FitzSimons, G. E. (2002). Adult numeracy and new learning technologies. In J. Searle & D. Roebuck (Eds.), *Envisioning practice – Implementing change. Proceedings of the 10th Annual International Conference on Post-Compulsory Education and Training* (Vol. 2) (pp. 45-52). Brisbane: Australian Academic Press.

ADULT NUMERACY AND NEW LEARNING TECHNOLOGIES

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In the adoption of new learning technologies (e.g., online, CD-ROMS) as alternative means of delivery for adult numeracy, high quality educational products, informed by a well-founded research base, are essential to benefit the individual student, and tutors/trainers (if any). Given that concept of adult numeracy itself is ill-defined and under-theorised in Australia, and that there are no entry standards for numeracy tutors/trainers, or even producers of resources, research is needed to synthesise a defensible definition of adult numeracy in the Australian context with evolving research on NLTs to guide producers and enable proper consumer evaluation.

The discipline of mathematics has evolved historically through a dialogical relationship with technology. Internationally, studies have researched workplace mathematics (or numeracy) — that is, how mathematical ideas and techniques are used in practice, as distinct from in the school classroom. 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 principles into high-quality technologised educational products relevant to the needs of Australians as citizens and workers. This paper will explore recent research on these issues.

Introduction

Adult numeracy and new learning technologies are both areas of major practical and political significance in Australia, as elsewhere. However, in the Australian VET sector the contested concept of adult numeracy has been little problematised in ANTA's research arm, the National Centre for Vocational Education Research [NCVER] funded reviews. On the other hand, reviews of new learning technologies generally take content as unproblematic, paying little attention to discipline-specific curriculum and pedagogy. In this paper I will review a selection of the research in adult numeracy and in new learning technologies, focusing on the potential of the latter as a vector for delivery and as a learning tool in the specific case of mathematics/numeracy education. Taken together, these issues represent a serious watershed in post-compulsory education for the development of a productive workforce and a critical citizenry.

Adult Numeracy

The concept of adult numeracy is contested. In recent reviews of numeracy published by 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 & 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 & Hartley, 2000). In the Kearns (2001) review, which stresses an increasing demand for generic skills, the word *numeracy* occurs several times, but the concept is neither defined nor problematised.

According to the OECD-sponsored *Adult Literacy and Lifeskills* [ALL] website [available via http://www.alm-online.org], *numerate behaviour involves*: *managing a situation or solving a problem in a real context* — such as everyday life, work, society, and further learning — *by responding* — through identifying or locating, acting upon, interpreting, and communicating — *to information about mathematical ideas* — such as quantity and number, dimension and shape, pattern and relationships, data and chance, or change — *that is represented in a range of ways* — such as objects and pictures, numbers and symbols, formulae, diagrams and maps, graphs, tables, and texts — *and requires activation of a range of enabling knowledge, behaviours, and processes* — mathematical knowledge and understanding, mathematical problem-solving skills, literacy skills, and beliefs and attitudes. Clearly mathematical knowledges and skills, together with dispositions, are encapsulated in this definition of numerate behaviour. However, the definition appears to stop short of the possibility of new knowledge construction by the person acting in context.

It is not characteristic of international surveys to encourage the development of a critical stance on the nature of the discipline of mathematics, the uses to which mathematical knowledge might be put, or the conditions of mathematics education for youth or adults. In an era of globalisation, there is a tendency for politically and economically oriented media, and indeed politicians, to accept uncritically the results of international surveys: the major question is "Where is *our* country positioned?". There is also a tendency by bureaucrats to adopt in some form the items as a de facto curriculum — even though this was never their intended purpose (constrained as they are by issues of validity and reliability) — which may even turn out to be a counter-productive strategy when statistical significance and practical significance are confounded.

The effect of technological changes on people's lives in terms of increasing the complexity of mathematical or numeracy demands has been observed by many authors. For example, Lesh (2000) notes that the *USA Today* newspaper contains editorials, sports, business, entertainment, advertisements and weather sections which are filled with tables, charts, graphs and formulas "intended to describe, explain, or predict patterns or regularities associated with complex and dynamically changing systems; and the kinds of quantities that they refer to go far beyond simple counts and measures …" (p. 179). He gives the example of used-car advertisements which no longer simply state the selling price, but which are instead mathematised to incorporate repayment terms and conditions. Accordingly, he recommends the design of learning and assessment tools which will help teachers to focus on: (a) simulations of problem-solving situations that are typical of those in which mathematics is useful outside of school; (b) a small number of *big ideas* (powerful constructs or conceptual tools) that are accessible to virtually all students; and (c) deeper and higher-order understandings of these big ideas. (See also Ernest, 1998; FitzSimons, in press.) Ernest (2002) argues that empowerment in mathematics education consists of: (a) mathematical empowerment — the gaining of power over the language, skills and practices of using and applying mathematics; (b) social empowerment — the ability to use mathematics to participate more fully in work, study, and society in general through critical citizenship; and (c) epistemological empowerment — the development of personal identity, portrayed in the growth of self-confidence in using mathematics, and a personal sense of power over the creation and validation of knowledge. (See also FitzSimons 2001b, 2002, for further analysis and development of these ideas.)

However, for adults returning to study, there may be problems of representation — not necessarily obvious to their tutors or trainers. Pea (1993, p. 62) notes that "… inscriptional systems often pose vast problems for the learner. Mapping relations between objects in the world and the written number system are problematic for many learners, as in the well-documented difficulties of place-value subtraction." He continues that "it is too rarely recognized that inscriptional systems, while allowing for efficient achievement of certain goal-directed activities, also make those very activities opaque to persons not privy to the conventions for their interpretation and use … since social practice does not lie "in" the representation itself, but in its roles in relation to the activities of persons in the world." Clearly the problem is exacerbated when adults are attempting to learn mathematics with instructors having no pedagogical content knowledge of mathematics or even any discipline knowledge beyond that which they are 'delivering.' (In Australia there are no entry standards for instructors of mathematics/numeracy related subjects in adult and vocational education.) The situation is even worse for those attempting to study by more remote educational delivery modes of individualised online study or through the use of CD-ROMs.

Recognising that workers often need to learn new things to resolve emergent dilemmas in their non-routine work functions (see FitzSimons, in press), Pea (1993, p. 81) argues that "a principal aim of education ought to be that of *teaching for the design of distributed intelligence.*" The educational emphasis should be reoriented "from individual, tool-free cognition to facilitating individuals' responsive and novel uses of resources for creative and intelligent activity alone and in collaboration." This is a major challenge for adult educators involved in program design and delivery, especially those with responsibility for the development of new learning technologies in adult and vocational mathematics/numeracy education.

New Learning Technologies

Bryson and De Castell (1998) identified three kinds of meta-narrative accounts concerning new learning technologies in education. The first, a technicist/modernist viewpoint, characterises the educational use of computers as a powerful information processing technology, portraying computers as value-neutral tools, to aid the autonomous, rational learner in developing higher-order thinking skills which enable the processing and interpretation of data in problem-solving exercises, and ultimately the accumulation of cultural capital (Bourdieu, 1991).

The second, critical discursive perspective, identifies the problematic nature of the first — especially the value-neutral role accorded to technology. In particular, Bowers (1988) is critical of an ideological view of progress which includes "(a) increased control over access to and manipulation of information, (b) abstract rationality as the most effective form of human thinking, and (c) individualism and entrepreneurship as constituting the most effective models for human commerce" (Bryson & De Castell, 1998, p. 73). Bowers is concerned with the prevalence of the Cartesian view and the obscuration of human authorship of knowledge; also the dominance of digital thinking over metaphorical thinking, including the lack of consideration given to historically and ethically informed decision-making in the adoption of a masculine model of knowing and its distancing gaze — which contribute to the personal alienation of so many, especially women.

Discussing the postmodernist account, Bryson and De Castell turn to a study by Griffin and Cole (1987, cited in Bryson & De Castell, 1998) and conclude that "technology provides a means for reconstructing the division of labor in classroom tasks and for restructuring power relations between participants in educational contexts who typically occupy very unevenly positioned discursive roles with respect to power" (p. 81). (See, for example, Goos, Galbraith, Renshaw & Geiger, 2000.) Ultimately, Bryson and De Castell claim that their focus is on possibilities for agency and equity, eschewing the critical perspective which they claim plays into the hands of the conservative and already privileged members of the educational community. Which viewpoint currently prevails in Australia?

In FitzSimons (2001a) I drew upon Giroux (1994), in particular his work on pedagogies of representation and representational pedagogies, to work towards enabling adult and vocational education students and educators to address representational practices that have the discursive power to construct common sense and textual authority in mathematics education. Grace and Gouthro (2000) address the issue of liberatory models of feminist pedagogy, which focus on the emancipation and empowerment of women as traditionally disenfranchised social, political and historical subjects. Drawing on the work of Tisdell (1995, cited in Grace & Gouthro, 2000, p. 17) four themes are variously emphasised:

1. knowledge production, exchange and distribution in relation to power, privilege and oppression;
2. voice in relation to issues of connection and relationship;
3. teacher authority in relation to responsibility and its appropriate use with students; and
4. difference in relation to culture, power and politics.

I would argue that these themes concern not only graduate women students but all adults who return to study, as well as their teachers — or, in this case, the developers of new learning technologies. So, what might this mean in the development of new learning technologies as vectors for adult numeracy/mathematics?

Design and evaluation perspectives.

There is a burgeoning literature in the area of new learning technologies as vectors for delivery. In the Australian VET sector pedagogical issues are discussed to varying degrees of depth and specificity in several recent NCVER reviews (e.g., Brennan, McFadden, & Law, 2001; Curtain, 2002; Harper et al., 2000; McKavanagh et al., 2002), but not at a level to sufficiently inform the production of adult numeracy/mathematics materials in particular.

Developmental work has begun in the design of proactive evaluative frameworks for new learning technologies. Using a taxonomy-based design framework approach, Bates and Leary (2001) identify four different teaching delivery approaches to support a range of learning styles, based upon their five primary classifications of goals, guidance, interaction, instructional process, and modelling complexity in a software package. The characteristic 'Goals' was most difficult to categorise — there were problems in the evaluation of the software demonstrator. Also, collaborative or co-operative issues were not addressed. Sims, Dobbs, and Hand (2001) present a very comprehensive set of evaluation criteria to inform the development of online learning resources. They suggest five options affecting online *content*, from static to dynamic, and raise seven major issues related to online content: the structure — organisation and information, the match with goals and outcomes, its contextualisation and situatedness, information accuracy and totality, accessibility, extensibility, and quality of expression. *Pedagogical options*, from instructivist to constructivist, are considered, as are seven related major issues: prior experience, approaches to learning, the learning environment, pathways/sequencing, outcomes, assessment, and level of learning. They identify five influences affecting the *interface design*: information design, interaction design, input/output, navigation design, and aesthetics. Related to these are six major issues: user comfort/connectedness, user control/user centredness, support for content structure, support for learning design approach, alignment of mental models, and customisation/individualisation. They also identify elements of interactivity among learner/s, teacher/s, content, and interface. The paper concludes with elements of assessment, student support, content utility, and outcomes. This paper by Sims et al. has the potential to alert both designers and potential users (students, instructors, learning communities) to a breadth and depth of qualities identified through research and practical experience that constitute a technological learning package in any discipline or vocation. As noted above, there are a range of issues to be considered in the case of the content and pedagogy of mathematics — not least the meta-narrative and representational perspectives. Then there are adult education perspectives related to the four liberatory themes listed above. Another important issue in the case of mathematics is the use of technology as a tool for learning, rather than just a vector.

Technology as a tool for learning.

Lagrange et al. (2001) conducted a meta-analysis of research into the impact of information and communication technologies in the classroom. They focused on the use of computer algebra systems [CAS]. Some papers adopted what they termed an “instrumental” approach which “distinguishes a technological artefact and the instrument that a human being is able to build from this artefact. While the artefact refers to the objective tool, the instrument refers to a mental construction of the tool by the user. The instrument is not given with the artefact, it is built in a complex instrumental genesis and it shapes the mathematical activity and thinking” (p. 8).

As visualisation tools, new learning technologies in mathematics offer possibilities for perceptive and conceptual approaches. According to Lagrange et al. (2001), more recent approaches have tended to emphasise the characteristics of problems and situations which can foster the dialectic interplay between these different competencies. Similarly, they observed an evolution towards study of the interplay between the different semiotic registers of representation through which mathematics objects are accessed and worked with and, more globally, by cognitive flexibility.

Apart from these dimensions, three other dimensions were considered:

1. the “situational” dimension, which refers to the changes that the introduction of technology brings into the didactical situations,
2. the “human-machine interaction” dimension which analyses students’ activity and interaction with the technological tools,

3. the “teacher” dimension which looks at the teacher’s beliefs and at the way (s)he organises the classroom activity.

The research team decided that the first two were not easy to include in a synthesis, and that there were too few papers on the third. However, I believe that these are critical areas for further research in the adult and vocational education sector, as elsewhere.

In relation to the instrumental uses of technology in mathematics classes, some research included in the Lagrange et al. (2001) study postulates that a tool or an artefact is not transparent. “The subject develops procedures and rules of action when using the artefact and so constructs *instrumentation schemes* and simultaneously a representation of the properties of the tool … But the knowledge acquired by the subject about the tool and the ways to use it may differ from what the tool was intended to do and the ways it was intended to be used” (Lagrange et al., 2001, p. 12).

In their meta-analysis Lagrange et al. (2001), found time to be a major issue. Even with technology, instant mathematical conceptualisation cannot happen and thus time is necessary for students to understand the mathematical implications of the use of the instrument. While some papers considered that technology provides a wealth of opportunities for a “more conceptual” use of time, others were doubtful or claimed that this issue deserves more reflection. There appeared to be an evolution in the research from ideas of “saving” time and ideas of a reorganisation of time to a balance between the constraints of technology and its potentialities.

In papers which considered the epistemological and semiotic dimension, some stressed the difficulty that representations of knowledge in new technological environments, even when epistemologically relevant, are not easy for the students to grasp (as discussed above) or for teachers to integrate into their teaching. In the cognitive dimension, there appeared to be an evolution from a general constructivism towards dialectical approaches to questions like visualisation, connection of representations, and contextualisation. The project team were unable to find sufficient information on methods for learning mathematics on CD-ROM or on the Internet, and called for more studies in these growing areas.

Lagrange et al. (2001) concluded that although the epistemological dimension was attracting major interest, “epistemological relevance is not sufficient in itself when no attention is paid to instrumental constraints and ecological validity” (p. 18). This brings us back to the evaluative frameworks discussed above.

Conclusion

In this paper I have attempted to reflect on the contested notion of adult numeracy, going beyond ANTA’s literacy-orientation to mathematics-oriented perspectives. I have also drawn on adult education perspectives — especially as they relate to the burgeoning of new learning technologies as a means of delivery in Australia’s adult and vocational education sector. I have presented accounts of research frameworks for new learning technologies in general and drawn from a French meta-analysis of technology as a tool for teaching and learning mathematics. By way of contrast with NCVER-funded research, I believe that particular care needs to be taken in the curricular development and its didactical transformation for adult numeracy/vocational mathematics — especially in view of the fact that, for whatever reason, many adult and vocational students consider themselves as unsuccessful learners of mathematics. Their precarious situation is further exacerbated by the paucity of mathematics discipline knowledge and virtual non-existence of mathematics pedagogical content knowledge in many tutors and trainers — not to mention the difficulties of those working in virtual isolation from any real assistance in the home or the workplace.

The future of the Australian economy and the possibilities of democratic participation by all adults depend on having a numerate population. This cannot happen in the absence of high quality educational products, based upon international research into the teaching and learning of mathematics/numeracy and international research into the development and ongoing amelioration of new learning technologies as both a teaching/learning tool and a vector for delivery. This combination of research agendas appears to be sadly lacking in Australia, at least. In fact, I would argue that a defensible definition of adult numeracy in the Australian context, suitable for transformation and adaptation to different settings such as the workplace and the community, would be a foundational educational requirement of the Australian VET sector. Such a definition would build upon the ALL survey working definition, to encourage critique of the uses of mathematics — for example, as a technology of management in the workplace or by government agencies etc. It would also encourage critique of the way mathematics has been taught to individuals in the past and is being taught in the present — whether by proximal or distal modes or some combination of these. Until these concerns are addressed, Australian adult and vocational education students run the risk of an impoverished — and potentially further damaging and alienating — mathematics/numeracy education, to the detriment of themselves as users and learners, the economy, and the community as a whole.

References

Bates, B, & Leary, J 2001 'Supporting a range of learning styles using a taxonomy-based design framework approach', in G Kennedy, M Keppell, C McNaught, & T Petrovic (Eds), *Meeting at the crossroads Proceedings of the 18th annual conference of the Australian Society for Computers in Learning in Tertiary Education*, Biomedical Multimedia Unit, The University of Melbourne, pp. 45-53.

Bourdieu, P 1991 *Language and symbolic power* (G Raymond & M Adamson, Trans), Polity Press, Cambridge, UK.

Bowers, C A 1988 *The cultural dimensions of educational computing: Understanding the non-neutrality of technology*, Teachers College Press, New York.

Brennan, R, McFadden, M, and Law, E 2001, *Review of research: All that glitters is not gold: Online delivery of education and training,* National Centre for Vocational Education Research, Adelaide.

Bryson, M, & De Castell, S 1998, 'Telling tales out of school: Modernist, critical, and postmodern "true stories' about educational computing', in H Bromley & M W Apple (Eds), *Education/technology/power: Educational computing as a social practice,* State University of New York Press, New York, pp. 65-84.

Curtain, R. 2002 *Online delivery in the vocational education and training sector: Improving cost effectiveness*, National Centre for Vocational Education Research, Adelaide.

Ernest, P 1998, 'Why teach mathematics? — The justification problem in mathematics education', in J H Jensen, M Niss, & T Wedege (Eds), *Justification and enrolment problems in education involving mathematics or physics*, Roskilde University Press, Roskilde, pp. 33-55.

Ernest, P 2002, 'Empowerment in mathematics education', *Philosophy of Mathematics Education Journal,* Vol. 15 [Retrieved April 15, 2002, from the World Wide Web: http://www.ex.ac.uk/~PErnest/pome15/empowerment.htm].

Falk, I, & Millar, P 2001, *Review of research: Literacy and numeracy in vocational education and training,* Adelaide, National Centre for Vocational Education Research.

FitzSimons, G E 2001a, 'Generating notions of democratic citizenship in adult and vocational education', in F Beven, C Kanes, & D Roebuck (Eds), *Knowledge demands for the new economy Proceedings of the 9th Annual International Conference on Post-Compulsory Education and Training* Vol 1, Centre for Learning and Work Research, Griffith University, Brisbane, pp. 231-238.

FitzSimons, G E 2001b, 'What counts as mathematics in adult and vocational education? Numeracy for empowerment and democracy' [Part 1], *ALM Newsletter,* Vol. 14, pp. 5-8.

FitzSimons, G E 2002, 'What counts as mathematics in adult and vocational education? Numeracy for empowerment and democracy' [Part 2] *ALM Newsletter,* Vol. 15, pp. 4-6, 8].

FitzSimons, G E in press, *What counts as mathematics? Technologies of power in adult and vocational education* Kluwer Academic Publishers, Dordrecht.

Giroux, H A 1994, 'Living dangerously: Identity politics and the new cultural racism', in H A Giroux & P McLaren (Eds.), *Between borders: Pedagogy and the politics of cultural studies,* Routledge, New York, pp. 29-55.

Goos, M, Galbraith, P, Renshaw, P, & Geiger, V 2000, 'Reshaping teacher and student roles in technology-enriched classrooms', *Mathematics Education Research Journal,* Vol. 12, no. 3, pp. 303-320.

Grace, A P, & Gouthro, P A 2000, 'Using models of feminist pedagogies to think about issues and directions in graduate education for women students', *Studies in Continuing Education,* Vol. 22, no. 1, pp. 5-28.

Harper, B, Hedberg, J, Bennett, S, & Lockyer, L 2000, *Review of research: The online experience: The state of Australian on-line education and training practices,* National Centre for Vocational Education Research, Adelaide.

Kearns, P 2001, *Review of research: Generic skills for the new economy,* Adelaide, National Centre for Vocational Education Research.

Lagrange, J-B, Artigue, M, Laborde, C, & Trouche, L 2001, *A meta study on IC technologies in education Towards a multidimensional framework to tackle their integration into the teaching of mathematics* [Long version] [Available at http://www.maths.univ-rennes1.fr/~lagrange/cncrerapport.htm. Accessed August, 2001].

Lesh, R 2000, 'Beyond constructivism: Identifying mathematical abilities that are most needed for success beyond school in an age of information', *Mathematics Education Research Journal,* Vol. 12, no. 3, pp. 177-195.

McKavanagh, C., Kanes, C., Beven, F., Cunningham, A., & Choy, S. 2002). *Evaluation of web-based flexible learning,* National Centre for Vocational Education Research, Adelaide.

Pea, R D 1993, 'Practices of distributed intelligence and designs for education', in G Salomon (Ed), *Distributed cognitions: Psychological and educational considerations,* Cambridge University Press, Cambridge, MA, pp. 47-87.

Sanguinetti, J, & Hartley, R 2000, *Building literacy and numeracy into training A synthesis of recent research into the effects of integrating literacy and numeracy into* *training packages,* Melbourne, Adult Literacy and Numeracy Australian Research Consortium.

Sims, R, Dobbs, G, & Hand, T 2001, ‘Proactive evaluation: New perspectives for ensuring quality in online applications’, in G Kennedy, M Keppell, C McNaught, & T Petrovic (Eds), *Meeting at the crossroads Proceedings of the 18th annual conference of the Australian Society for Computers in Learning in Tertiary Education*, Biomedical Multimedia Unit, The University of Melbourne, pp. 509-517.

Watson, M, Nicholson, L, & Sharplin, E 2001, *Review of research:* V*ocational education and training: Literacy and numeracy,* National Centre for Vocational Education Research, Adelaide.