these innovative materials. According to Engeström's (1999) framework, transformative learning requires qualitative transformations, questioning and deviation from established norms, a collaborative journey through the Zones of Proximal Development of Activity groups, and expansion from isolation to collaboration, through dialogue and debate. Or, as Brennan (2000) expresses it: learning from conversations and research partnerships.

This paper is the first in a series that will evolve as data begins to be collected, with the ultimate goal of producing a multi-layered framework for the evaluation of NLTs in adult numeracy for learners in (semi)autonomous situations, with possible extensions to other post-compulsory mathematics and statistics education.

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