The Inclusion of Numeracy in Adult Basic Education

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Numeracy is an essential skill. In the United States, it may be the cognitive skill that most highly correlates with economic success (Murnane, Willet, & Levy, 1995). It is thus troubling that some segments of the population have been found to be much less numerate than others, limiting their potential to fully participate in and benefit from what society has to offer. The U.S. adult basic education (ABE) system has yet to sufficiently address the gap between those who are less numerate and those who are more numerate. Research on numeracy is minimal. Instructional practice is often constrained by commercial publications and standardized tests and often operates from an outdated notion of what constitutes "basic math." Policy has yet to recognize numeracy as an essential part of being "literate" enough to negotiate the demands of the contemporary workplace and modern life.

Even so, this is also a particularly active, promising time in the developmental trajectory of adult numeracy education. In 2000, two compendia concerned with how adults use and learn mathematics were published. Numeracy is treated as a distinct domain in the international Adult Literacy and Lifeskills (ALL) assessment survey to be conducted in

2002; the National Science Foundation (NSF) has for the first time funded a major mathematics curriculum project for adults enrolled in adult basic and adult secondary education programs; and in July 2000 a conference was held that brought together researchers and practitioners from twelve countries to discuss a wide range of emergent issues in the field of adult numeracy. The time thus seems ripe to examine just how far the field of adult numeracy has come, how far it yet needs to go, and where it might look for models of progress and accomplishment.

NUMERACY VERSUS MATH

Before we can consider research, examine practice, or describe and evaluate policy, we must define and understand the object of research, instruction, and policy. We are only beginning to develop an understanding and consensus around the meaning of the term numeracy.

Whether it is to interpret information in a political television ad, make a deal when buying a car, or follow the instructions in a diagram at work, most people today need a range of mathematical skills to negotiate the demands of our information-intensive culture. That set of necessary skills involves much more than being able to add, subtract, multiply, and divide with numbers. It includes the ability to manage and solve problems using measurements, space, data, and numbers in a variety of formats and for a variety of purposes. What do we call this type of skill, in which mathematics is applied to real life? Is it numeracy? Or is it mathematics? Today there exists neither a universally accepted definition of numeracy nor an agreement about its relationship to mathematics. In fact, in the United States, the term has only recently been added to the vernacular (Gal & Schmitt, 1994; Curry, Schmitt, & Waldron, 1996).

Numeracy has often been cast as the pretender, the junior, inferior partner to mathematics, because it is considered to deal only with numbers and the four basic arithmetic operations of addition, subtraction, multiplication, and division. It conjures the image of doing computation with pencil and paper. Many people-in education, the media, government, and the general public-still take this view (see Harris, 1997, pp. x, 161, 197). Perhaps because numeracy has long been thought of as a lesser academic discipline, many ABE teachers prefer to speak of mathematics. But the term mathematics also has its naysayers, especially among many adult numeracy students who associate it with the vagaries of secondary school "math classes." These ABE students most likely failed mathematics in the secondary school system, and they return to math as adults with much trepidation. They associate "math" with feelings of failure, stupidity, and powerlessness. Such negative feelings toward math are often collectively referred to as math anxiety (Frankenstein, 1989; Tobias, 1978; Zaslavsky, 1994b). Mathematics has also been used as a social divider, a marker that sets apart those who can "do" math from those who can't-a gatekeeper rather than a gateway. Mathematics has also been something of a nemesis to women. Traditionally, math is a subject in which girls have received little encouragement and a professional field in which they have had few role models (Barnes, 1988; Walkerdine, 1989; Willis, 1989; Secada, Fennema, & Adajian, 1995; Harris, 1997).

The first known use of the term numeracy appeared in a British publication in 1959, in which it is described as the mirror image of literacy (Crowther Report, 1959). One of the first attempts to fully define numeracy-in this case, the word used was numerate-appeared in another British publication in 1982: "We would wish the word ënumerate' to imply the possession of two attributes. The first is an ëat homeness' with numbers and an ability to make use of the mathematical skills which enable an individual to cope with the practical demands of . . . everyday life. The second is an ability to have some appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease. Taken together these imply that a numerate person should be expected to be able to appreciate and understand some of the ways in which mathematics can be used as a means of communication" (Cockcroft, 1982, paragraph 39).

"Most important of all," the authors of the report said, "is the need to have sufficient confidence to make effective use of whatever mathematical skill and understanding is possessed, whether this be little or much" (paragraph 34).

Some later definitions are more expansive. Here is an example from the Queensland, Australia, Department of Education in 1994: "Numeracy involves abilities that include interpreting, applying and communicating mathematical information in commonly encountered situations to enable full, critical and effective participation in a wide range of life roles" (quoted in Gal, van Groenstijn, Manly, Schmitt, & Tout, 1999, p. 10). What appears in most definitions of numeracy from the 1980s and 1990s is the use of mathematics in real-life situations and the idea that it can be used in a goal-oriented way, depending on the needs and interests of the individual in a given context (home, community, workplace). These definitions also incorporate the ability to communicate about math. Collectively, they suggest that numeracy refers not just to the ability to perform basic calculations but to the ability to perform a wider range of math skills, such as making measurements, interpreting statistical information, and giving and following directions.

In recent years, especially in Australia, much discussion and debate in the ABE community has focused on defining the relationship between mathematics and numeracy and on coming to terms with the concept of critical numeracy, or the use of mathematics for purposes of meaningful engagement with one's community. As Johnston (1994) argues, "To be numerate is more than being able to manipulate numbers, or even being able to ësucceed' in school or university mathematics. Numeracy is a critical awareness which builds bridges between mathematics and the real world, with all its diversity. . . . In this sense . . . there is no particular ëlevel' of mathematics associated with [numeracy]: it is as important for an engineer to be numerate as it is for a primary school child, a parent, a car driver or a gardener. The different contexts will require different mathematics to be activated and engaged in" (p. 34). Essential to the concept of critical numeracy is the view that mathematics is a vital tool in today's society-a bridge between school-based, or traditional, mathematics and the real world-and a tool that should be accessible to all members of society, not just a few "brainy" mathematicians.

This wider view of the concept of numeracy is also evident in the planned 2002 redesign of the 1992 International Adult Literacy Survey (IALS), a large-scale comparative survey. Like the IALS, the Adult Literacy and Lifeskills (ALL) survey is intended to assess the distribution of basic skills in the adult populations of participating countries and to analyze the possible relationship of those skills to various economic indicators, but ALL is expanding the domains assessed. It will include an assessment of numeracy skills, and thus represents the first instance of international cooperation in the effort to develop numeracy as a theoretical and research-supported domain. The authors of an ALL working paper (Gal et al., 1999) have arrived at a definition of adult "numerate behavior," the observable characteristics of numeracy: "Numerate behavior is observed when people manage a situation or solve a problem in a real context;1 it involves responding to information about mathematical ideas that may be represented in a range of ways; it requires the activation of a range of enabling knowledge, behaviors, and processes" (p. 11).

Exhibit 5.1 presents the ALL numeracy team's description of numerate behavior.

It distinguishes five facets (context, response, mathematical ideas, mathematical representation, and enabling knowledge and behaviors), each of which has several components. In the ALL framework, numeracy involves much more than the "quantitative literacy" described in the IALS. Numeracy has to do not only with quantity and number but also with dimension and shape; patterns and relationships (such as being able to generalize and represent the relationship between where one lives and the cost of housing); data and chance (such as being able to understand how polls are based on sampling); and the mathematics of change (such as being able to represent how prices fluctuate and populations vary). The ALL team argues that people need to identify, interpret, act upon, and communicate about mathematical information, and the framework details the ways mathematical information can be represented; it also recognizes that to be numerate, adults need not only mathematical skills but also literacy and problem-solving skills. In this view, numeracy is also dependent on disposition, such as anxiety or self-confidence, which affects how one responds in situations requiring use of numeracy skills.

In this new light, numeracy is seen as the bridge between math and the real world. It is an umbrella term that expands both the breadth of the mathematics that is considered and the contexts in which adults use that mathematics. Numeracy is about making meaning of mathematics, at whatever level of mathematical skill, and mathematics is a tool to be used in a variety of applications in both education and life. "Numeracy is not less than mathematics, but more" (Johnston & Tout, 1995, p. xiii).

In further explaining the concept of

numeracy, it is helpful to contrast the way in which the new numeracy might be taught with the way math tends to be taught in a traditional classroom. Very generally, when teachers teach math, students use a textbook or workbook and do lots of repetitive practice, they prepare for tests and exams, and they learn formal rules, often by rote, with little consideration of why and how the skills they are expected to learn can be put to use in the real world. When teachers teach numeracy, they are more likely to teach math from a more authentic, contextual point of view, one in which math is derived from some actual or modeled activity, in which investigations and projects are used as vehicles for learning. Teachers of numeracy are also more likely to take into account the students' various informal ways of doing math, allowing the understandings and strategies amassed in and out of school to serve as valid resources.

This essential difference between the teaching of math and the teaching of numeracy is the reason why terminology is important. And it is the reason why the term numeracy, as described above, should be used to indicate what it is we do when we teach math in ABE. It is a way forward. As Schmitt (2000) writes: "Adult basic education and GED [General Educational Development] mathematics instruction should be less concerned with school mathematics and more concerned with the mathematical demands of the lived-in world: the demands that adults meet in their roles as workers, family members, and community members. Therefore we need to view this new term numeracy not as a synonym for mathematics but as a new discipline defined as the bridge that links mathematics and the real world" (p. 4).

NUMERACY IN U.S. ADULT BASIC EDUCATION

We began our search for the state of adult numeracy education in the United States by sampling two bodies of literature: the general literature on adult basic education and literacy,[2] including federal and state government policy documents, reference documents, and research reports,[3] and the literature that directly addresses adult numeracy or mathematics in ABE.[4] Our search of the general literature confirmed the findings of researchers in the mid-1990s that scant reference is made to numeracy or mathematics in such sources (Gal, 1993; Nesbit, 1996). Our search of the more focused literature suggests that information on numeracy and math is easy to find in practitioner writings and field-initiated studies (Gal, 1993; Mullinix, 1994; Leonelli, Merson, & Schmitt, 1994; Beder, 1999). In terms of research, however, there is little to report.

Research

Research in U.S. adult numeracy education appears at the intersection of two fields: mathematics education and adult basic education. The former concerns the development of mathematical knowledge in individuals and, more recently, in groups (primarily children), the latter the development of basic skills among adults. (For the purposes of this chapter our definition of ABE includes adult secondary and GED instruction.) Our survey of the literature on adult numeracy education revealed a dramatic absence of attention to the development of mathematics skills in adults enrolled in basic education courses. Almost ten thousand articles in the ERIC (Educational Resources Information Center) database, all of which were published between 1980 and 2001, concern mathematics education, and about six thousand relate to ABE, but only seventeen relate to both. When we limited our search to articles published in the United States, we found that an equal number concern each field (approximately three thousand to four thousand each), while only nine deal with the mathematics education of adults in basic education.

Literature surveys conducted by other researchers produced comparable results. From 1982 to 1998, more than three thousand articles in forty-eight education research journals dealt with mathematics education research where ethnicity, gender, social class, or disabilities were also considered. Of those, only 0.2 percent (five) concerned ABE (Lubienski, 1999). This figure sits in stark contrast with the 79 percent that examined K-12 mathematics education or a subset thereof and the 18 percent that concerned math education on the postsecondary level. Safford-Ramus (2000) identified and examined 113 U.S. dissertations listed in the databases of Dissertation Abstracts from 1980 to 2000 dealing with adult mathematics education, 34 of which addressed ABE.

Does this small body of research on ABE mathematics education say anything of value to the field? While we yearn for more research, the existing articles do reveal two interesting trends. First, unlike the research in mathematics education for children, research on mathematics education for adults for the most part does not address cognition or learning (student achievement). In the ERIC documents, Ginsburg and Gal's (1995) study of adults' informal and formal knowledge of percentages stands alone as a study of how adults think mathematically. Safford-Ramus (2000) found little attention paid to cognition when looking at adult mathematics education research: most of the work published in doctoral dissertations and journals concerned topics such as math anxiety. Outside of ABE, however, "the majority of mathematics education research focused on student cognition and outcomes, with relatively little attention to contextual or cultural issues" (Lubienski, 1999, p. 1).

Some attempts are being made to set the stage for more research. The National Center on Adult Literacy (NCAL) has published technical reports (Gal, 1993; Gal & Schmitt, 1994) that lay out the need for a research program, and the National Center for the Study of Adult Learning and Literacy (NCSALL) took a major step in connecting with international research efforts by hosting Adults Learning Mathematics-A Research Forum (ALM7 Conference) in July 2000. The topics discussed at the forum exemplify the field's emergent issues: assessment, frameworks, and standards, contexts in which adults practice mathematics, instructional approaches, parents as co-learners, research into practice, teacher knowledge, theoretical frameworks for adults learning mathematics, adults' understandings of mathematical concepts, and the use of mathematics in the workplace.

Practice

The dearth of material on adult numeracy education in research is not reflected in practice. Gal (1993, 2000) observed that while official reports, such as state reports on ABE provision and the outcomes of test results, convey the impression that little adult mathematics instruction takes place, numeracy activity is evident in publishers' materials and in surveys of adult education centers. A survey of 650 ABE programs in fifteen states indicated that more than 80 percent of adults enrolled received some math-related instruction (Gal & Schuh, 1994). Numeracy skills have also been identified alongside literacy skills as being important to successful employment, training and workplace practices, helping to establish numeracy training as part of workplace basic skills programs (Secretary's Commission on Achieving Necessary Skills [SCANS], 1991, 1992; Mikulecky, 1994; Bynner & Parsons, 1997). Despite the scant attention paid outside the classroom, mathematics teaching and learning does appear to be going on inside the classroom.

TEACHING STAFF AND PROFESSIONAL DEVELOPMENT. The most complete picture of the teachers who provide ABE math instruction can be found in two state-focused studies that were the subjects of dissertations. One was conducted in Massachusetts (Mullinix, 1994) and the other in Arkansas (Ward, 2000). In her survey of 167 Arkansas GED teachers, Ward profiled the typical GED teacher as one who teaches all subjects (including math) (96 percent) and has a bachelor's degree in elementary education (64 percent). An Arkansas GED teacher is almost certain to prefer teaching math with individualized instruction (95 percent) and to use repeated practice as the method of choice (99 percent). The Mullinix survey of 141 Massachusetts ABE math teachers found that over half of them came to be math instructors either "by accident" (36 percent) or as "part of the program package" (24 percent)-that is, math was included in the subjects they must teach. At least 55 percent reported having no training in mathematics pedagogy. In another estimate, fewer than 5 percent of teachers in programs providing numeracy education were found to be certified to teach mathematics (Gal & Schuh, 1994).

Although it may not have been noticed by policymakers or government, the need for teacher support and professional development made evident by Ward and Mullinix has not gone unnoticed by teachers. In recent years several practitioner groups have emerged to create opportunities for themselves and others to increase their knowledge of both mathematics content and pedagogy. The Massachusetts ABE Math Team in 1994 formed a collective of sixteen teachers to study the standards developed for K-12 students by the National Council of Teachers of Mathematics (NCTM), the U.S.-based professional organization for mathematics educators. The Massachusetts team then published a set of standards adapted for adults in ABE and GED programs (Leonelli & Schwendeman, 1994; Leonelli, Merson, & Schmitt, 1994). The Math Exchange Group (MEG) in New York City meets regularly to work on math problems and to promote their own and their students' understanding of math.

Ohio, Maine, Oregon, Illinois, and Pennsylvania have teachers and staff developers who lead workshops for their colleagues. Most of these teachers are founding members of the Adult

Numeracy Network (ANN is now an at-large NCTM affiliate that meets during the annual NCTM conference).5 ANN has reached out to hundreds of ABE teachers through its newsletter, the Math Practitioner, and has engaged many teachers in conversation about math through its numeracy electronic discussion list.6 ANN also published the Framework for Adult Numeracy Standards (Curry et al., 1996). These curriculum standards consolidate several perspectives, mainly those supported by the NCTM, the Secretary's Commission on Achieving Necessary Skills (SCANS, 1991), and the ABE Mathematics Team in Massachusetts as well as those of adult learners, numeracy teachers, and employers. The aim of the standards is to present a framework which would form a comprehensive basis for states to develop their own numeracy curriculum standards. It is based on seven themes-three about the processes of learning math (relevance and connections, problem solving and reasoning, and communication) and four that are content-based (number and number sense, data, geometry, and algebra).

Various members of ANN continue to take leading roles in significant projects. Two members run the new LINCS Science and Numeracy Collection, and others have received a grant from the National Science Foundation to adapt three standards-based K-12 curricula to ABE environments. This effort-called the Extending Mathematical Power (EMPower) project-is being developed at TERC in Massachusetts. The impact of these practitioner groups can also be seen in the growing number of sessions focused on math at state and regional ABE conferences.

These valuable efforts notwithstanding, no organized or structured form of professional support exists to meet the ongoing needs of those ABE practitioners who teach math. No government-sponsored programs or initiatives such as "family literacy" or "workplace education" have been developed, and no universities offer formal courses in adult numeracy or adult mathematics education.

CURRICULUM, INSTRUCTION, AND ASSESSMENT. At present, the two primary drivers of the math curriculum in ABE are the GED exam and commercially published workbooks. The 1988 version of the GED mathematics test, which is being revised for 2002, is a prime motivator for including math in instruction. The test consists largely of multiple-choice word problems presented in adult contexts that are classified as 50 percent arithmetic, 30 percent algebra, and 20 percent geometry. Many GED and pre-GED mathematics workbooks reflect this breakdown, and, in general, present computational routines, with opportunities for repeated practice of these routines in direct preparation for the test. Teachers looking for something more often turn to materials that emphasize cooperative problem solving and visualization. Although such materials were developed for middle or secondary school students, they are full of ideas suitable for teaching adults. Examples include equals project materials (for example, family math and get it together), the visual math materials (Foreman & Bennett, 1995), the NCTM addenda series (for example, Burton, 1993; del Grande, 1993), and some of the Australian adult numeracy materials (strength in numbers; mathematics: a new beginning; numeracy on the line).

Unfortunately, as the Arkansas teachers reported in Ward's survey, much math teaching is based on practicing routine procedures with students using workbooks (Schmitt, 2000; Kloosterman, Hassan, & Wiest, 2000).

Workbooks, if used as the sole source of math instruction, discourage intuitive approaches and promote a mathematics that comes from an outside authority rather than a personal mathematics that can be applied in many situations. This style of math instruction has largely been discredited in the field of children's mathematics education, where a range of different strategies are recommended (see Grouws & Cebulla, 2000).

Although the GED is the high-stakes assessment of choice, ABE programs are often required to demonstrate student progress through standardized tests. The Tests of Adult Basic Education (TABE), which is reportedly used in 80 percent of all U.S. adult literacy programs (Gal & Schuh, 1994), is another major influence on the teaching of adult numeracy. The TABE includes two math sections, Computation and Concepts/Applications, and it is in many ways similar to the GED except that it more specifically diagnoses skills. Another driver of the curriculum will undoubtedly be the National Reporting System (NRS), which at present suggests that the TABE, the Comprehensive Adult Student Assessment System (CASAS), and the Adult Measure of Essential Skills (AMES) be used to assess student progress. The possible danger with a nationally directed assessment scheme like the NRS is that it can promote teaching that is focused predominantly on raising standardized test scores. Adults who may want classroom learning to address the mathematical demands of their daily life, to prepare them for further education, or for specific work or employment purposes may find themselves in competition with the program's need to demonstrate progress against the assessment scheme.

Policy

Each year more than 4 million adults attend federal- and state-funded ABE programs in the United States. In 1997, 39 percent of these adults enrolled in classes in English for speakers of other languages (ESOL), 38 percent attended classes in literacy and basic skills instruction (ABE), and 23 percent entered classes in adult secondary education (ASE) (U.S. Department of Education, 1997).7 In each of the three instructional groupings, the need for literacy-the ability to read and write-is accepted by policymakers and practitioners alike. Similarly, few would question the need for newcomers to the United States to become fluent speakers of English. Periodically, other types of knowledge or skill are added to the agenda of ABE, ASE, and ESOL services. For example, at various times funders have decided that ABE programs should include instruction on citizenship, health, parenting, or technology.8 However, literacy and language learning and improvement remain the focus of ABE.9

Public relations and advocacy play an important role in shaping and promoting government educational policy. For more than a decade, advocates for ABE have campaigned hard to make sure that literacy becomes a national priority. The fruits of their efforts are evident in the titles of the major organizational structures created in the 1990s to advance the cause of ABE: the National Center for the Study of Adult Learning and Literacy, the National Center on Literacy, the National Institute for Literacy, the Division of Adult Education and Literacy (prior to 1991, the Division of Adult Education). Likewise, the titles of major legislative actions and documents authorizing and regulating adult basic skills provision have come to stress the importance of "literacy." The Adult Basic Education section of the Economic Opportunity Act of 1964 and the Adult Education Act of 1966 have been replaced by the National

Literacy Act of 1991 and the Adult Education and Family Literacy Act of the Workforce Investment Act of 1998. Looking beyond the titles for evidence that numeracy is on policymakers' radar screen is revealing as well. Numeracy-whether sought in terms of its most restrictive definition (as merely "computation"), in terms of a commonly used less restrictive definition (as "computation and problem solving"), or in terms of the comprehensive definition supported in this chapter-appears only sporadically in the text of major policy and public relations documents aimed at expanding and improving ABE.

Numeracy is sometimes omitted entirely. One example is the widely promulgated document From the Margins to the Mainstream: An Action Agenda for Literacy, which was one result of the National Literacy Summit 2000. According to the National Institute for Literacy (NIFL), "Hundreds of individuals and organizations across the country have contributed to the Summit document, which can guide the field's work over the next decade" (NIFL, 2000). Yet in this important paper the only mention of "computation," "mathematics," or "numeracy" appears in a sidebar quoting the definition of literacy from the Adult Education Act of 1991. One might surmise that when the term literacy is used in the document it is intended to include numeracy, but this may not be the case, as is evident in the definition of literacy on the cover as "the quality or state of being literate" and of literate as "one who can read and write" (National Literacy Summit 2000 Steering Committee, 2000).

Some policy documents do include numeracy. The National Reporting System (NRS) for Adult Education is an outcomes-based reporting system for state-administered, federally funded adult education programs. It holds states'

ABE programs accountable for tracking student progress. Across the NRS's six levels of educational gain in numeracy skills, mathematical progress is described primarily in terms of increases in students' decontextualized computational skills with whole numbers, fractions, decimals, and percents. In the NRS Implementation Guidelines (U.S. Department of Education, 2000b), Level 1, Beginning ABE Literacy, addresses number recognition, counting, and addition and subtraction of single-digit numbers; Level 2, Beginning Basic Education, expands to three-digit addition and subtraction, multiplication tables through twelve, and simple fractions; Level 3, Low Intermediate Basic Education, includes the four operations with three-digit whole numbers; and Level 4, High Intermediate Basic Education, sets expectations for all operations on whole numbers and fractions as well as fraction and decimal conversion. Any instruction that goes beyond computation is reserved for the two higher levels of learners. It is not until Level 5, Low Adult Secondary Education, that operations with decimals, simple algebraic equations, tables and graphs, and "use of math in business transactions" are inserted. Finally, the description of High Adult Secondary Education, Level 6, requires that the "individual can make estimates of time and space and can apply principles of geometry to measure angles, lines, and surfaces; can also apply trigonometric functions" (p. 16). The message here is that context is not important and that adult education programs are accountable to get computation out of the way in the first four levels, and introduce concepts and skills around space, geometry and measurement, data, statistics, and graphs, and algebra only after number skills are developed.

Thus, while the NRS does make use of the term numeracy, it is not used in the same way the term is understood in this chapter, where adult context and various math content areas are integrated at all levels of progress. The Adult Literacy and Lifeskills Survey's facets of numerate behavior, the NCTM Principles and Standards, and the ANN Framework for Adult Numeracy Standards are consistent in the perspective that context and the four domains of mathematics are critical to all stages of a person's mathematical development.

Another policy document starts from contexts that are real and important for adults. Equipped for the Future [EFF] Content Standards: What Adults Need to Know for the Twenty-First Century (Stein, 2000) is grounded in data gathered from adults on their roles as workers, parents, and community members. As such it attempts to holistically describe the core skills adults need to carry out their roles effectively as parents, citizens, and workers.

However, of the sixteen EFF standards, only one specifically addresses numeracy or mathematics. This one is under the banner of Decision-Making Skills and is called Use Math to Solve Problems and Communicate. In our view, this perspective is more adult-appropriate than the NRS perspective because it starts from the position of adults' using a range of purposeful skills to participate effectively in society. Even so, the EFF standards could go further to explicate the mathematics and skills within those contexts. While many of the other sixteen standards could incorporate some math skills and understanding, or could be integrated with the math standard, this is not made explicit in any way. In the section of EFF that illustrates how the EFF might work in practice, there are no examples of applying the math standard. Without this explication and support to teachers, it is possible that numeracy practice will not be enhanced or encouraged by this major program of the National Institute for Literacy.

LESSONS FROM K-12

Given the short history of adult numeracy education, ABE might make use of the research, practice, and policy in mathematics education that is not directly focused on adults. Surely some characteristics of sound teaching practice can cross such boundaries.

Research in mathematics education is explicitly driven and practice and policy implicitly driven by underlying epistemologies about the nature of thinking and knowledge acquisition. Over the last few decades, great interest has been stirred in the mathematics education community over alternatives to the traditional perspectives on what it means to learn and know mathematics. The discussion has centered largely on the concept of constructivism as opposed to transmissionism and its many variations and interpretations.

In the transmissionist model, teachers act as the experts, and their role is to transmit their knowledge directly to their students. The knowledge is seen as objective, and the learning is about receiving the information handed down, absorbing the facts, and reproducing them. Constructivists see learning as a form of understanding constructed by the learner, and they focus on the ways in which the individual learner makes sense of mathematics. In social constructivism, an offshoot of constructivism, learning is seen as an activity in which shared mathematical meanings are constructed with others and drawn from the environment. Recent cognitive theories hold that knowledge is constructed and restructured under a variety of constraints or conditions that either facilitate or limit the range of what can be learned. Here are some interpretations of the key implications of constructivism for classroom practice, paraphrased from

Hatano (1996, pp. 211-213):

- Mathematical knowledge is acquired by construction; therefore, students should be given the opportunity to actively participate in the learning process rather than be forced to swallow large amounts of information.
- Cognitive restructuring is necessary to advance mathematical knowledge; to that end, instruction should induce successive restructurings of mathematical knowledge.
- Mathematical knowledge is constrained by internal factors (cognitive, such as innate and early understandings and previous knowledge) and external factors (sociocultural, situated in contexts, such as peers, teachers, tools, and artifacts); it follows that each collection of factors may either facilitate or limit mathematical learning.

Because constructivism is a theory about the nature of learning, it does not directly address classroom practice. Nevertheless, constructivist research has highlighted the many shortcomings of traditional mathematics education, which is rooted in transmissionism, and has raised awareness of the different theories and philosophies behind mathematics and mathematics education. (Key players in these discussions and debates have included Piaget, Vygotsky, Mellin-Olsen, von Glaserfield, Cobb, Noss, Ernest, Wittgenstein, and Lakatos. Some useful readings on constructivism and related debates include Davis, Maher, & Noddings, 1990; Ernest, 1989, 1998; Mellin-Olsen, 1987; and Malone & Taylor, 1993.)

Research

Considerable research has been conducted on how children learn math. Profoundly influenced by Piaget's theories of genetic epistemology and developmental psychology, research in mathematical thinking and learning has focused on the psychology of the individual and the personal construction of knowledge. More recently, social and cultural aspects of mathematical activity have been included in theories of mathematical learning.

In a summary of the significant findings in international K-12 mathematics research, Grouws and Cebulla (2000) outline the implications for teaching as follows:

- Opportunity to learn: The extent of the students' opportunity
  to learn mathematics content bears directly and decisively on student mathematics achievement (p. 10).
- Focus on meaning: Focusing instruction on the meaningful development of important mathematical ideas increases the level of student learning (p. 13).
- Learning while solving problems: Students can learn both concepts and skills by solving problems (p. 15).
- Opportunity for both invention and practice: Giving students opportunities to discover and invent new knowledge and to practice what they have learned improves student achievement (p. 17).
- Openness to student solution methods and student interaction: Teaching that incorporates students' intuitive methods of solving problems can increase student learning, especially when combined with opportunities for student interaction and discussion (p. 19).
- Small group learning: Letting students work in small groups
  on activities, problems, and assignments can increase student mathematics achievement (p. 21).
- Whole-class discussion: Whole-class discussion

following individual and group work improves student achievement (p. 23).

- Number sense: Teaching mathematics with a focus on number sense encourages students to become problem solvers in a wide variety of situations and to view mathematics as a discipline in which thinking is important (p. 25).
- Concrete materials: Long-term use of concrete materials is positively related to increases in student mathematics achievement and improved attitudes toward mathematics (p. 27).
- Use of calculators: Using calculators in the learning of mathematics can result in increased achievement and improved student attitudes (p. 29).

In our view, all of these strategies and approaches can be applied to teaching mathematics at any level, including ABE.

Two areas of research in K-12 math education that are especially relevant to adult mathematics education are ethnomathematics, a relatively new term for a field of study that has captured the interest of educators throughout the twentieth century, and gender.

ETHNOMATHEMATICS AND

FUNCTIONAL MATH. Sometimes called street math, ethnomathematics is concerned with how mathematics is used in different cultures and in social and work situations outside the classroom-that is, in real life. Bishop (1994) writes that mathematics has generally been "assumed to be culture-free and value-free knowledge; explanations of 'failure' and 'difficulty' in relation to school mathematics were sought either in terms of the learner's cognitive attributes or in terms of the quality of the teaching . . . Received . . . 'social' and 'cultural' issues in mathematics education research were rarely considered" (p. 15). In the late 1970s and early 1980s, interest in the social and cultural aspects of mathematics and mathematics education increased. According to gerdes (1994), it is during this period that d'ambrosio proposed his "ethnomathematical program" as a means of tracking and analyzing the processes of generalization, transmission, diffusion, and institutionalization of [mathematical] knowledge in diverse cultural systems" (p. 19).

Ethnomathematics can inform mathematics education. Zaslavsky (1994a) stated the following:

Why is it important to introduce ethnomathematical perspectives into the mathematics curriculum? Students should recognize that mathematical practices and ideas arose out of the real needs and interests of human beings. . . . Students should learn how mathematics impacts on other subject areas-social studies, language arts, fine arts, science. Most important, they should have the opportunity to see the relevance of mathematics to their own lives and to their community, to research their own ethnomathematics. [p. 6]

Zaslavsky goes on to recommend how an ethnomathematical perspective could be incorporated into a mathematics curriculum:

The entire mathematics curriculum must be restructured so that mathematical concepts and ethnomathematical aspects are synthesized. Rather than a curriculum emphasizing hundreds of isolated skills, mathematics education will embody real-life applications in the form of projects based on themes and mathematical concepts.

Teachers at all levels must be well grounded in mathematics and at the same time be familiar with the interface between mathematics and other subject areas. [p. 7]

Much research on the ways people use math every day does in fact focus on adults rather than children, looking at how adults perform mathematical tasks in their daily lives, and as such is relevant to adult numeracy practices.

Three main messages to adult educators seem to emerge from this research. One is the acknowledgment that formal, or school-based, math is not the only math. A person's mathematical knowledge has probably been acquired via both formal and informal learning. The second message is that informal learning is as valuable as formal, school-based learning. The third is that students should be encouraged to build on this range of real-life mathematics experiences while also learning the practices of formal math.10

A related view of how to improve school mathematics instruction, especially at the high school level, concerns functional math, wherein the instruction and the curriculum are connected to real-world applications. Forman and Steen (1999) describe and promote the need for a functional math curriculum:

Any mathematics curriculum designed

on functional grounds . . . will emphasize authentic applications from everyday life and work. . . . By highlighting the rich mathematics embedded in everyday tasks, this approach . . . can dispel both minimalist views about the mathematics required for work and elitist views of academic mathematics as an area with little to learn from work-based problems.

Neither traditional college-preparatory mathematics curricula nor the newer standards-inspired curricula were designed specifically to meet either the technical and problem solving needs of the contemporary workforce or the modern demands of active citizenship. [p. vi]

Forman and Steen then proceed to explain why and how such a functional mathematics curriculum could work to cater to both the traditional and reformist views of mathematics while at the same time making the learning of mathematics relevant and meaningful to all students.

Functional math has much in common with ethnomathematics. Both argue for an approach that covers a wide range of math skills embedded within social contexts and purposes and that values personal ways of doing math. Both sit comfortably alongside the view of numeracy advocated in this chapter.11

GENDER STUDIES. Much has been written about girls and mathematics (Walkerdine, 1989; Willis, 1989; Secada et al., 1995; Harris, 1997), and much of the research in this area is linked with the ethnomathematics movement. A quote from a U.K. report by Harris (1997) demonstrates how these fields overlap in their view that informal, real-life mathematical knowledge is as valuable as that gained through formal instruction: "Throughout the world it is women and girls who underachieve in mathematics. Mathematics is the study above all others that denotes the heights of intellect. Throughout the world, the activity that most clearly denotes the work of women, in both the unpaid, domestic sphere and in paid employment, is work with cloth. Work with cloth symbolizes women as empty-headed and trivial. Yet constructing cloth, decorating it during construction and converting it into garments, is work that cannot be done without involving spatial and numerical concepts that are the foundations of mathematics" (p. 191).

In the United States, much work has been done to promote the success of girls in mathematics, most notably by the Lawrence Hall of Science in Berkeley, California, through the EQUALS project, which since 1977 has been developing programs that promote equity for underrepresented groups in mathematics. These approaches to teaching have challenged the traditionally male-dominated domain of math education and promoted alternatives that in many cases are attractive not only to girls but to the many boys who struggle with learning mathematics in a traditional classroom. Such approaches include working cooperatively, promoting discussion and idea sharing, and using hands-on materials. They have much in common with the approaches to learning math promoted by ethnomathematicians and social constructivists.

Practice

For some time now there has been evidence of dissatisfaction with what children are learning-or not learning-in math class. In 1990, in a national publication about mathematics education, Davis, Maher, and Noddings (1990) described the situation as follows:

By now nearly everyone has probably read, or at least heard of, the recent spate of reports showing that students in the United States are not doing very well in mathematics. . . . This leaves the United States with what might be called a war on two fronts. There is first, the fact of unsatisfactory results. But the second front is perhaps even more threatening: there is major disagreement on how to proceed in order to make things better. One school of thought would argue for "more" and "more explicit." That is to say, they would argue that the United States needs more days of school per year, or more hours of mathematics instruction per week, or more homework, or all of the above, together with a highly explicit identification of the knowledge that we want students to acquire, and a sharply directed emphasis on precisely this knowledge. Prescriptions in this direction usually suggest more frequent testing, and making more-perhaps even teachers' salaries-dependent on the outcome of this testing.

A different diagnosis and prescription might be said to tend in nearly the opposite direction. . . . These recommendations argue for making mathematics more natural, fitting it better into the context of children's lives, conceivably even moving toward less testing. [p. 1]

Nearly ten years later, Forman and Steen (1999) expressed similar sentiments:

Despite mathematics' reputation as an ancient subject consisting of indisputable facts, mathematics education has recently become the source of passionate debate. At stake is nothing less than the fundamental nature of school mathematics: its content (what should be taught), pedagogy (how it should be taught), and assessment (what should be expected). At times these "math wars" have become so heated that [U.S.] Education Secretary Richard Riley has issued a public call for a truce.

At the risk of oversimplifying, this debate can be characterized as a clash between "traditionalists," who expect schools to provide the kind of well-focused mathematics curriculum that colleges have historically expected, and "reformers," who espouse a broader curriculum that incorporates uses of technology, data analysis, and modern applications of mathematics. The reform approach is championed by the National Council of Teachers of Mathematics, whose standards advocate a robust eleven-year core curriculum for all students. [p. 2]

What seems to be a universal point of agreement is that current and past methods of teaching math to children have not been entirely successful. Researchers have attempted to determine why this is the case, and their efforts have resulted in some of the debates and recommendations just described. So far, the research seems to have had little impact on the outcome of mathematics education-that is, on student abilities. But this isn't to say that progress has not been made. Studies of student performance, such as those conducted through the National Assessment of Educational Progress (NAEP), indicate that student performance is rising, albeit slowly (Dossey & Usiskin, 2000, pp. 20-22).

Probably the strongest influence in terms of school practice has been the standards established by the National Council of Teachers of Mathematics. Building on recommendations from the mathematics education community at large, NCTM went through a long process culminating in the production of three standards documents on curricula and evaluation: Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989), Professional Standards for Teaching Mathematics (NCTM, 1991), and

Assessment Standards for School Mathematics (NCTM, 1995). Based on research findings and generally supportive of the constructivist view of learning mathematics, these standards drove the reform agenda in school math education through the 1990s. The NCTM standards influenced state standards and curriculum frameworks, instructional materials, teacher education, and classroom practice (NCTM, 2000). In 2000, NCTM published a revised version called Principles and Standards for School Mathematics. Despite the apparent value of the NCTM standards and knowledge about constructivism and ethnomathematics, great unrest about teaching practice and student outcomes continues to exist. Tradition in the way math is taught in the classroom is deeply entrenched, and no effort as yet has appeared capable of initiating fundamental change in teaching practice. Changing and developing new curriculum standards, writing new teaching materials, and the like appear only to chip away at the edges. Tradition is often the barrier to progress.

What mathematics teachers seem to do in their classrooms is teach in much the same way that they themselves were taught; what they experienced themselves as successful mathematics students is what they hand on to their own students. An Australian educator stated the problem as follows: "While teachers operate at an intuitive level as pragmatists, not articulating to themselves the present theory which drives their practice, they are effectively paralyzed in terms of their capacity to change radically. The non-theorized practitioner is a kind of well-intentioned misguided or unguided missile in the classroom, likely to take up a new idea and add it to the repertoire but unable to generate infinite practice for new contexts" (Boomer, 1986/1994, p. 68).

Another issue is the focus on computation. In a recent commentary on the similarities and differences between adult and K-12 mathematics teaching, Kloosterman, Hassan, and Wiest (2000) said, "One explanation for the gap between mathematical experiences in school and workplace or everyday mathematics is tradition. The curriculum has always been focused on computation, so that is what is expected in mathematics classrooms" (p. 52). Grouws and Cebulla (2000) report the following: "Data from the Third International Mathematics and Science Study (TIMSS) video study show that over 90 percent of mathematics class time in the United States eighth grade classrooms is spent practicing routine procedures, with the remainder of the time generally spent applying procedures in new situations. . . . In contrast, students at the same grade level in typical Japanese classrooms spend approximately 40 percent of instructional time practicing routine procedures, 15 percent applying procedures in new situations, and 45 percent inventing new procedures and analyzing new situations (p. 17).

As we have stated a number of times, it does appear that practice in the traditional math classroom may focus on calculations and routine procedures to the detriment of other recommended activities and strategies, such as those listed earlier by Grouws and Cebulla. These include constructivist-based strategies such as encouraging students to discover their own, personal, and invented procedures and applying them to new situations, which as noted earlier seems to be more the case in Japan than in the United States.

Other initiatives in practice have been in the development of classroom teaching resources: textbooks and workbooks. But it is estimated that only about 10-15 percent of elementary schools are using one of the newer, more conceptually based series of mathematics texts, most of which are the result of projects supported by the National Science Foundation. At the middle school level (grades 6-8) and the high school level (9-12), newer resources emanating from other NSF-supported projects are becoming more widespread (Dossey & Usiskin, 2000). In all states except Iowa, state-level education authorities set curriculum guidelines, and this often determines which textbooks will be adopted by local school districts. Most of these books take a conservative pencil-and-paper approach to teaching in which students are shown one approach to problem solving.

Policy

Dissatisfaction with student performance in mathematics has driven major policy initiatives for K-12 mathematics education at the federal, state, and local levels. In K-12 education, unlike ABE, the national political dialogue has focused fairly equally on literacy and numeracy. This was true when the National Educational Goals (U.S. Department of Education, 1989) were put in place during the administration of President George H. W. Bush and remained so in 1997 when the first two of President Bill Clinton's seven educational priorities were stated as follows: "All students will read independently and well by the end of 3rd grade," and "All students will master challenging mathematics, including the foundations of algebra and geometry, by the end of 8th grade" (Clinton, 1997). Following these announcements, a presidential directive was issued to the U.S. Department of Education and the National Science Foundation that resulted in America Counts, an initiative focusing on six strategic areas in math and science education: teacher preparation, increased learning time for students, research into best practices, public understanding of today's mathematics, challenging and engaging curriculum, and coordinated federal, state, and local efforts (U.S. Department of Education, 1998). In Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the Twenty-First Century, the authors point to four enduring reasons why the nation should take action to improve children's education in the arenas of math and science: to address the rapid pace of change in the global economy and the workplace, to facilitate everyday decision making, to bolster national security, and to acknowledge the intrinsic cultural value of mathematic and scientific knowledge (U.S. Department of Education, 2000a). This initiative may have a chance of being more than a rhetorical vehicle for politicians-it has struck a chord with the educational leadership of the NCTM and the National Science Foundation as well as with community, business, and political leaders.

As is the case in practice, probably the most significant recent influence on mathematics education policy in the United States has been the standards developed by the NCTM. A new, revised set of standards was released in April 2000 under the title Principles and Standards for School Mathematics (NCTM, 2000). The standards are guided by six principles:

1. Equity: Excellence in mathematics education requires equity-high expectations and strong support for all students.
2. Curriculum: A curriculum is more than a collection of activities. It must be coherent, focused on important mathematics, and well articulated across grade levels.
3. Teaching: Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.
4. Learning: Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.

5. Assessment: Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.
6. Technology: Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student learning.

At each of four grade levels-pre-K-2, 3-5, 6-8, and 9-12-the Principles and Standards contains a comprehensive body of mathematical understandings and competencies organized into five content areas-number and operation, algebra, geometry, measurement, and data analysis and probability-and five ways of acquiring and using that content-problem solving, reasoning and proof, communication, connections, and representation. Despite its potential for influencing policy and practice, the Principles and Standards is only a resource and guide; it carries no legal weight. Still, previous NCTM standards had a major influence on state curriculum and policy, and it is expected that the 2000 standards will have a similar impact.

LESSONS FROM ABROAD

America is not alone in its need to face up to the problem of "innumeracy." A quick analysis of ERIC documents on adult numeracy gives a broad indication of the state of adult numeracy education in other English-speaking countries relative to the United States. Of 412 documents found as the result of a Boolean search for the words adult and numeracy where the country of origin could be identified, 29 percent originated in the United States, compared with 30 percent in Australia, 22 percent in the United Kingdom, and 8 percent in Canada. We will take a fairly close look at some of the numeracy activity in Australia and touch on some of the significant work done in other countries that may be of interest to ABE educators in considering future approaches to adult numeracy provision in the United States.

In the late 1970s, the time at which adult numeracy practice was more or less officially recognized in the United States and abroad, the country with the most activity was the United Kingdom. In 1981, the United Kingdom undertook what was probably the first large-scale assessment of the numeracy skills of a general adult population, basing it on interviews with 2,890 individuals (Advisory Council for Adult and Continuing Education, 1982). It was there, in 1982, that the Cockcroft report, a very important document in the history of adult numeracy education, was completed. The United Kingdom continued to be active in researching adult numeracy, and a study and consequent report, Does Numeracy Matter? (Bynner & Parsons, 1997), found that poor numeracy skills did have a major impact on an adult's life, compounding the problems that can result from poor literacy skills: "People without numeracy skills suffered worse disadvantage in employment than those with poor literacy skills alone. They left school early, frequently without qualifications, and had more difficulty in getting and maintaining full-time employment. The jobs entered were generally low grade with limited training opportunities and poor pay prospects. Women with numeracy difficulties appeared especially vulnerable to exclusion from the clerical and sales jobs to which they aspired" (p. 27).

A number of reports and articles have described the development of adult numeracy research and practice in the United Kingdom, including Coben (2000) and Benn (1997). The United Kingdom has also recently launched Skills for Life-The National Strategy for Improving Adult Literacy and Numeracy Skills (Department for Education and Employment, 2001). Indeed, the decades of work by British numeracy practitioners have made numeracy a solid partner with literacy in policy as well as practice.

Elsewhere, including in the Netherlands, Australia, and Canada, the late 1970s and early 1980s saw the gradual emergence of adult numeracy practice, usually following and modeled on adult literacy teaching practice. It was not until the 1990s that recognition of the need for numeracy education became a subject of significant interest to education providers, writers, and researchers. There seem to be a couple of reasons for this. One was International Literacy Year in 1990, which stirred many countries to put more money into adult literacy provision, some of which undoubtedly flowed into numeracy provision. The other significant influence was the interest in workplace reform and the provision of workplace basic skills training, where numeracy skills were recognized as being as important as literacy and communication skills (for example, the Essential Skills Research Project in Canada and the Workplace English Language and Literacy [WELL] program in Australia).

Research

A few attempts have been made to review research in the area of adult numeracy (Adult Literacy and Basic Skills Unit, 1994; Brooks et al., 2001; Coben, 2000; Gal, 1993), but these reports indicate that little research has been completed. However, adult numeracy interest groups have been developed, either in their own right or as part of other, larger organizations. Conferences have been held to bring together researchers and experienced practitioners within countries and from around the world. One example of this kind of activity is a UNESCO international seminar on adult numeracy held in Paris in 1993. Another was the development in 1994 of the research group Adults Learning Mathematics-A

Research Forum. This group, initially a U.K.-based interest group, drew the interest of other countries and is now international in scope. An annual conference is held, and the proceedings of each have been published. In 2000, the group held its first ever conference outside of Europe, in Boston. In addition, two successful working groups were held as part of the large quadrennial International Congresses on Mathematical Education in Sevilla, Spain, in 1996 (ICME 8; see FitzSimons, 1997), and in Tokyo, Japan, in 2000 (ICME 9; see Fujita, 2000). Taken together, the proceedings from these conferences are a rich resource on current thinking about adult numeracy education.

Almost as a direct consequence of these activities, two new international compilations of research and study into adult numeracy have been published: in the United States, Adult Numeracy

Development: Theory, Research, Practice (Gal, 2000), and in the United Kingdom, Perspectives on Adults Learning Mathematics: Research and Practice (Coben, O'Donoghue, & FitzSimons, 2000). Most of the articles in both date from 1995 or 1996. Together the two books represent the first major commercially published, internationally based collections of writings about adult numeracy, including chapters or sections that review current research. The U.S. publication, edited by Iddo Gal, is more practical in its focus and is of particular interest to an American audience in that a number of the authors write about practices in the United States. The book has four parts: perspectives on numeracy, approaches to instruction, reflecting on practice and learning, and assessment. The U.K. publication is more research-oriented and has a more international flavor. The section titled "Perspectives on Research on Adults Learning" brings together probably the most comprehensive analysis of research in this area to date. There is some overlap between the two books, with many authors in common, but they provide a solid base of reflection and research on which to move forward.

Another significant publication on theory and research in adult numeracy education, this one from the United Kingdom, is Roseanne Benn's Adults Count Too: Mathematics for Empowerment (1997). Benn locates numeracy practice within the wider sphere of ABE, describes and discusses relevant theories such as constructivism and fields of research such as ethnomathematics, and looks at the meaning of numeracy and implications for teaching, curriculum, and professional development.

In Australia, a number of projects were launched in the mid-1990s focusing on areas of research such as the pedagogical relationship between adult literacy and numeracy (Lee, Chapman, & Roe, 1993). One research project, called Numeracy in Practice (Johnston, Baynham, Kelly, Barlow, & Marks, 1997), looked at teaching numeracy to young unemployed people. A major influence in Australian numeracy research and development has been the work of Betty Johnston and her colleague, Keiko Yasukawa, who have argued for a critical constructivist approach to adult numeracy teaching (see Johnston, 1994). This approach was the basis for a substantial adult numeracy teaching training program (discussed later in this chapter) and has also influenced teaching practice and curriculum development across Australia.

Practice

In the area of practice, developments abroad have paralleled those in the United States, taking place in curriculum or standards frameworks, associated assessment practices, and professional development and training.

CURRICULUM AND INSTRUCTION. For most of its history here and abroad, ABE has been an informal, student-focused form of education with no formal accreditation process or systemwide curriculum. But in the 1990s the pressure for competency-based education and training pushed the field to develop an accredited curriculum built on competency-based learning outcomes. While many countries have adopted a school-based and traditional transmissionist model in developing curriculum standards for adult numeracy (Ciancone & Tout, 2001; Tout, 2000), there are examples of constructivist approaches to curriculum development. Following are two such examples, one from the Netherlands and one from Australia.

Realistic Mathematics Education (RME) was developed in the Netherlands during the 1970s.12 It was developed primarily for schools but has also formed the basis of adult numeracy practice in the Netherlands, and the provision of adult numeracy education coincided with the development of RME. RME starts from the assumption that students should be given the opportunity to reinvent mathematics for themselves and that the subject matter should be "real" for them. This concept of the student reinventing and conceptualizing a personal mathematics is central to RME and is called mathematizing. It has much in common with the concept of social constructivism.

Building on RME, adult numeracy provision in the Netherlands focuses on functional contexts and applications, values problem solving, and encourages interactions between students, thereby making communication an important aspect of mathematics education. RME values individual, informal approaches to problem solving; in this it is unlike many other approaches to mathematics education (Gravemeijer, 1994; Matthijsse, 2000). This is taken into account in assessment as well, as discussed later in this chapter (van Groenestijn, 2000).

A range of work has been done in Australia to create standards and a hierarchy of numeracy skill development for adult basic education that is not based on school mathematics. As in the United States, individual Australian states can develop their own curriculum. The most widely adopted approach is the Certificates in General Education for Adults (CGEA) (Kindler, Kenrick, Marr, Tout, & Wignall, 1996), a nationally accredited, competency-based curriculum framework. The CGEA takes the view that numeracy is about making meaning of mathematics and has developed a set of learning outcomes in keeping with this view.

Rather than organizing learning outcomes in the traditional fashion (in accordance with the five standard areas of school math education-number and operation, geometry, data analysis and probability, measurement, and algebra-as described, for example, in the NCTM standards), the CGEA organizes outcomes around the purpose and use of mathematics in social contexts. These outcomes are organized into four different categories, or domains (referred to as different numeracies), across four different levels of student development:

- Numeracy for practical purposes concerns aspects of the physical world that have to do with designing, making, and measuring. There are two learning outcomes: design (for example, recognizing and using shapes in packaging, buildings, and art) and measurement (for example, in cooking and making furniture).
- Numeracy for interpreting society concerns interpreting and reflecting on numerical and graphical or statistical information of relevance to

self, work, or community. The two learning outcomes are data (for example, graphs and statistics of consumer prices or sporting event scores) and numerical information (for example, information on financial transactions from banks or newspaper articles).

- Numeracy for personal organization focuses on personal situations and interactions involving money, time, and travel. There are two learning outcomes, one dealing with money and time, the other with location and direction.
- Numeracy for knowledge is introduced only at level 3 of the four-level CGEA curriculum framework and deals with the skills needed for further study in mathematics or in other areas of study that require an understanding of math. Learning outcomes focus on problem solving and algebraic and graphical techniques. At this level adults begin to learn (or relearn) the formal aspects of mathematics.

Within the individual CGEA learning outcomes themselves, the assessment criteria that need to be met by students are broken down into three subcategories: mathematical knowledge and techniques, language, and interpretation. Even at this level of detail the emphasis is not only on mathematical skills but on the skills of communicating about the mathematics involved in problems and interpreting the solutions.

Consequences follow from this way of designing curriculum standards. First is the actual importance of mathematics. The CGEA states that numeracy is about using math for some particular social purpose within a certain context, and the implication is that mathematics is an important, useful, and vital tool in contemporary society. It also acknowledges that formal mathematics has its place, at least as a pathway to further study, through the fourth category of learning outcomes, "numeracy for knowledge." Second, the CGEA encourages the teaching of numeracy in a holistic, integrated way, and literacy and numeracy are often taught together. For numeracy teachers who do not have formal training in math, the CGEA learning outcomes are easier to understand and work with than the traditional school-based mathematics curriculum (Ciancone & Tout, 2001).

In both the RME approach of the Netherlands and the CGEA in Australia, the curriculum is based on teaching in a context. In such environments, teaching becomes task-oriented-that is, it involves engaging students in problem solving via investigations or projects involving real-life mathematics. Teachers develop realistic tasks or investigations that are of interest to the students, and students then go about solving the problems posed. The mathematics skills that are taught arise out of the tasks being investigated. One consequence of this arrangement is that classes engage in whole group, small group, and individual work, and this is also how the math skills are learned and practiced. Another consequence is that conventional textbooks do not really suit this approach. The learning involved requires students to work actively on projects or investigations, not to work their way through a sequence of sums or word problems in a book. As discussed further later in this chapter, the assessment that tends to follow from this approach is not test-based.

A range of teaching resources have been developed in Australia that model a constructivist approach to what is considered to be good adult numeracy teaching practice (Marr & Helme, 1990; Goddard, Marr, & Martin, 1991). These resources are grounded in a method of teaching adult numeracy that does the following:

- Encourages and uses familiar and relevant language in the classroom
- Encourages students to work cooperatively to encourage interaction and discussion and to help them learn from each other
- Encourages enjoyment and success
- Uses practical and "hands-on" materials
- Tries to place learning in a context that students know and understand, drawing on their backgrounds, interests, and experiences
- Helps students learn through understanding, not by relying
on memorization

ASSESSMENT. To match the philosophy and approach of their RME framework, adult educators in the Netherlands developed a comprehensive assessment scheme called the Supermarket Strategy (van Groenestijn, Matthijsse, & van Amersfoort, 1992). The Supermarket Strategy is designed to evaluate not only students' success or failure in solving mathematics problems but also the strategies they use to do so. To be consistent with the RME approach, assessment items and processes consist of functional problems from everyday life that students can solve by means of their own methods. A mock advertising leaflet is used to provide a realistic stimulus for sets of supermarket-related problems. Observation of the ways in which the students solve the problems are the source of profiles of their "capabilities that combine both qualitative and quantitative elements, rather than a single summary ëstandardized score' or a ëgrade level' as often used in other countries" (van Groenestijn, 2000, p. 342).

In Australia, most assessments in ABE (for both literacy and numeracy) are based on a range of different options through which teachers create a portfolio of evidence by collecting samples of student work, recording their observations of student activities, and collecting student self-assessments or journal entries. The nature of the portfolio that is developed depends on the curriculum being followed. Neither national nor state-based tests are used. Standards are maintained and kept consistent by having teachers moderate student work with other teachers-that is, teachers from different providers meet to discuss and come to a general agreement about the proficiency scope and level of samples of student work.

On a national level, the Australian government instituted a scheme of assessment that all nationally funded programs in adult literacy or ESOL are required to use. Because the federal government runs a number of labor market programs and workplace education programs, along with migrant education programs, this scheme, called the National Reporting System (NRS), has become a major assessment tool in ABE across the country (Coates, Fitzpatrick, McKenna, & Makin, 1995). A team of adult numeracy practitioners was recruited to write the numeracy components of the NRS, and this group, working within a very tight time frame, developed an assessment scheme that attempted to support a constructivist view of numeracy education. Student performance is assessed on the basis of four criteria, which are described somewhat differently for each of the five levels of the NRS. Generally, the criteria can be described in terms of the ability to

- Identify the mathematical information and relationships in the task

- Perform the mathematics required to carry out the task
- Reflect on the effect of the use of the mathematics for the task, including interpreting results and commenting on the appropriateness of the mathematics for the circumstances
- Use informal and formal language, symbolic notation, and the conventions of mathematics needed to carry out and report on the task

These indicators are then supported in detail by such criteria as mathematical knowledge, conditions of performance, problem-solving strategies, mathematical representation, and meaning-making strategies.

The NRS has not resulted in the development of standardized tests, either for placement or for formative or summative assessment. Teachers and programs are encouraged to develop tools for assessment that are suited to the needs of their programs and students. In recent years, as use of the NRS has increased, inexperienced teachers have wanted to use students' pages of sums to assess numeracy. Doing sums does not meet the requirements of the NRS-to meet the four criteria, students need to undertake some form of problem solving that involves a range of skills (identification, communication, reflection, and so on), not just computation.

TEACHER SUPPORT AND PROFESSIONAL DEVELOPMENT. As in the United States, countries such as the United Kingdom and Australia have begun to recognize the need for adequate training and support of adult numeracy practitioners. Coben and Chanda (1997) describe the ad hoc nature of adult numeracy training in the united kingdom and list a range of reasons why this training is unpopular with practitioners: lack of experienced or qualified numeracy staff to act as leaders or mentors, lack of funding, lack of well-developed training materials-all of which reflect numeracy's somewhat second-class status in ABE when compared with literacy. The authors believe that a program for teacher training in numeracy should be developed that is based on articulated theory and research: "the accreditation framework for numeracy teachers has developed largely without benefit of research and underpinning theory. There has been no involvement of universities, which are, after all, institutions where educational research is undertaken" (p. 386). The authors go on to recommend a program for teacher training developed in Australia in 1995 by the ABE faculty at a university. Called adult numeracy teaching: making meaning in mathematics (Johnston & Tout 1995), the published program was designed to establish a link between theory, research, and practice.

Adult Numeracy Teaching (ANT) is an eighty-four-hour training program developed as a continuation of other available numeracy training programs (such as Breaking the Maths Barrier [Marr & Helme, 1991]) and as a pathway to postgraduate courses in ABE at universities. In discussing professional development courses in Australia, Tout and Marr (1997) cite the need to develop "four models of adult numeracy professional development and training. These can be described loosely under the categories (a) conference sessions and workshops, (b) short-term in-service programs, (c) long-term in-service programs, and (d) postgraduate study" (p. 149). The third and fourth of these are needed, the authors argue, because "substantial change in teaching practice requires extensive attention to teacher attitudes and hidden theories upon which their current teaching is based. Thus the need has emerged for even more substantial, theoretically based, professional development programs, which provide opportunities for participants to reflect seriously on their current practice and the inner beliefs which guide such practice" (p. 150). Out of this perceived need, the ANT course was developed. A number of universities across Australia have given ANT advanced credit status, such that completing the course makes practitioners eligible for credit toward subjects in postgraduate ABE teacher training courses.

The ANT program is designed to help practitioners develop a critical appreciation of the role mathematics plays in society and espouses a constructivist approach to teaching and learning, calling for practitioners to do some mathematics themselves. The idea that "to teach numeracy you must know how to do mathematics" (p. x) is clearly communicated.

Policy

As in the United States, adult numeracy provision in other countries is often the poor relation to literacy. In Australia, federal policy initiatives refer largely to "literacy," although somewhere in a document a clause may be added stating that literacy includes numeracy or some more minor form of numeracy, such as recognition of numbers. In other countries numeracy is often included under the label "basic skills."

All the same, numeracy is alive and well in both Australia and the Netherlands because it is now embedded in curriculum and assessment frameworks and instructional materials. One way to ensure proper acknowledgment of numeracy in policy is to involve numeracy educators in the development of curriculum frameworks, assessment schemes, and teaching materials. Once numeracy is written into such frameworks on an equal footing with literacy, students and teachers will expect numeracy education to be provided. This expectation can then lead to policy development. In Australia, for example, all ABE and adult ESOL curriculum documents now incorporate a substantial numeracy stream. Its inclusion began when a number of ABE programs made numeracy an equal partner to literacy. The NRS followed suit, and now the ESOL curriculum, which had been concerned mainly with oral communication, has been extended to include numeracy skills.

IMPLICATIONS FOR RESEARCH, PRACTICE, AND POLICY

Numeracy, not just literacy and language, should be considered a central focus of adult basic education. If this goal is to be realized, adult numeracy education must be supported by research, embraced in practice, and clearly communicated in policy at federal, state, and local levels.

As a first step toward significantly improving numeracy education for adults, those in the ABE field might consider the strategies for improving math and science education for K-12 students recommended in An Action Strategy for Improving Achievement in Mathematics and Science (U.S. Department of Education, 1998). These strategies correspond with those identified at the Conference on Adult Mathematical Literacy (Gal & Schmitt, 1994) and published in the ensuing Framework for Adult Numeracy Standards sponsored by the Adult Numeracy Network (Curry et al., 1996). From these recommendations, we emphasize the following:

- Conduct research into how adults learn mathematics.
- Improve teacher preparation.
- Create challenging and engaging curricula.
- Improve public understanding of today's mathematics.
- Coordinate federal, state, and local efforts.

This coherent list of strategies could provide a strong foundation from which the field can plan to proceed. We have used them as such to formulate our specific recommendations for improving research, practice, and policy in adult numeracy education.

Research

Research in adult numeracy in the United States is thin. We need to develop a research culture. Research should focus on issues of cognition and attempt to ask questions about both the numeracy demands of society and the ways in which adults can develop numerate thinking to meet those demands. We need to know more about how adults think mathematically, what resources they bring to bear in approaching and solving problems, and what instructional interventions support the development of adult numerate thinking. Research also needs to be conducted about adult students' inherent attitudes toward math-about math anxiety and the effect it has on students' ability to learn. Research centers such as NCSALL, NCAL, and NIFL should join with collaboratives such as the Adult Numeracy Network and Adults Learning Mathematics to develop a strategic research agenda that connects research with practice and policy. Practitioner research such as that described by Meader (2001) or that conducted by the Massachusetts ABE Math Team is a good model for moving forward in this respect. But other lines of research need to be developed as well.

There is no doubt that the research in K-12 mathematics education has much to offer ABE. Methods and findings from studies on children's and teachers' mathematical understandings published in the NCTM's Journal for Research in Mathematics Education, for example, can serve as models for research into the adult learners and their teachers. Gender studies conducted in K-12 math education are particularly relevant to adult numeracy practice because the majority of ABE students are women, as are their teachers. There are also lessons from the research into instruction that has produced the recommendations promoted by Grouws and Cebulla (2000), the functional math curriculum for schools, and the standards described by the NCTM. The outcomes of such K-12 research should be adapted and used in teaching adult numeracy.

However, it must also be acknowledged that adult numeracy educators are faced with a set of circumstances quite different from those of K-12 educators. In his preface to Perspectives on Adults Learning Mathematics, Bishop (2000) argues, for instance, that research in adult mathematics education is a much more complex endeavor than research in K-12 mathematics education. In many ways, he says, practice in the former is less circumscribed, its goals less explicit, the location and time more varied, materials and assessments less publicly available, and teachers less recognized and, by many accounts, uncertified.

These differences suggest that school mathematics' theoretical paradigms in research, practice, and policy must be carefully scrutinized for appropriateness to ABE.

Consequently, it is also important to learn from overseas research on adult numeracy. The proceedings from the annual conferences of Adults Learning Mathematics-A Research Forum (to date, seven volumes) and the recent compendia edited by Gal (2000) and Coben et al. (2000) are books that must become part of the knowledge base of U.S. practitioners and policymakers as well as researchers.

Practice

Improvements in practice will depend on improvements in teacher preparation and in curriculum, instruction, and assessment.

TEACHER PREPARATION. Adult

numeracy personnel in the united states seem to be in need of more teacher support and professional development. A large segment of ABE teachers lacks pedagogical and content knowledge adequate to teach adults mathematics. Any change in practice needs to begin by equipping ABE teachers with both pedagogical and content knowledge of numeracy as well as with good instruction techniques, instructional materials, curriculum frameworks, and assessment instruments. A range of substantial and innovative professional development and training programs can support this knowledge acquisition. These programs should be built on the broad definition of numeracy described in this chapter and on what is known from K-12 mathematics research, from fields such as ethnomathematics, and from overseas numeracy practices in these areas.

Toward these ends, ABE should consider

using some of the Australian adult numeracy teacher training materials as a basis for developing a similar range of training and professional development materials in the United States. Once these materials have been developed, state and regional adult literacy resource centers and state departments of education should provide teachers and volunteer tutors with the training, and universities should be encouraged to offer courses in adult numeracy or adult mathematics education. The creation of state and local teams of teachers who come together over a period of years to implement change in their classrooms is as important as the development of training materials. This team approach has proven to be an essential factor in making progress in this area, as is seen in the teams in New York City and Massachusetts.

CHALLENGING AND ENGAGING CURRICULUM, INSTRUCTION, AND ASSESSMENT. Another crucial aspect of improving practice is the writing of innovative curriculum. Cohesive, comprehensive curricula are needed that will provide students with opportunities for problem solving and communication and that connect with real and important issues in their lives. One good U.S. curriculum guide is a framework for adult numeracy standards (Curry et al., 1996). These curriculum standards consolidate several perspectives, mainly those supported by the NCTM, the Secretary's Commission on Achieving Necessary Skills (SCANS, 1991), and the ABE mathematics team in Massachusetts (Leonelli & Schwendeman, 1994) but also those of adult learners, numeracy teachers, and employers. The framework for adult numeracy standards is organized into seven broad themes or areas:

- Relevance and connections to real-life situations
- Problem solving, reasoning, and decision making
- Communication of mathematical ideas and processes
- Number and number sense

- Data
- Geometry: spatial sense and measurement
- Algebra: patterns and functions

The first three themes concern processes of being numerate, while the latter four cover key content areas of mathematics. This model supports the view that numeracy is about making meaning of mathematics. It should be promoted and used in more states in the development of ABE curriculum. More documentation of good practice in adult numeracy curriculum and instruction is already starting to appear through organizations such as ANN and Adults Learning Mathematics. Other, more recent articles that promote good practice in teaching numeracy (such as Ginsburg & Gal, 2000; Kloosterman et al., 2000) need to be disseminated and their recommended approaches actively promoted to teachers and instructors.

Curriculum developers should look further afield than to those materials now available commercially. They should examine the reform curriculum in K-12 that emphasizes problem solving and investigation over formulaic approaches. The EMPower Project currently in development at TERC has been funded by the National Science Foundation to do just that. Guided by the ANN framework, the project is adapting three K-12 reform curricula to ABE settings.

The field might also consider using some of the ideas behind the Australian Certificates in General Education for Adults (Kindler et al., 1996). In instruction, curriculum, and assessment, both the Netherlands and Australia have developed frameworks (for example, RME, the CGEA, and the Australian NRS) and related teaching approaches and materials that appear to be consistent with recommendations and approaches developed for U.S. K-12 math education, including ethnomathematics and functional math. It also appears that

Australia has developed a comprehensive range of numeracy teacher preparation programs (Breaking the Maths Barrier and Adult Numeracy Teaching). Although all these frameworks and approaches cannot simply be transported and directly applied to ABE in the United States, it would be worthwhile to consider how they might be adapted and utilized in developing similar schemes here.

An analysis of good adult numeracy practice overseas (for example, the activities in both the Netherlands and Australia) and in K-12 mathematics education (for example, the NCTM standards) shows that those in the best position to improve numeracy education in ABE are practitioners, especially experienced practitioners. These practitioners need to become involved in developing curriculum standards, assessment tools, training programs for other teachers, and instructional materials for students. There are signs of such activity already. The Adult Numeracy Network and citywide and statewide teams of practitioners have become involved with developing curriculum frameworks, and the EMPower Project at TERC is developing teaching materials.

Similarly, any assessment or testing systems used should be aligned with and support these new types of curriculum and instruction. Improvement in curriculum will have little effect if assessment practices conflict with teaching practices. Morale and practice can suffer, and assessment practices can end up driving instructional and materials development. Assessment practices based on NCTM approaches such as the ANN framework and on overseas adult numeracy practices, such as those in the Netherlands and Australia, should be considered. For the U.S. assessment systems now being used, such as the GED, CASAS, TABE, ABLE, and AMES, it would be useful to have numeracy practitioners and researchers work with test developers to institute strategies and resources that will support teachers in introducing good assessment practices.

Policy

Why has literacy upstaged numeracy in the language of policymaking? One obvious reason is that leadership and advocacy for ABE comes from practitioners and researchers with backgrounds in language and literacy. They are the ones who have helped their respective fields mature, developed theoretical frameworks, and conducted research to advance the body of knowledge about how adults come to acquire another language and learn to read. They are the ones who have influenced policy. Experienced numeracy practitioners and researchers-and they do exist-need to be included and supported in the development of any ABE policy.

PUBLIC UNDERSTANDING OF TODAY'S MATHEMATICS. The public needs to see the importance of numeracy-not simply mathematics-as a personal resource that can benefit the community at large. A campaign promoting the idea that all adults can and should improve their numeracy skills could be the backdrop for the involvement of ABE. Numeracy campaigns should stress the need for all adults to expand their repertoire of math skills in interpreting and manipulating numerical information and concepts. We've been a population ridden with math fear and math avoidance. A campaign to educate the public about the importance of numeracy must address these issues. ABE needs to join forces with K-12 as well as international adult numeracy experts to develop a successful public relations campaign.

COORDINATED FEDERAL, STATE, AND

LOCAL EFFORTS. Changes at the policy level often flow from the work undertaken by practitioners, as can be illustrated by the stable and established state of numeracy practices in the Netherlands, the United Kingdom, and Australia, where over a number of years practitioners successfully developed the curriculum standards, assessment tools, training programs, and instructional materials. All the strategies outlined here in the sections on research and practice, if pursued over a period of time, will eventually filter through at the policy level. But, again, experienced teachers must become involved to argue the adult numeracy case-not only with the policymakers but with their literacy and ABE, ASE, and ESOL colleagues. Other practitioners must be convinced that numeracy should be an equal and valid part of service provision. The National Council of Teachers of Mathematics, the National Science Foundation, and the U.S. Department of Education should be lobbied to launch a campaign to improve adult numeracy. In addition, the National Reporting System and the Equipped for the Future initiative should establish links with the Adult Numeracy Network and Adults Learning Mathematics-A Research Forum to open up the lines of communication between practitioners and policymakers.

Two documents have the potential to serve as unifying guides for efforts at all levels: the Adult Literacy and Lifeskills Survey's Numeracy Framework, which defines numeracy and numerate behavior, and the ANN framework, which targets the curricular areas to be developed.

CONCLUSION

Numeracy, as defined in this paper, should be viewed as part of the core skill base of any literate individual. ABE advocates need to share that view as well, and this new "language, literacy, and numeracy" perspective should be clearly articulated in federal, state, and local policy and public relations documents. Only then will policy documents and the necessary teacher training programs and curriculum and assessment practices provide a platform from which comprehensive and successful numeracy instructional programs can be developed. Without the emphasis on numeracy as a core essential skill, one that is critical for adults in society, ABE will be unable to fulfill its promise as a second chance for all the adults who choose to participate. Numeracy needs to be brought to the fore.

Notes

1. The authors make a distinction between the words real and realistic. The former refers to real adults managing real situations in the real world, whereas the latter implies adults operating within someone's simulation or approximation of the real world. A word problem from a math book about unit pricing would be an example of "realistic" math, whereas the shopper's activity while making

decisions in the supermarket would be a "real" situation.

2. Since literacy is sometimes used as a synonym for adult basic education, we include in this first grouping the body of literature about literacy programs and the practice of literacy instruction.

3. For these we drew from the Division of Adult Education and Literacy Clearinghouse Bibliography of Resource Materials 1998 because it lists the major U.S. policy and advocacy documents published from 1989 to 1998 and from other major documents published from 1998 to 2000 (for example, From the Margins to the Mainstream, EFF Content Standards).

4. For this we referred to the results of an ERIC search of the Boolean logic on keywords adult basic education and mathematics education, with the United States as the geographic source. We also consulted dissertation abstracts (1980-2000) that deal with math in U.S. ABE and GED settings, publishers' catalogs for 1999-2000 on adult education instructional and assessment materials, and a sampling of practitioner-published work on the issue of ABE/GED mathematics instruction.

5. ANN was founded in 1994 at the Conference on Adult Mathematical Literacy, sponsored by the National Center on Adult Literacy, the National Council of Teachers of Mathematics, and the U.S. Department of Education.

6. To subscribe to the Math Practitioner discussion list, send an e-mail message to majordomo@world.std.com. Type subscribe numeracy in the message area.

7. Although this number comes from participation data directly reported by ABE, ASE, and ESOL programs to federal and state government agencies, it is interesting to note its close approximation to findings from the 1999 National Household Education Survey. From this survey, it was estimated that 46 percent of the U.S. adult population, or 90 million adults, participated in some form of adult education. Adult basic education participants (ABE, GED, and ESOL) accounted for about 5 percent of adults who participate in some form of adult education. According to this report, more than 50 percent of those adults with less than a high school diploma who participate in any adult education activity reported being enrolled in ABE, GED, or ESOL (NCES, 1999).

8. In the Division of Adult Education and Literacy Clearinghouse Bibliography of Resource Materials 1998 (http://www.ed.gov/offices/OVAE/bib98.html), a list of special populations and areas of interest included adults with disabilities/special learning needs; correctional education; English as a second language (ESL); family literacy; health literacy; homeless, welfare reform; older persons; staff development; technology, volunteers, and

workplace/workforce literacy; skill standards; adult education program management; competency based
education; evaluation/assessment; GED; and life skills.

9. In the Division of Adult Education and Literacy Clearinghouse Bibliography of Resource Materials 1998, a manual search found the word math or mathematics or numeracy listed in the titles of 5 documents, whereas the term literacy was listed 213 times.

10. For more information about ethnomathematics, see Ascher, 1991; Harris, 1991; Nelson, Joseph, & William, 1993; Powell & Frankenstein, 1997.

11. For more information on ethnomathematics research with adults, see Harris, 1991, 1997, 2000; Knijnik, 1997, 2000; Nunes, Schliemann, & Carraher, 1993; and Schliemann, 1998.

12. For interpretations in terms of adult numeracy see van Groenestijn, 2000, and Matthijsse, 2000.

References

Adult Literacy and Basic Skills Unit. (1994). Basic skills research: Bibliography of research in adult literacy and basic skills. London: Author.

Advisory Council for Adult and Continuing Education. (1982). Adults' mathematical ability and performance. Leicester, UK: Author.

Ascher, M. (1991). Ethnomathematics: A multicultural view of mathematical ideas. New York: Chapman & Hall.

Barnes, M. (1988). Mathematics: A barrier for women? In B. Caine, M. de Lepervach, & E. Grosz (Eds.), Crossing boundaries. Sydney: Allen & Unwin.

Beder, H. (1999). The outcomes and impacts of adult literacy education in the United States (NCSALL Report #6.). Cambridge, MA: National Center for the Study of Adult Learning and Literacy.

Benn, R. (1997). Adults count too: Mathematics for empowerment. Leicester, UK: National Institute of Adult Continuing Education (NIACE).

Bishop, A. (1994). Cultural conflicts in mathematics education: Developing a research agenda. For the Learning of Mathematics, 14(2).

Bishop, A. (2000). Overcoming obstacles to the democratization of mathematics education. In H. Fujita (Ed.), Abstracts of plenary lectures and regular lectures, ICME 9. Japan: International Congress on Mathematical Education.

Boomer, G. (1994). From catechism to communication: Language, learning and mathematics. In D. Bell & S. Guthrie (Eds.), An integrated approach to teaching literacy and numeracy. Sydney: NSW TAFE Commission. (Original work published 1986)

Brooks, G., Giles, K., Harman, J., Kendall, S., Rees, F., & Whittaker, S. (2001). Assembling the fragments: A review of research on adult basic skills.

(Research Report No. 220). Norwich, UK: DfEE Publications.

Burton, G. M. (1993). Curriculum and evaluation standards for school mathematics. Addenda series, grades K-6: Number sense and operations. Reston, VA: National Council of Teachers of Mathematics.

Bynner, J., & Parsons, S. (1997). Does numeracy matter? Evidence from the National Child Development Study on the impact of poor numeracy on adult life. London: Basic Skills Agency.

Ciancone, T., & Tout, D. (2001). Learning outcomes: Skills or function? In K. Safford-Ramus & M. J. Schmitt (Eds.), A conversation between researchers and practitioners: Proceedings of the Seventh Annual Conference on Adults Learning Mathematics-ALM7. Cambridge, MA: National Center for the Study of Adult

Learning and Literacy.

Clinton, W. J. (1997, March 6). Preparing students to meet national standards of excellence in eighth grade math and improving math and science education. Presidential Memo for the Secretary of Education and the Director of the National Science Foundation.

Coates, S., Fitzpatrick, L., McKenna, A., & Makin, A. (1995). National Reporting System. Melbourne, Australia: Adult, Community and Further Education Board.

Coben, D. (2000). Numeracy, mathematics and adult learning practice. In I. Gal (Ed.), Adult numeracy development: Theory, research, practice. Cresskill, NJ: Hampton Press.

Coben, D., & Chanda, N. (1997). Teaching "not less than maths, but more": An overview of recent developments in adult numeracy teacher development in England, with a sidelong glance at Australia. Teacher Development, 1(3), 375-392.

Coben, D., O'Donoghue, J., & FitzSimons, G. E. (Eds.). (2000). Perspectives on adults learning mathematics: Research and practice. Dordrecht, Netherlands: Kluwer.
Cockcroft, W. H. (1982). Mathematics counts. London: HMSO.

Crowther Report. (1959). 15-18: Report of the Central Advisory Council of Education (England). Vol. 1, London: HMSO.

Curry, D., Schmitt, M. J., & Waldron, S. (1996). A framework for adult numeracy standards: The mathematical skills and abilities adults need to be equipped for the future. Boston: World Education.

Davis, R., Maher, C., & Noddings, N. (Eds.). (1990). Constructivist views on the teaching and learning of mathematics. Reston, VA: National Council of Teachers of Mathematics.

Del Grande, J. (1993). Curriculum and evaluation standards for school mathematics. Addenda series, grades K-6: Geometry and spatial sense. Reston, VA: National Council of Teachers of Mathematics.

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

Department of Education, Queensland. (1994). Literacy and numeracy strategy, 1994-98. Brisbane, Australia: Author.

Dossey, J., & Usiskin, Z. (2000). Mathematics education in the United States 2000. Reston, VA: National Council of Teachers of Mathematics.

EQUALS (1986). Get it together. Berkeley, CA: Lawrence Hall of Science, University of California.

Ernest, P. (Ed.). (1989). Mathematics teaching: The state of the art. Barcombe, UK: Falmer Press.

Ernest, P. (1998). Social constructivism as a philosophy of mathematics. Albany, NY: State University of New York Press.

FitzSimons, G. E. (Ed.). (1997). Adults returning to study mathematics: Papers from working group 18 at the 8th International Congress on Mathematical Education (ICME 8), Sevilla, Spain. Adelaide: Australian Association of Mathematics Teachers (AAMT).

Foreman, L., & Bennett, A. (1995). Visual mathematics. Salem, OR: Math Learning Center.

Forman, S. L., & Steen, L. A. (1999). Beyond eighth grade: Functional mathematics for life and work. Berkeley, CA: National Center for Research in Vocational Education, University of California.

Frankenstein, M. (1989). Relearning mathematics: A different third R-radical maths. London: Free Association Books.

Fujita, H. (Ed.). (2000). Abstracts of plenary lectures and regular lectures, ICME 9. Japan: International Congress on Mathematical Education.

Gal, I. (1993). Issues and challenges in adult numeracy. Philadelphia: National Center on Adult Literacy, University of Pennsylvania.

Gal, I. (Ed.). (2000). Adult numeracy development: Theory, research, practice. Cresskill, NJ: Hampton Press.

Gal, I., & Schmitt, M. J. (Eds.). (1994). Proceedings: Conference on Adult Mathematical Literacy. Philadelphia: National Center on Adult Literacy, University of Pennsylvania.

Gal, I., & Schuh, A. (1994). Who counts in adult literacy programs? A national survey of numeracy education. (Technical Report No. TR94-09). Philadelphia: National Center on Adult Literacy, University of Pennsylvania.

Gal, I., & Stoudt, A. (1997-98, Winter). Numeracy: Becoming literate with numbers. Adult Learning, 9(2).

Gal, I., van Groenestijn, M., Manly, M., Schmitt, M. J., & Tout, D. (1999). Numeracy conceptual framework for the international Adult Literacy and Lifeskills (ALL) Survey. Ottawa: National Center for Educational Statistics and Statistics Canada.

Gerdes, P. (1994, June). Reflections on ethnomathematics. For the Learning of Mathematics, 14(2).

Ginsburg, L., & Gal, I. (1995, October 21-24). Linking formal and informal skills: The case of percents. Paper presented at the 17th annual meeting of the North American chapter of the International Group for the Psychology of Mathematics Education, Columbus, OH.

Ginsburg, L. & Gal, I. (2000). Instructional strategies for adult numeracy education. In I. Gal (Ed.), Adult numeracy development: Theory, research, practice. Cresskill, NJ: Hampton Press.

Goddard, R., Marr, B., & Martin, J. (1991). Strength in numbers. Melbourne, Australia: Adult, Community and Further Education Board.

Gravemeijer, K.P.E. (1994). Developing realistic mathematics instruction. Utrecht, Netherlands: Freudenthal Institute.

Grouws, D. A., & Cebulla, K. J. (2000). Improving student achievement in mathematics. Brussels: International Academy of Education and International Bureau of Education.

Harris, M. (1991). Schools, mathematics and work. Basingstoke, UK: Falmer Press.

Harris, M. (1997). Common threads: Women, mathematics and work. Stoke on Trent, Staffordshire: Trentham Books.
Harris, M. (2000). Women, mathematics and work. In D. Coben,

J. O'Donoghue, & G. E. FitzSimons (Eds.), Perspectives on adults learning mathematics: Research and practice. Dordrecht, Netherlands: Kluwer.

Hatano, G. (1996). A conception of knowledge acquisition and its implication for mathematics education. In L. Steffe & P. Nesher (Eds.), Theories of mathematical learning. Mahwah, NJ: Erlbaum.

Johnston, B. (1994, Summer). Critical numeracy. FinePrint, 16(4). Melbourne, Australia: VALBEC.

Johnston, B., Baynham, M., Kelly, S., Barlow, K., & Marks, G. (1997). Numeracy in practice: Effective pedagogy in numeracy for unemployed young people. Sydney: University of Technology.

Johnston, B., & Tout, D. (1995). Adult numeracy teaching: Making meaning in mathematics. Melbourne, Australia: National Staff Development Committee.

Kindler, J., Kenrick, R., Marr, B., Tout, D., & Wignall, L. (1996). Certificates in general education for adults. Melbourne, Australia: Adult, Community and Further Education Board.

Kloosterman, P., Hassan, M. A., & Wiest, L. (2000). Building a problem-solving environment for teaching mathematics. In I. Gal (Ed.),

Adult numeracy development: Theory, research, practice. Cresskill, NJ: Hampton Press.

Knijnik, G. (1997). Mathematics education and the struggle for land in Brazil. In G. E. FitzSimons (Ed.), Adults returning to study mathematics: Papers from working group 18 at the 8th International Congress on Mathematical Education (ICME 8), Sevilla, Spain. Adelaide: Australian Association of Mathematics Teachers (AAMT).

Knijnik, G. (2000). Ethnomathematics and political struggles. In D. Coben, J. O'Donoghue, & G. E. FitzSimons (Eds.), Perspectives on adults learning mathematics: Research and practice. Dordrecht, Netherlands: Kluwer.

Lee, A., Chapman, A., & Roe, P. (1993). Report on the pedagogical relationships between adult literacy and numeracy. Canberra, Australia: Department of Employment, Education and Training.

Leonelli, E., Merson, M. W., & Schmitt, M. J. (Eds.). (1994). The ABE math standards project. Vol. 2: Implementing the Massachusetts adult basic education math standards: Our research stories. Holyoke, MA: SABES, Holyoke Community College.

Leonelli, E., & Schwendeman, R. (Eds.). (1994). The ABE math standards project. Vol. 1: The Massachusetts adult basic education math standards. Holyoke, MA: SABES, Holyoke Community College.

Lubienski, S. T. (1999). What's hot? What's not? A survey of mathematics education research 1982-1998. Paper presented at the American Education Research Association Meeting, Montreal.

Malone, J., & Taylor, P. (Eds.). (1993). Constructivist interpretations of teaching and learning mathematics. Perth, Australia: National Key Center for School Science and Mathematics, Curtin University of Technology.

Marr, B., & Helme, S. (1990). Mathematical literacy. In D. Tout & J. Kindler, Working together: New directions in adult basic education. Melbourne, Australia: Division of Further Education.

Marr, B., & Helme, S. (1991). Breaking

the maths barrier. Canberra, Australia: Department of Employment, Education and Training.

Matthijsse, W. (2000). Adult numeracy at the elementary level: Addition and subtraction up to 100. In I. Gal (Ed.), Adult numeracy development: Theory, research, practice. Cresskill, NJ: Hampton Press.

Meader, P. (2001). A teacher's transformation into teacher-researcher. In K. Safford-Ramus & M. J. Schmitt (Eds.), A conversation between researchers and practitioners: Proceedings of the Seventh Annual Conference on Adults Learning Mathematics-ALM7. Boston: National Center for the Study of Adult Learning and Literacy.

Mellin-Olsen, S. (1987). The politics of mathematics education. Reidel: Dordrecht.

Mikulecky, L. (1994). Needed skills and skill gaps: Adult numeracy demands, abilities, and instruction. In I. Gal & M. J. Schmitt (Eds.), Proceedings: Conference on Adult Mathematical Literacy. Philadelphia: National Center on Adult Literacy, University of Pennsylvania.

Mullinix, B. (1994). Exploring what counts: Mathematics instruction in adult basic education. Boston: World Education.

Murnane, R., Willet, J., & Levy, F. (1995, March). The growing importance of cognitive skills in wage determination. (Working Paper No. 50-76). Cambridge, MA: National Bureau of Economic Research.

National Center for Education Statistics (NCES). (1999).

National Household Education Survey (NHES), Adult Education Component. Available online: http://www.nces.ed.gov/surveys/nsopf. Access date: April 4, 2000.

National Council of Teachers of Mathematics (NCTM). (1989). Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (1991). Professional standards for teaching mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (1995). Assessment standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics (NCTM). (2000). Principles and standards for school mathematics. Reston, VA: Author.

National Institute for Literacy. (2000). NIFL Web site, http://www.nifl.gov. Accessed October 2001.

National Literacy Summit 2000 Steering Committee. (2000). From the margins to the mainstream: An action agenda for literacy. Washington, DC: Author. Available online: http://www.natcoalitionliteracy.org/. Accessed October 2001.

Nelson, D., Joseph, G. G., & William, J. (1993). Multicultural mathematics: Teaching mathematics from a global perspective. Oxford, UK: Oxford University Press.

Nesbit, T. (1996, Summer). What counts? Mathematics education for adults. Adult Basic Education, 6, 69-83.

Nunes, T., Schliemann, A., & Carraher,

D. (1993). Street mathematics and school mathematics. Cambridge, UK: Cambridge University Press.

Powell, A. B., & Frankenstein, M. (Eds.). (1997). Ethnomathematics: Challenging Eurocentrism in mathematics education. Albany, NY: State University of New York Press.

Safford-Ramus, K. (2000). A review and summary of research on adult mathematics education in North America (1980-2000). In Hiroshi Fujita (Ed.), Abstracts of Plenary Lectures and Regular Lectures, ICME 9. Japan: International Congress on Mathematical Education.

Schliemann, A. D. (1998). Everyday mathematics and adult mathematics education. In M. van Groenestijn and D. Coben, Eds. Mathematics as part of lifelong learning. Proceedings of the fifth international conference of "Adults

Learning Maths-A Research Forum." London: Goldsmiths College.

Schmitt, M. J. (2000, September). Developing adults' numerate thinking: Getting out from under the workbooks. Focus on Basics, 4(B).

Secada, W., Fennema, E., & Adajian, L. (Eds.). (1995). New directions for equity in mathematics education. Cambridge, UK: Cambridge University Press.

Secretary's Commission on Achieving Necessary Skills (SCANS). (1991). What work requires of schools: A SCANS report for America 2000. Washington, DC: U.S. Department of Labor.

Secretary's Commission on Achieving Necessary Skills (SCANS). (1992). Learning a living: A blueprint for high performance. Washington, DC: U.S. Department of Labor.

Stein, S. (2000). Equipped for the Future content standards: What adults need to know and be able to do in the twenty-first century. (ED Pubs document EX0099P.) Washington, DC: National Institute for Literacy.

Tobias, S. (1978). Overcoming math anxiety. New York: Norton.

Tout, D. (2000, September). A Global numeracy? Does it exist? Paper presented at "Lens on Literacy," the Australian Council for Adult Literacy National Conference, Perth, Australia.

Tout, D., & Marr, B. (1997). Changing practice: Adult numeracy professional development. In G. E. FitzSimons (Ed.), Adults returning to study mathematics: Papers from working group 18 at the 8th International Congress on Mathematical Education (ICME 8), Sevilla, Spain. Adelaide: Australian Association of

Mathematics Teachers (AAMT).

U.S. Department of Education. (1989). Report of the National Educational Goals Panel. Washington, DC: U.S. Department of Education.

U.S. Department of Education. (1997). Statistical performance tables. Washington, DC: Author.

U.S. Department of Education. (1998). An action strategy for improving achievement in mathematics and science. Washington, DC: Author.

U.S. Department of Education. (2000a). Before it's too late. A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century [The Glenn Commission Report]. Washington, DC: Author.

U.S. Department of Education. (2000b,

June). National reporting system for adult education: Implementation guidelines. Washington, DC: Author.

van Groenestijn, M. (2000). Assessment of adult students' mathematical strategies. In I. Gal (Ed.), Adult numeracy development: Theory, research, practice. Cresskill, NJ: Hampton Press.

van Groenestijn, M., Matthijsse, W., & van Amersfoort, J. (1992). Supermarktstrategie, een procedure voor niveaubepalen bij rekenen in de basiseducatie [Supermarket strategy: A procedure to determine the level of numeracy in adult basic education]. Utrecht, Netherlands: Stichting IDEE.

Walkerdine, V. (1989). Counting girls out. London: Virago Education and University of London Institute of Education.

Ward, J. E. (2000). Arkansas GED mathematics instruction: History repeating itself. In K. Safford-Ramus & M. J. Schmitt (Eds.), Proceedings of the Seventh Annual Adult Learning Mathematics Conference-ALM7. Cambridge, MA: National Center for the Study of Adult Learning and Literacy.

Willis, S. (1989). Real girls don't do math: Gender and the construction of privilege. Geelong, Australia: Deakin University Press.

Zaslavsky, C. (1994a). "Africa Counts" and ethnomathematics. In For the Learning of Mathematics, 14(2).

Zaslavsky, C. (1994b). Fear of math: How to get over it and get on with your life. New Brunswick, NJ: Rutgers University Press.

Chapter 6