What is specific about research in adult numeracy and mathematics education?

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Abstract

After decades of neglect, adult numeracy and mathematics education are coming to be recognised as worthy of serious research but the area is beset by conceptual difficulties. Adult numeracy and mathematics may at last be ‘on the educational research map’, but where exactly are they on the map? This article explores the question of what is specific about research in adult numeracy and mathematics education. It reviews ways of conceptualising adult numeracy and mathematics education for research purposes and considers the implications of these conceptualisations for research and for the development of the field.

Key words: conceptualisations, adult numeracy, mathematics education, policy, research, development frameworks

Introduction

In the latest International Handbook of Research on Mathematics Education, it is suggested that:

- ….adult mathematics teaching and learning deserve attention in their own right;
- practice and research in adult mathematics education demand a broad conception of mathematics that is not limited to specialized mathematics…;
- there is a coalition of interests in the field across a wide spectrum of related or contributing disciplines;
- there is a recognition that research must be closely linked with practice in a field where development and improvement in practice have priority status; and
- the community of researchers is truly international...

(FitzSimons, Coben, & O'Donoghue, 2003, p.117)

The inclusion of an adult-focussed chapter in the International Handbook attests to the growing international recognition of the importance of research and development in this area. While most research about mathematics education focuses on children (Dossey, 1992), adult mathematics teaching and learning both deserve, and are beginning to receive attention in their own right. Adult numeracy and mathematics are at last ‘on the educational research map’, but where exactly are they on the map and what is specific about research in this area?

In attempting to answer these questions, I shall first explore debates in the international research community, including the relationship between numeracy, mathematics, adult literacy and lifelong education, before turning to consider what kind of studies should be prioritised, given that "research must be closely linked with practice in a field where development and improvement in practice have priority status" (FitzSimons et al., 2003, p.117).

Adult numeracy and mathematics teaching and learning

The conception of mathematics implied by adult mathematics education is broad and inclusive, encompassing diverse areas of activity, including:

> specialized mathematics and service mathematics (as in higher education), school mathematics, vocational mathematics, street mathematics, mathematics for everyday living, and adult numeracy. (FitzSimons *et al*., 2003)

Against this background, the specificity of adult numeracy and mathematics teaching and learning is the subject of a wide-ranging and passionate debate amongst researchers and practitioners, much of it conducted through Adults Learning Mathematics – A Research Forum (ALM).

A key feature of the debate has been attempts to map the position of adult numeracy and mathematics teaching and learning (which I shall abbreviate to ANMTL) in relation to neighbouring fields of research and practice in order to establish what is specific about it. In one sense this is a question of positioning ANMTL amongst what Becher calls the 'academic tribes and territories' (Becher, 1989; Becher & Trowler, 2001). It matters because if research in ANMTL is to develop and inform practice and policy, it needs to have a sound academic base. Arguably this is what has been happening through the community of researchers and practitioners gathered together through ALM and other national and international fora, such as successive Working Groups of the International Congress on Mathematics Education (ICME). Becher concludes that groups of academics representing a discipline are closely linked to the characteristics and culture of the professional knowledge domain to which they belong. This is true of academic researchers in ANMTL, who reflect the diversity of ANMTL as a field of practice in their professional backgrounds as, for example, adult numeracy, literacy or ESOL (English for Speakers of Other Languages) practitioners, university lecturers teaching Mathematics as a service subject, tutors preparing students for access to further study or training for which Mathematics is required, teachers of vocational subjects, etc..

So how does ANMTL relate to the wider field of education research? In the *International Handbook* it is situated within the field of lifelong education and lifelong learning, encompassing ideas such as equality of educational opportunity, democratisation of education, and self-actualisation (Knapper & Cropley, 2000). Here it should be noted that the field of adult and lifelong education and lifelong learning is itself emergent rather than well-established in research terms. Like ANMTL, it is beset by difficult conceptual issues and has had to define itself in relation to a research field dominated by studies of children's education (Field & Leicester, 2000).

Within lifelong education, ANMTL practice and provision is located at the intersection of what Bishop (1993), building on the work of Coombs (1985), has identified as Formal Mathematics Education (FME), Informal Mathematics Education (IFME) and Non-formal Mathematics Education (NFME). These categories are developed in the *Handbook* in relation to ANMTL as Formal Adult Mathematics Education (FAME), Non-formal Adult Mathematics

Education (NFAME) and Informal Adult Mathematics Education (IFAME) (FitzSimons *et al*., 2003). FAME is provided through the formal and institutional structures which society intentionally establishes for this purpose (Bishop, 1993, p. 3) and involves

> full-time, sequential study extending over a period of years, within the framework of a relatively fixed curriculum [It is] in principle, a coherent, integrated system, [which] lends itself to centralized planning, management and financing. (Coombs, 1985, p. 24)

NFAME is part-time, shorter in duration than FAME, focussing on more limited, specific, practical types of knowledge and skills of fairly immediate utility to particular learners (Coombs, 1985, p. 24). It is an "organised, systematic educational activity, carried on outside the framework of the formal system, to provide selected types of learning to particular subgroups in the population" (Coombs, 1985, p. 23). IFAME is:

> The life-long process by which every person acquires and accumulates knowledge, skills, attitudes and insight from daily experiences and exposure to the environment. […] Generally informal education is unorganized, unsystematic and even unintentional at times, yet it accounts for the great bulk of any person's total lifetime learning - including that of even a highly 'schooled' person (Coombs, 1985, p. 24).

The interdisciplinary nature of ANMTL is explored by Wedege and colleagues (Wedege, Benn, & Maaß, 1999, p.57) who locate it "in the border area between sociology, adult education and mathematics education". The research domain is described as a moorland, rather than a bounded field, because, like moorland, the land is wild and uncultivated. In this conceptualisation, adults learning mathematics are at the centre and adult education, mathematics education, and mathematics are the closest disciplines, as shown in Figure 1:

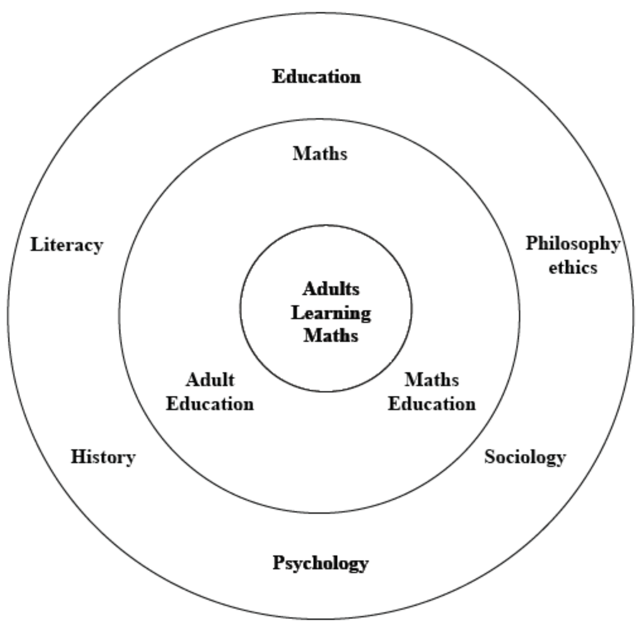

Figure 1. *Benn's conception of the research domain of adults learning mathematics (Wedege et al., 1999)*

For Wedege, the ANMTL research domain encompasses three superordinate subject areas: teaching, learning and knowing mathematics. She summarises the provisional conclusions of the debate as follows:

- Preliminary place in the scientific landscape: The [ANMTL] community of practice is accepted as a research domain within the didactics of mathematics;
- Subject area: The learner is the focus of the [ANMTL] studies and her/his 'numeracy' is understood as mathematics knowledge.
- Problem field: Didactic questions are integrated with general adult education questions in [ANMTL] and the studies are interdisciplinary.
- Two perspectives: The duality between the objective and subjective perspective is implicit, or explicit, in all [ANMTL] problematiques.
- Justification problem: The general aim of [ANMTL] practice and research is 'empowerment' of adults learning mathematics. (Wedege, 2001, p.112)

In my review of the debate (Coben, 2000, pp 50-51), I characterise ANMTL as an emerging research domain, interdisciplinary within the social sciences and spanning the sub-fields of mathematics education and adult education. 'Mathematics' is taken to mean mathematics learned and taught at any level, including the most basic and, in Wedege's terms, it includes 'numeracy', or mathematics in the social context. In the *Handbook*, FitzSimons, O'Donoghue and I examine the problematic relationship between the related disciplines and the core of the research domain. We contend that, "what is needed is a field-specific framework (or frameworks) for adult mathematics education that integrates all contributions from the core and elsewhere", with adults and mathematics making adult mathematics education specific as a research enterprise (FitzSimons *et al*., 2003, p.116). Such contributions must engage with the vexed question of 'what is numeracy?' and it is to this question we turn next, considering first, how it relates to mathematics and then how it relates to literacy.

How does numeracy relate to mathematics?

The nature of the relationship between numeracy and mathematics is elusive.
Concepts and definitions of numeracy with respect to adults are many and varied (Coben *et al.*, 2003)[1], but typically assert, or assume, some relationship between numeracy and mathematics. It is not a relationship of equals: conceptualisations of numeracy commonly refer to mathematics but the converse is not true; conceptualisations of mathematics do not usually involve numeracy.

The origins of 'numeracy'

The term 'numeracy' originated in the Crowther Report in England and Wales in 1959 (Ministry of Education, 1959) as the "mirror image of literacy" (Ministry of Education, 1959) (para.398). Numeracy here refers to a sophisticated level of familiarity with the numerate disciplines, just as 'literacy' means familiarity with literature – being well-read, rather than simply being able to read. The intention was to bridge the gap between literary and scientific cultures.

[1] See Coben *et al*. (2003) for a comprehensive review of concepts of numeracy.

Numeracy in the modern sense came to prominence later, in the wake of the Cockcroft Committee's influential 1982 report on mathematics education. The report proposed reform of the way mathematics was taught to children in schools based on the mathematical demands of adult life (DES/WO, 1982, p.11). The Cockcroft 'Foundation list of mathematical topics' (para.458, pp135-140) includes: number; money; percentages; use of calculator; graphs and pictorial representation; spatial concepts; ratio and proportion; and statistical ideas.

Current formulations of numeracy

Via the schools' National Curriculum in Mathematics, established in 1989, and the National Numeracy Strategy in schools in England from the mid-1990s (DfES, 2002), the Cockcroft list formed the basis for the Adult Numeracy Core Curriculum (DfES, 2001), part of the UK government's *Skills for Life* strategy to improve standards of adult literacy and numeracy in England (DfEE, 2001). In *Skills for Life* numeracy is defined as:

> the ability to use mathematics at a level necessary to function at work and in society in general [i.e.,] to: understand and use mathematical information; calculate and manipulate mathematical information; interpret results and communicate mathematical information (DfES, 2001, p.3).

Recently, a new and as yet undefined formulation, 'functional mathematics', has emerged in England following publication of Professor Adrian Smith's Report on post-14 Mathematics education (Smith, 2004), Tomlinson's Report on *14-19 Curriculum and Qualifications Reform* (Tomlinson, 2004) and the UK government's White Paper on *14-19 Education and Skills* (DfES, 2005). The relationship between 'functional mathematics' and adult numeracy has yet to be established in the English policy arena.

Meanwhile, on the international scene, the UNESCO International Standard Classification of Education (UNESCO, 1997), links literacy and numeracy together at a basic level, as "Literacy and numeracy: Simple and functional literacy, numeracy" and this is the sense in which the term is often used today. But what does this mean in practice and how can it be elaborated to inform policy, practice and further research in this area?

The latest survey of adult skills (and the first to include numeracy), the Adult Literacy and Lifeskills (ALL) Survey, attempts to do this. It defines numeracy as: "the knowledge and skills required to effectively manage the mathematical demands of diverse situations" (Manly & Tout, 2001, p.81). The ALL framework sets out five key facets of numerate behaviour, as follows:

- managing a situation or a problem in a realistic context such as everyday life, work-related, societal or community, and further learning;
- responding to a situation through identifying, interpreting, acting upon, and communicating;
- information about mathematical ideas such as quantity and number, dimension and shape, pattern and relationships, data and chance, and change;
- representations of mathematical information including objects and pictures, numbers and symbols, formulae, diagrams and maps, graphs, tables, and text
- enabling knowledge bases and reasoning processes including contextual knowledge, mathematical (and statistical) knowledge and understanding, mathematical problem-solving skills, literacy skills, and beliefs and attitudes (Manly & Tout, 2001, p. 81).

In addition, a scheme of five factors has been developed to account for the difficulty of different tasks, which, it is claimed, enables an explanation of observed performance in terms of underlying cognitive factors. These are: (1) type of match/problem transparency; (2) plausibility of distractors (including in text); (3) complexity of mathematical information/data; (4) type of operation/skill; (5) expected number of operations (Manly, Tout, van Groenestijn, & Clermont, 2001).

To summarise the relationship between numeracy and mathematics in the discussion thus far: in some conceptualisations of numeracy, including *Skills for Life* and the ALL Survey, numeracy is regarded as contained within mathematics, and some conceptualisations of adult mathematics learning, such as Wedege *et al.*'s (1999), see it as encompassing numeracy. In this view, numeracy is seen as an aspect of mathematics; adult numeracy learning (ANL) is seen as an area within adult mathematics learning (AML). This may be represented as M > N, with the corollary that AML > ANL.

An alternative conceptualisation, developed in Australia, sees numeracy as "not less than maths but more" (Johnston & Tout, 1995), a way of negotiating the world through mathematics (Johnston & Yasukawa, 2001). In this conceptualisation mathematics and numeracy are not congruent, nor is numeracy "an accidental or automatic by-product of mathematics education at any level. When the goal is numeracy some mathematics will be involved but mathematical skills alone do not constitute numeracy", as O'Donoghue writes of Ireland (O'Donoghue, 2003, p.8). In Denmark, also, Lindenskov and Wedege have introduced '*numeralitet*', which has been adopted by the Danish Ministry of Education. It focusses on functional mathematical competence in the changing social and technological context and Wedege defines it as "a math-containing everyday competence" (Wedege, 2001, p.27). In this view, numeracy encompasses more than mathematics (N > M) and adult numeracy learning encompasses more than mathematics learning (ANL > AML). The fact that some of the same people (e.g., Wedege and O'Donoghue) locate numeracy both within and beyond mathematics may serve to indicate some of the complexity and shifting nature of the conceptualisation of numeracy with respect to adults.

At this point it may be useful to consider Maguire and O'Donoghue's organising framework for gauging increasing sophistication in the conceptualisation of numeracy along a continuum (Figure 2).

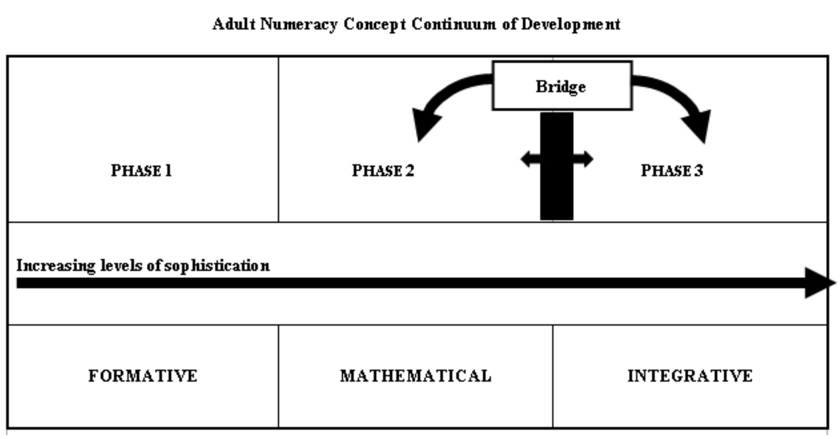

Figure 2: *A continuum of development of the concept of numeracy showing increased level of sophistication from left to right (from Maguire & O'Donoghue, 2005)*

The framework is intended to facilitate international comparisons. In the first, ‘Formative Phase’, numeracy is considered as basic arithmetic skills; in the second ‘Mathematical Phase’, numeracy is ‘mathematics in context’, entailing explicit recognition of the importance of mathematics in daily life. The framework culminates in the ‘Integrative Phase’, in which numeracy is viewed as “a complex multifaceted sophisticated construct incorporating the mathematics, cultural, social, emotional and personal aspects of each individual in a particular context” (Maguire & O'Donoghue, 2003, pp. 155-6). Maguire and O’Donoghue situate the Cockcroft conceptualisation at the upper end of the Mathematical Phase and that of the ALL survey at the beginning of the Integrative Phase, with a bridge and arrows between the two phases indicating that there is movement in both directions between them. In their comparison of the development of the concept of numeracy in policy terms in seven countries (Ireland, Canada, USA, UK, the Netherlands, Denmark and Australia), only Denmark and Australia are located in the Integrative Phase, with the UK in the Mathematical Phase and Ireland in the Formative Phase.

Overall, we can see that numeracy and mathematics are not totally distinct from each other: in some conceptualisations, numeracy encompasses mathematics, whereas in others mathematics encompasses numeracy. Either way, mathematics is key to conceptualisations of numeracy, and the degree of integration with and beyond mathematics is taken as a measure of the sophistication of concepts of numeracy in Maguire and O’Donoghue’s framework. Nevertheless, the relationship between mathematics and numeracy remains to a certain extent ambiguous. Any theorisation of that relationship must recognise that education is inherently multidisciplinary and that education is a field of practice as well as a field of research (FitzSimons *et al*., 2003). But what of numeracy’s other ‘neighbouring’ concept – often a very close neighbour in the realms of policy, practice and educational provision - literacy?

How does numeracy relate to literacy?

Adult numeracy is often subsumed within literacy in educational policy, practice and research. For example, Tout and Schmitt point out that “the titles of major legislative actions and documents authorizing and regulating adult basic skills provision in the USA stress the importance of ‘literacy’”, with numeracy appearing only sporadically or omitted entirely in major policy and public relations documents aimed at expanding and improving adult basic education (Tout & Schmitt, 2002).

In this configuration literacy is greater than numeracy: L > N. This conceptualisation has been challenged by Maguire and O’Donoghue (2002) with respect to Ireland and by Cumming (1996) with respect to Australia. Cumming contends that “the inclusion of numeracy as a component of literacy: sometimes explicitly included in literacy agendas, sometimes implicitly, sometimes omitted; is not sufficient”. What is lost when numeracy is subsumed within literacy in this way is the possibility of identifying and exploring key questions and issues in numeracy, including identifying the extent of expenditure of human, financial and other resources on numeracy and hence of redressing any imbalance. In policy and provision terms the effect is clear: expenditure and information on numeracy that might lead to improvements in practice are often impossible to disaggregate from information on literacy; numeracy is rendered invisible.

Gal, one of the authors of the ALL Survey numeracy framework, opposes this tendency. He characterises numeracy as a semi-autonomous area at the intersection between literacy and mathematics (Gal, 2000, p.23). He discusses the links between literacy, language and numeracy under three headings: mathematics as language, in which mathematics is viewed as a separate language system; language factors in learning mathematics, referring to the role of written and oral language in communicating mathematics; and language-mathematics links in real-world contexts, referring to the varying degrees of involvement of language in different numeracy situations (Gal, 2000, p. 22). Hence, insofar as numeracy is implicated in written texts and other situations involving literacy, literacy may be seen as a component of numeracy, rather than *vice versa*; in this sense, numeracy is greater than literacy: N > L.

The close association of numeracy with literacy and language has informed research on pedagogy, for example: Zevenbergen's (2000) investigation of the literacy demands of adult numeracy; and Durgunoglu and Öney's (2000) discussion of the numeracy needs of adult literacy students. Stoudt (1994) discusses the process of enhancing numeracy skills in adult literacy programmes and Tomlin (1995, 2002) discusses the use of approaches developed in adult literacy work to encourage student writing in numeracy classes. These and other studies show a lively interest amongst researchers in working out the potential benefits of an integrated approach to pedagogy, reflecting the fact that provision in adult numeracy is often organized alongside adult literacy, with some teachers working in both areas. This is so not only in the industrialised world but also in poorer countries, for example, in the REFLECT programme, where literacy and numeracy are integrated (Foroni & Newman, 1998).

Literacy and numeracy are also implicated in adults' life experiences and opportunities generally. The impact of poor literacy and numeracy on adults' lives has been investigated by Parsons and Bynner, using data from two of the British Birth Cohort studies. They asked *Does Numeracy Matter More?* and found that "For men the combination of poor literacy and poor numeracy was significant" while "For women, poor numeracy, independently of the standard of literacy, is more significant". This is due to changes in the nature of employment, since "Poor numeracy skills make it difficult to function effectively in all areas of modern life, particularly for women" (Parsons & Bynner, 2005, pp. 6-7).

In terms of research methodologies linking literacy and numeracy, a recent research project at King's College London has investigated low achievement in children's numeracy through an exploration of home and school numeracy practices, using a 'social literacies' approach associated with the New Literacy Studies (Street *et al.*, 2005). Mary Hamilton characterizes this approach as follows:

> The essence of this approach is that literacy competence and need cannot be understood in terms of absolute levels of skill, but are *relational* concepts, defined by the social and communicative practices with which individuals engage in the various domains of their life world. It sees literacy as historically and socially situated (Hamilton, 2000).

The project considered how far this approach could be applied in research in mathematics education (Baker *et al.*, 2000, p.159) but while many researchers (including this one) might be happy to substitute 'numeracy' for 'literacy' in Hamilton's statement, above, there are aspects of the social literacies approach which may not translate well to the investigation of numeracy. For example, Alison Tomlin, herself a member of the home and school numeracies project team, points out the invisibility of many numeracy events and practices (Tomlin, 2002). These may be deeply embedded in context (FitzSimons, 2002) and involve unobservable thought (e.g., calculating 'in the head'), rather than observable action (such as calculating on paper or with a calculator). As a result, a social literacies approach based in observation and discourse analysis may have limitations in the development of research methodologies in adult numeracy (Coben *et al*., 2003). However, such an approach may be helpful in locating different conceptualisations of ANMTL for research purposes, as we see next.

Locating different conceptualisations of numeracy

My delineation of two domains of numeracy (Coben 2002, outlined in Figure 3, below) is adapted from a schema developed for adult literacy by Kell (2001) in South Africa. Adult numeracy in Domain One is characterized by formalisation and standardization of the curriculum, and technologisation, unitisation and commodification of learning and learning materials. It is competency-based and outcomes-focussed, with certification being the desired outcome, and explicit equivalence with educational levels in schools. It supports normative claims about the beneficial effects of numeracy for the individual and for society. Adult numeracy education in *Skills for Life* is located in Domain One because, as Kell puts it, speaking of literacy in Domain One, it is "created through the standardising processes of fixing levels, writing unit standards and setting performance criteria" (Kell, 2001, p.100). By contrast, numeracy in Domain Two is "about informal and non-standard mathematics practices and processes in adults' lives, which may bear little relation to formal, taught mathematics". Domain One numeracy may have low use value but high exchange value "it is 'hard currency', yielding certificates tradeable on the labour market. Domain Two is the opposite: it has high use value but no exchange value beyond the community of practice in which it occurs...; it is 'soft currency'... [and] situated in Jean Lave's sense"; it is often 'invisible' or unregarded by those directly concerned; and it is often elided with 'common sense' (Coben, 2002, p.27).

Kanes' (2002) "three lenses each offering alternative and competing views of the terrain numeracy encompasses": visible-numeracy; useable-numeracy; and constructible-numeracy, may be aligned with Domains One and Two. Visible-numeracy "names the kind of knowledge which is intended when using commonly accepted mathematical language and symbols to formulate mathematical relationships and communicate these to others" (p. 341), these are the currency of Domain One. 'Useable-numeracy' is "the kind of numerical knowledge exhibited when a person is engaged in real-life problem-solving" (pp. 341-2). It is "complex, and deeply embedded in the context in which it acquires meaning" (p. 344); in my terms, it belongs in Domain Two. Constructible-numeracy brings the education process into play, since it is "produced by an individual/social constructive process usually in a learning situation" (p. 342). Kanes (2002) alerts us to the challenge for adult numeracy educators when he points to the tension between numeracy which is useable but not easily constructible, and numeracy which is easily constructible but less useable (p. 346). This is the tension I perceive for educators attempting to bridge the gap between numeracy in Domains One and Two. I agree with Kanes that "much of what makes numeracy interesting, challenging and important has to do with the ambiguity of its status among the senses of visibility, useability and constructability" (p. 42) and, I would argue, also its ambiguous position in relation to Domains One and Two. Adult numeracy in the two domains is outlined in the Figure 3. This delineation of two domains of adult numeracy may be brought together with Maguire and O'Donoghue's conceptual framework, as shown in Figure 4.

ADULT NUMERACY IN DOMAINS ONE AND TWO		
	DOMAIN 1 use value low; exchange value high	DOMAIN 2 use value high; no exchange value
Why?	To gain access to institutions of modernity; based on the belief that to be numerate is beneficial both to the individual and to society	To do something; to understand something
What?	Formalised, standardised, certificated curriculum, positioned as 'basic skills' (Kanes' 'visible-numeracy')	Informal, non-standard mathematics practices which may be (dis)regarded as 'just common sense' by all concerned; invisible mathematics (Kanes' useable-numeracy)
How?	Through teaching and learning materials that may be technologised, unitised, commodified	Through social activity and alone 'in your head'
Who?	Learners: those deemed to be deficient in mathematics	Learners: everyone, as part of processes of enculturation into 'communities of practice'.
	Teachers: professional experts (problematic in adult numeracy as the very concept of numeracy is debated and the field of professional practice is relatively new and poorly defined); non-professionals; volunteers	'Teachers': more experienced people, who 'know the ropes'
When?	At set times, except in Open and Distance Learning (ODL)	Anytime, incidental
Where?	In set locations, except in ODL	Anywhere, in context, in 'real life'; 'everyday life'; workplace

Figure 3. *Adult Numeracy Learning in Domains One and Two (adapted from Coben, 2002)*

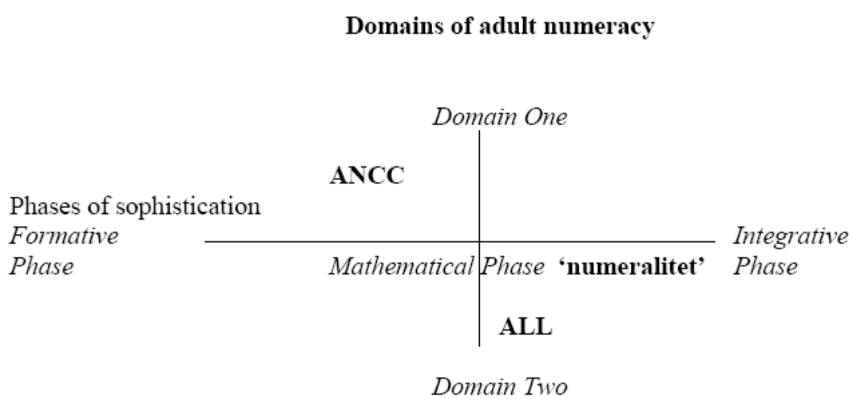

Figure 4. *Comparing conceptualisations of adult numeracy in terms of conceptual sophistication and domain of operation.*

Using this matrix, it is possible to plot the positions of different conceptions of adult numeracy both in terms of their degree of sophistication (along the horizontal axis) and in terms of the discursive domain in which they operate (along the vertical axis). Thus the conceptualisation of numeracy expressed in the English Adult Numeracy Core Curriculum (ANCC) is in the top left quadrant: it is located in the Mathematical Phase and operates primarily in Domain One. That expressed in the ALL Survey is located in the bottom right hand quadrant: it is in the Integrative Phase in terms of its degree of sophistication and in Domain Two because it is concerned with adults' 'numerate behaviours' in their lives as a whole. The Danish concept of *numeralitet* is also in this quadrant, but further to the right, since it is more firmly located in the Integrative Phase, and closer to the line dividing Domain One from Domain Two because it has the capacity to generate certification. Elsewhere, Kanes presents a way of thinking about numeracy as a cultural historical activity system, as shown in Figure 5.

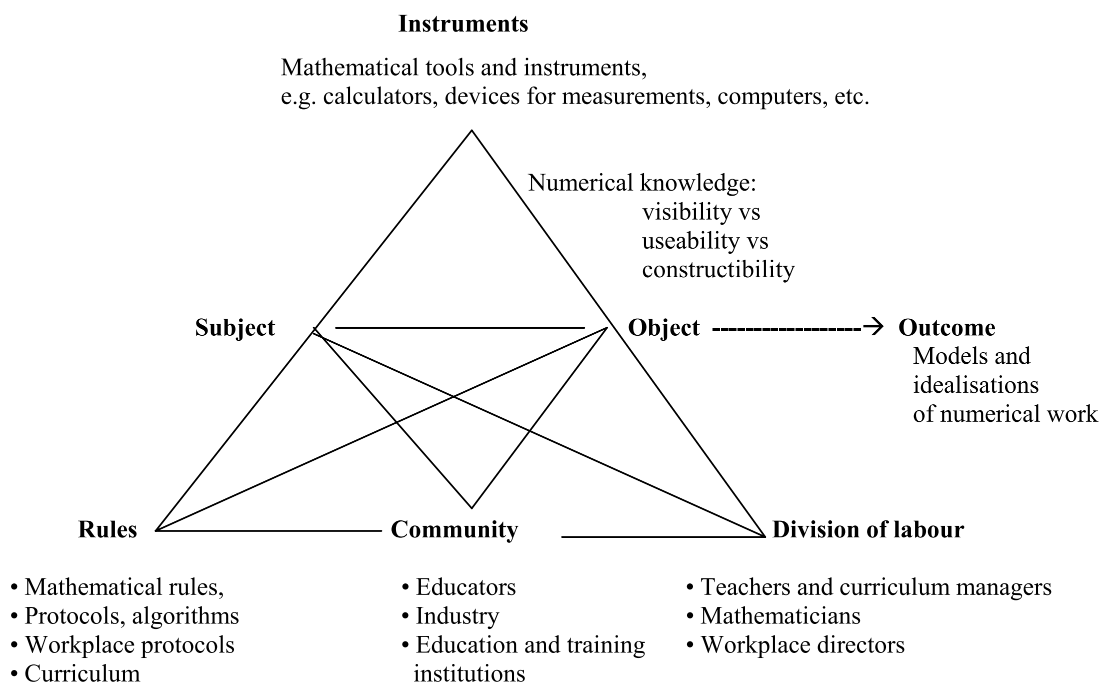

Figure 5. *Kanes' model of numeracy as a cultural historical activity system (Kanes 2002, p. 348).*

In this model, numeracy is the subject of the cultural historical activity system and numerical knowledge is its object (with tensions and anomalies between the visibility, useability and constructability of that knowledge, as outline above). The instruments of the activity system are mathematical tools and instruments such as calculators, devices for measurements, computers, and so on. The community engaged in the activity is comprised of educators, industry and education and training institutions and the division of labour comprises teachers and curriculum managers, mathematicians and workplace directors. The rules are mathematical rules, protocols and algorithms, as well as workplace protocols and curricula. These elements all interact in the activity system to produce the outcome of models and idealisations – conceptualizations - of numerical (or mathematical) work that we know as numeracy, conditioned by the cultural and historical contexts in which the activity system has developed and "intrinsic to the nature of numeracy in its current state of development" (Kanes, 2002, p.348).

As I noted in my review of research on adult numeracy, any chosen concept of numeracy has significance for key decisions about what is taught, to whom, under what circumstances, and for what purposes, and it is important to recognise that some definitions carry more weight than others because they are enshrined within powerful policy formulations. Against this background,

> Kanes' formulation seems to offer a way forward to help us understand the complexity inherent in conceptualising numeracy; it may even help us to live with the uncertainty surrounding the term (Coben *et al*., 2003, p.21).

Locating adult numeracy and mathematics research

Research in adult numeracy and mathematics teaching and learning is still in the exploratory phase of development. There is much conceptual uncertainty, manifested in shifting relationships between numeracy and mathematics and between numeracy and literacy, and reflecting similarly shifting relationships between these areas in educational practice. Conceptual clarity is needed if research and development are to be clearly focussed, but not at the expense of ignoring awkward realities. Given the diversity of the field – or moorland – there are likely to be many of these. We probably have to live with many of the ambiguities in our present conceptualisations. The map of educational research is itself evolving. It is likely to change still further as insights from contributing disciplines and practices, including new information and communications technologies in the workplace (Hoyles, Wolf, Molyneux-Hodgson, & Kent, 2002) and education (Mellar, Kambouri, Sanderson, & Pavlou, 2004), and the fast-developing field of brain research (Kelly & Davis, 2004), shed light on teaching and learning in all its complexity. It is also possible to select from amongst the models currently available those that seem most suited to the task in hand. For example, anyone developing instruments to assess adults' numerate behaviours would be well advised to consult the work of the ALL Survey Numeracy team, while anyone attempting to understand educational or other activity involving numeracy and mathematics could choose to do so using the model of numeracy as a cultural and historical activity system outlined in Figure 5, above.

So what kind of research is needed now, given that "research must be closely linked with practice in a field where development and improvement in practice have priority status", with the relationship between research and practice interactive, mutually beneficial and supportive, and with research and development leading to improved practice in the field of adult mathematics education (FitzSimons *et al*., 2003, p.117)?

Drawing on a conceptualisation from the 'hard sciences', a recent review of educational research and development policy in England (OECD/CERI, 2002) advocates "use-inspired basic research", situated within what Stokes (Stokes, 1997) has called "Pasteur's Quadrant". Stokes recasts the conventional view of the tension between understanding and use, citing as a model the work of Louis Pasteur in laying the foundations of microbiology.

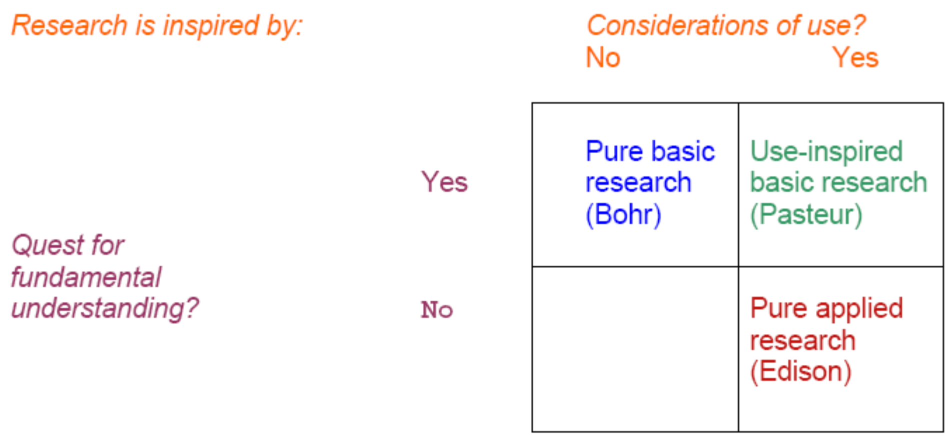

Figure 6. *Inspirations for research (adapted from Pasteur's Quadrant: Basic Science and Technological Innovation, Stokes 1997)*

Pasteur's Quadrant would seem to be an appropriate location for research in adult mathematics and numeracy teaching and learning, as Black (2003) argues it is for mathematics education research generally. "Use-inspired basic research" has the potential to generate useful knowledge and address issues related to the accumulation and dissemination of such knowledge. It must be both inspired by the problems and issues arising in practice and basic in the sense of laying the foundations for the further development of the field.

References

Baker, D. A., Street, B. V., & Tomlin, A. (2000). Schooled and community numeracies: Understanding social factors and "under achievement" in numeracy. In J. F. Matos & M. Santos (Eds.), *Mathematics education and society. Proceedings of the second international mathematics education and society conference (MES2), 26th-31st March 2000* (pp. 158-168). Lisbon, Portugal: Centro de Investigação em Educação da Faculdade de Ciências, Universidade de Lisboa.

Becher, T. (1989). *Academic Tribes and Territories: Intellectual enquiry and the cultures of disciplines*. Milton Keynes: Society for Research into Higher Education and Open University.

Becher, T., & Trowler, P. (2001). *Academic tribes and territories* (2nd ed.). Buckingham: Open University Press.

Bishop, A. J. (1993). Influences from society. In A. J. Bishop, K. Hart, S. Lerman, & T. Nunes, *Significant influences on children's learning of mathematics* (pp. 3-26). Paris : UNESCO (Science and Technology Education, Document Series No. 47).

Black, P. (2003). Turning research results into practice: How does the D fit into R&D? Draft paper presented at the AERA conference April 21st. Mathematics education SIG session 20.061. AERA RAND Maths 4/03 1 24/4/03. Retrieved 2006, 20 January, from http://www.kcl.ac.uk/education/papers/AERA_Maths_SIG_20.pdf

Coben, D. (2000). Section 1: Perspectives on research on adults learning mathematics (introduction). In D. Coben, J. O'Donoghue & G. E. FitzSimons (Eds.), *Perspectives on adults learning mathematics: Research and practice* (pp. 47-51). Dordrecht, NL: Kluwer Academic Publishers.

Coben, D. (2002). Use value and exchange value in discursive domains of adult numeracy teaching. *Literacy and Numeracy Studies, 11*(2), 25-35.

Coben, D., Colwell, D., Macrae, S., Boaler, J., Brown, M., & Rhodes, V. (2003). *Adult numeracy: Review of research and related literature*. London: National Research and Development Centre for Adult Literacy and Numeracy (NRDC).

Coombs, P. H. (1985). *The world crisis in education: The view from the eighties*. Oxford/New York: Oxford University Press.

Cumming, J. (1996). *Adult numeracy policy and research in Australia: The present context and future directions*. Melbourne, Australia: National Languages and Literacy Institute.

DES/WO. (1982). *Mathematics counts: Report of the committee of inquiry into the teaching of mathematics in schools*. London: Department of Education and Science/Welsh Office.

DfEE. (2001). *Skills for life: The national strategy for improving adult literacy and numeracy skills*. London: Department for Education and Employment (UK).

DfES. (2001). *Adult numeracy core curriculum*. London: Department for Education and Skills.

DfES. (2002). National numeracy strategy. Retrieved 2006, 20 January, from http://www.standards.dfee.gov.uk/numeracy

DfES. (2005). *14-19 education and skills* (No. Cm 6476). Norwich: The Stationery Office.

Dossey, J. A. (1992). The nature of mathematics: Its role and its influence. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 39-48). New York: Macmillan.

Durgunoglu, A. Y., & Öney, B. (2000). Numeracy needs of adult literacy participants. *Focus on Basics, 4*(B), 18-20.

Field, J., & Leicester, M. (Eds.). (2000). *Lifelong learning: Education across the lifespan*. London: Routledge-Falmer.

FitzSimons, G. E. (2002). *What counts as mathematics? Technologies of power in adult and vocational education* (Vol. 28). Dordrecht, The Netherlands: Kluwer Academic Publishers.

FitzSimons, G. E., Coben, D., & O'Donoghue, J. (2003). Lifelong mathematics education. In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick & F. K. S. Leung (Eds.), *International handbook of mathematics education* (pp. 105-144). Dordrecht, NL: Kluwer Academic Publishers.

Foroni, N., & Newman, K. (1998). Numeracy in reflect. *PLA Notes*(32), 109-115.

Gal, I. (2000). The numeracy challenge. In I. Gal (Ed.), *Adult numeracy development: Theory, research and practice* (pp. 9-31). Cresskill, NJ: Hampton Press.

Hamilton, M. (2000). Sustainable literacies and the ecology of lifelong learning. *Working Papers of the Global Colloquium on Supporting Lifelong Learning* Retrieved 2006, 5 October, from http://www.open.ac.uk/lifelong-learning/papers/393CCAC1-000B-67AA-0000015700000157.html

Hoyles, C., Wolf, A., Molyneux-Hodgson, S., & Kent, P. (2002). *Mathematical skills in the workplace. Final report to the Science, Technology and Mathematics Council. Foreword and executive summary*. London: Institute of Education, University of London; Science, Technology and Mathematics Council.

Johnston, B., & Tout, D. (1995). Adult numeracy teaching - making meaning in mathematics. Melbourne: National Staff Development Committee for Vocational Education and Training.

Johnston, B., & Yasukawa, K. (2001). Numeracy: Negotiating the world through mathematics. In B. Atweh (Ed.), *Sociocultural research on mathematics education: An international perspective* (pp. 279-294). Mahwah, NJ: Laurence Erlbaum.

Kanes, C. (2002). Towards numeracy as a cultural historical activity system. In P. Valero & O. Skovsmose (Eds), *Mathematics Education and Society, Part 2. Proceedings of the Third International Mathematics Education and Society Conference, MES3, 2nd-7th April 2002,Helsingør, Denmark* (pp. 341-350). Roskilde: Centre for Research in Learning Mathematics, The Danish University of Education, Roskilde University, Aalborg University.

Kell, C. (2001). Literacy, literacies and ABET in South Africa: On the knife-edge, new cutting edge or thin end of the wedge? In J. Crowther, M. L. Hamilton & L. Tett (Eds.), *Powerful literacies* (pp. 94-107). Leicester: NIACE.

Kelly, A. E., & Davis, C. (2004). *Ciencias del aprendizaje e investigación sobre el cerebro: 2°encuentro de las redes de expertos en lecto-escritura y cálculo/Learning sciences and brain research: 2nd literacy & numeracy networks meeting. El Escorial - Madrid, Spain, 1-2-3.03.04*. Paris: OECD.

Knapper, C. K., & Cropley, A. J. (2000). *Lifelong learning in higher education* (3rd ed.). London: Kogan Page.

Maguire, T., & O'Donoghue, J. (2002). A grounded approach to practitioner training in Ireland: Some findings from a national survey of practitioners in adult basic education. In L. Ø. Johansen & T. Wedege (Eds.), *Numeracy for empowerment and democracy? Proceedings of the 8th international conference of Adults Learning Mathematics - A Research Forum (ALM8)* (pp. 120-132). Roskilde, Denmark: Centre for Research in Learning Mathematics, Roskilde University, in association with Adults Learning Mathematics - A Research Forum.

Maguire, T., & O'Donoghue, J. (2003). Numeracy concept sophistication - an organizing framework, a useful thinking tool. In J. Maaß & W. Schlöglmann (Eds.), *Learning mathematics to live and work in our world. ALM-10. Proceedings of the 10th international conference on Adults Learning Mathematics in Strobl (Austria)* (pp. 154-161). Linz, Austria: ALM and Johannes Kepler Universität Linz.

Manly, M., & Tout, D. (2001). Numeracy in the adult literacy and lifeskills project. In G. E. FitzSimons, J. O'Donoghue & D. Coben (Eds.), *Adult and lifelong education in mathematics. Papers from working group for action (WGA) 6, 9th International Congress on Mathematics Education, ICME9* (pp. 71-83). Melbourne: Language Australia in association with ALM.

Manly, M., Tout, D., van Groenestijn, M., & Clermont, Y. (2001). What makes one numeracy task more difficult than another? In M. J. Schmitt & K. Safford-Ramus (Eds.), *A conversation between researchers and practitioners. Adults learning mathematics - 7. Proceedings of ALM-7 the seventh international conference of Adults Learning Mathematics - A Research Forum* (pp. 78-85). Cambridge, MA: National Center for the Study of Adult Learning and Literacy (NCSALL), Harvard University Graduate School of Education, in association with Adults Learning Mathematics - A Research Forum (ALM).

Mellar, H., Kambouri, M., Sanderson, M., & Pavlou, V. (2004). *ICT and adult literacy, numeracy and ESOL*. London: National Research and Development Centre for Adult Literacy and Numeracy (NRDC).

Ministry of Education. (1959). *15 to 18, a report of the Central Advisory Committee for Education (England)*. London: Ministry of Education.

O'Donoghue, J. (2003). Mathematics or numeracy: Does it really matter? In J. Evans, P. Healy, D. Kaye, V. Seabright & A. Tomlin (Eds.), *Policies and practices for adults learning mathematics: Opportunities and risks. Proceedings of the 9th international conference of Adults Learning Mathematics (ALM9) - A Research Forum* (pp. 34-43). London: ALM and King's College, London.

OECD/CERI. (2002). *Educational research and development in England* (Examiners' Report No. 10). Paris: OECD.

Parsons, S., & Bynner, J. (2005). *Does numeracy matter more?* London: National Research and Development Centre for Adult Literacy and Numeracy.

Smith, A. (2004). *Making mathematics count: The report of Professor Adrian Smith's inquiry into post-14 mathematics education* (No. 2/04 937764). London: The Stationery Office.

Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation*. Washington, DC: Brookings Institution Press.

Stoudt, A. (1994). Enhancing numeracy skills in adult literacy programs: Challenges and new directions. *NCAL Connections, 10-11*.

Street, B. V., Baker, D. A., & Tomlin, A. (2005). *Navigating numeracies: Home/school numeracy practices*. London: Kluwer.

Tomlin, A. (1995). Writing in a basic maths group. In D. Coben (Ed.), *Mathematics with a human face: Proceedings of ALM-2, the second international conference of Adults Learning Maths - A Research Forum (ALM-2) held at University of Exeter, 7-9 July 1995* (pp. 119-122). London: Goldsmiths College, University of London, in association with ALM.

Tomlin, A. (2002). Literacy approaches in the numeracy classroom. *Literacy and Numeracy Studies, 11*(2), 9-24.

Tomlinson, M. (2004). *14-19 curriculum and qualifications reform. Final report of the Working Group on 14-19 reform* (No. DfE-0976-2004). Annesley: Department for Education and Skills.

Tout, D., & Schmitt, M. J. (2002). The inclusion of numeracy in adult basic education. In J. Comings, B. Garner & C. Smith (Eds.), *The annual review of adult learning and literacy* (Vol. 3, pp. 152-202). San Francisco: Jossey-Bass.

UNESCO. (1997). *International standard classification of education: ISCED*. Paris: UNESCO.

Wedege, T. (2001). Epistemological questions about research and practice in alm. In M. J. Schmitt & K. Safford-Ramus (Eds.), *A conversation between researchers and practitioners. Adults Learning Mathematics - 7. Proceedings of ALM-7 the seventh international conference of Adults Learning Mathematics - A Research Forum* (pp. 109-115). Cambridge, MA: National Center for the Study of Adult Learning and Literacy (NCSALL), Harvard University Graduate School of Education, in association with Adults Learning Mathematics - A Research Forum (ALM).

Wedege, T., Benn, R., & Maaß, J. (1999). 'Adults learning mathematics' as a community of practice and research. In M. van Groenestijn & D. Coben (Eds.), *Mathematics as part of lifelong learning. The fifth international conference of Adults Learning Maths - A Research Forum, ALM-5* (pp. 54-63). London: Goldsmiths College, University of London.

Zevenbergen, R. (2000). Identifying literacy demands of adult numeracy. *Literacy and Numeracy Studies, 10*(1-2), 39-53.