

SABES Math Bulletin

●●●●●●●●●● Building Research Into Practice
●●●●●●●●●● Volume 2 , Issue 3 April, 2008

As we wrap up our summaries from the *Review of the Literature in Adult Numeracy: Research and Conceptual Issues* in this issue, we look more closely at numeracy-related professional development research. Also, we capture the final recommendations for future work in ABE numeracy research by touching on an array of topics.

Through these summaries, you will discover keys to effective professional development, assessment improvement recommendations, a range of definitions for numeracy, and much more. All of this material is shared in order to generate discussion among numeracy practitioners seeking to improve classroom practices. We also share some thoughts about the entire report on p. 5.

Finally, we include insights into the early development of number sense from the book: *How People Learn: Brain, Mind, Experience, and School*. These insights, the authors suggest, can help explain why fractions frazzle learners—a question that plagues each new generation of ABE teachers.

Feel free to download and distribute the SABES *Math Bulletin* to your colleagues. It is one way to get the numeracy improvement dialogue started. (See Math Bulletin Vol. 1 Issue 1, October 2006 to better understand why such dialogue remains imperative.)

The Review of the Literature in Adult Numeracy: Research and Conceptual Issues was commissioned by the Office of Vocational and Adult Education (OVAE) and represents the US Department of Education's first substantive effort to study adult basic numeracy education. The report was coordinated and published by the American Institutes for Research (AIR). You can access a complete version of the Review, published March 2006 in a PDF available at: http://www.air.org/projects/Adult%20Numeracy%20Lit%20Review%203-24-06%20_2_%20-%20FINAL.pdf

Reference

American Institutes for Research, (2006). *A review of the literature in adult numeracy: Research and conceptual issues*, Condelli, L., Safford-Ramus, K., Sherman, R., Coben, D. Gal, I. and Hector-Mason, A. American Institutes for Research, Washington, DC.

Inside This Issue

Addressing the Problem.....	2
Needed: Professional Development.....	3
5 Key Features of Quality PD.....	4
The Adult Numeracy Review Sums Up....	5
Improved Assessment	6
Early Development of Number.....	7
Numeracy Definitions.....	9

Looking Ahead

In the next issue we continue looking at professional development in adult numeracy education with an examination of *An Environmental Scan of Adult Numeracy Professional Development Initiatives and Practices*. We will see what programs states and organizations are offering to adult education numeracy teachers.

Addressing the Problem

One overarching theme emerged from our reporting on the *Review of Literature in Adult Numeracy*—the scantiness of research on adults’ math learning and teaching. Given the national emphasis on research-supported instruction, we at the SABES Math Bulletin remain curious about the implications for adult education, where the data to draw upon appear alarmingly scarce. We take comfort in the fact that “research” includes “professional wisdom,” according to Grover Whitehurst, Director of Institute of Education Sciences (Taylor, J., Smith, C. and Bingman, B., December 2005, *Program Administrator’s Sourcebook*, NCSALL). However, professional wisdom must be shared if it is to inform practitioners’ choices at the classroom, program, and policy levels. To encourage such sharing, SABES, in conjunction with World Education, is currently exploring the possibility of launching a national ABE math publication. This publication would offer practitioners one forum for exchanging ideas about best practices and learning from numeracy and ABE math experts. Stay tuned for more news about this publication in the coming months.

SABES Math Bulletin Editor, Tricia Donovan

The *SABES Math Bulletin* was initiated as part of the SABES Math Initiative, an intensive professional development project designed to meet three basic goals:

- To increase the competence and confidence of ABE teachers in teaching math
- To change teachers’ classroom practices in teaching math
- To encourage “all math at all levels” in ABE classrooms, drawing from, and deepening the understanding of, the Massachusetts ABE Curriculum Frameworks

Sharing research and professional literature related to math and numeracy teaching and learning seemed a natural way to supplement face to face professional development workshops designed to enhance ABE math teacher competence and confidence while changing classroom practices. The *SABES Math Bulletin* provides ABE teachers ready access to important statistical and research data, as it seeks to introduce current research, math and numeracy concepts and policies to teachers who are often too busy working with students to search out and digest such works in their entirety. By highlighting key points and connecting concepts to everyday practice, the *SABES Math Bulletin* links ABE math/numeracy teachers with the broader world of ideas in an approachable manner.



Needed: Professional Development for Adult Numeracy Teachers

Adult educators need professional development to enhance their often limited math/numeracy instructional skills and content knowledge, but they have limited opportunities to access that training. And when they do access numeracy training, they receive it from providers who often must depend on “opinion and limited experience, rather than ...research” when designing professional development experiences. (Condelli et al., 2006, p. 57)

The Review of Literature in Adult Numeracy concludes that professional development for adult numeracy teachers is crucial because “Adult education teachers appear to be especially unprepared to teach math,” (Ibid., p. 50) a situation “compounded by low teacher retention” rates; however, they maintain there is little research on the books to inform us regarding good practices for such numeracy professional development. “...The state of numeracy professional development is such that teachers who are not adequately prepared to teach adult numeracy may have some difficulty identifying good practice because of the relatively limited repertoire of information currently available.” (Ibid., p. 57). Issues outlined in the AIR report’s section on “Research in Professional Development and Adult Numeracy” cover a broad range of topics. Among the concerns surfaced by the authors, two are key:

- A lack of content-based math/numeracy professional development
- The tendency of teachers to “pivot back on traditional pedagogical techniques” which focus on rote memorization and decontextualized situations, “strategies deemed futile for adult numeracy students.” (Ibid., p. 51)

Relying on K-8 research from the National Research Council’s Mathematics Learning

Study Committee (2001), the authors further identify five kinds of knowledge needed to teach mathematics proficiently:

- Teachers must possess a deep understanding of core mathematical concepts and of the ways their students’ understanding matures. Teachers must be able to see and make connections between their knowledge and their classroom practices.
- Teachers must possess a repertoire of instructional and classroom management routines that they can implement fluently.
- Teachers must possess a strategic competence of mathematics in order to respond, on the fly, to students’ questions or statements. Professional development programs can give teachers practice in analyzing and dealing with instructional problems.
- Teachers must exercise adaptive reasoning. They must reflect frequently on topics such as the difficulties their students are encountering.
- Teachers must bear a disposition that is productive: they must view their own knowledge, practice, and learning as valuable, and they must feel confident in their own ability to learn from their students’ thinking. (Ibid., pp. 51-52)

Given the strong overlap between literacy and numeracy instruction in much of the United States, where adult education teachers often instruct on all academic topics, the Review authors also advocate that math/numeracy professional development in adult education “integrate numeracy with literacy instruction and teach in a way that is ‘relevant, contextualized and essentially linked to overall literacy,’” (Stout, 1994, p. 11) though they caution that such a mix can easily result in a weakened emphasis on numeracy education. Despite the

Continued on page 4

Needed: Professional Development...

continued from page 3

risk of decreased emphasis on numeracy, the authors do offer several ways that the two domains — literacy and numeracy — might be linked in professional development efforts.

The limited research reviewed on numeracy professional development indicated that “the model of professional development was not a factor” in the overall quality of the training. (Ibid, p. 55). What matters, according to a NCSALL study by Christine Smith et al., *How Teachers Change*, is that teachers have “access to preparation time, access to benefits as part of their adult education jobs, and a voice in decision making.” (Ibid, p. 54) In other words, what makes a huge difference are the conditions at one’s teaching ‘home’ to which one returns after a training.

The national Eisenhower Professional Development Study (2004) identified different professional development factors as important. These factors focused on the structure of successful professional development. (See side bars on 5 Key Issues of Professional Development for more details and to find a link to the SABES “Elements of Excellence in Professional Development Standards.”)

In their conclusion, the Review authors declare that “what adult numeracy professional developers need to know to facilitate the development of adult numeracy teachers has not been articulated clearly, nor has it emerged in any research.” (Ibid., p.)

Editor’s Note: As practitioners and professional developers this lack of articulation leaves us to piece together information from existing sources and to keep an eye on current developments, such as Massachusetts’ Teacher to Teacher (T2T) extended numeracy professional development program and the TIAN professional development program developed by TERC, also of Massachusetts. But keep an eye and mind open we must, because the need is great. If we want to build successful numeracy programs for adult students, we must find ways to successfully prepare teachers.

5 Key Features of Quality PD

The Eisenhower Professional Development Study (Porter et al., 2004) involved thousands of teachers and determined there are five key elements of quality professional development. ... “A major finding in the Eisenhower study is that to improve professional development, it is more important to focus on duration, collective participation, content, active learning, and coherence than on the type of development (e.g. mentoring, teacher networks, individual research project, traditional workshop or conference).” (Condelli et al., 2006, p.)

Below, we quote from the *AIR Review of the Literature in Adult Numeracy* the five key features of quality professional development (p.54):

1. **Duration** – is sustained over time (including the total number of contact hours and the span over which the activity takes place)
2. **Content Knowledge** – focuses both on content in the subject area and how students learn that content
3. **Active Learning** – promotes active learning, gives teachers opportunities for hands-on work, and includes opportunities for teachers to observe expert teachers, to link ideas learned in professional development to the teaching context, to examine and review student work, and to make presentations, lead, and write
4. **Collective Participation** – emphasizes collective participation of groups of teachers from the same school, department, or grade level
5. **Coherence** – forms part of a coherent program for teacher learning and development (e.g. consistent with teachers’ goals and aligned with state and district standards and assessments) (Porter et al., 2004)

The Adult Numeracy Review of Literature Sums Up and Looks Ahead

Authors of the *Review of the Literature in Adult Numeracy: Research and Conceptual Issues* summarize their findings on theories and definitions by noting the shift in pedagogical viewpoint from behaviorist to constructivist approaches. They explain that theories have moved from "...behaviorist theories, where the teacher is the conveyor of objective knowledge to students who absorb it to create a response, to constructivist theories ... (in which) mathematics instruction corresponds to the adoption of integrative definitions of numeracy. ..." (Ibid., p. 59) These integrative definitions cover broad territory. In fact, "Research inspired by constructivist theories has examined the role of social and cultural perspectives, personal experience and situations, affective factors and individual learning styles on how adults construct meaning about and learn mathematics." (Idem.) (See article "Nine Definitions of Numeracy" on page 9 for a sense of the range of meanings for the term.)

The researchers conclude that frameworks and standards numeracy projects "reflect integrative definitions of numeracy and principles of constructivist theories toward learning." (Idem.) However, while the frameworks and standards (from NCTM to ANN to EFF) agree "on the need for specific skills such as critical thinking and problem solving," they do not all agree on "specific content and teaching methods," according to the authors. (Ibid., pp. 59-60)

Therefore, the specific numeracy/math framework or standards followed in a state can have significant impact on the content ABE students encounter in the classroom and the ways in which they encounter it.

Instruction, Assessment, and Professional Development

Among the other conclusions the authors present in their summary:

- Few studies have used ABE students to conduct research on the effects of adult numeracy instruction. The authors reviewed the literature from 1985 to 2005 and found only 24 studies focused on instructional interventions in adult education, and many of these were "neither theory-driven or guided by any systematic approach." (Ibid., p. 60) They found five studies that examined approaches based on constructivist theories, but the findings were "inconclusive, though suggestive that cooperative and discovery learning might be effective." (Ibid., p. 60)
- Professional development is the main mechanism for advancing effective instruction, which ABE teachers especially need. They found "almost no research on the characteristics of effective professional development approaches for ABE teachers of mathematics." (Idem.) As a result, they suggest further research in three areas:
 1. Study the relationship between teachers' knowledge of mathematics and instructional effectiveness.
 2. Study the effectiveness of professional development delivery systems.
 3. Study the impact of numeracy professional development on teacher knowledge, behaviors and learner outcomes.
- "Current assessments are not aligned with the predominant instructional frameworks." (Idem.)
- The general paucity of research on adult numeracy instruction, assessment, and professional development coupled with field constraints (part-time teaching staff and non-traditional student educational paths) make progress in the field difficult.
- To move the field forward from what the researchers describe as research "guerilla warfare more than an organized victory campaign toward improving adult numeracy

Continued on page 6

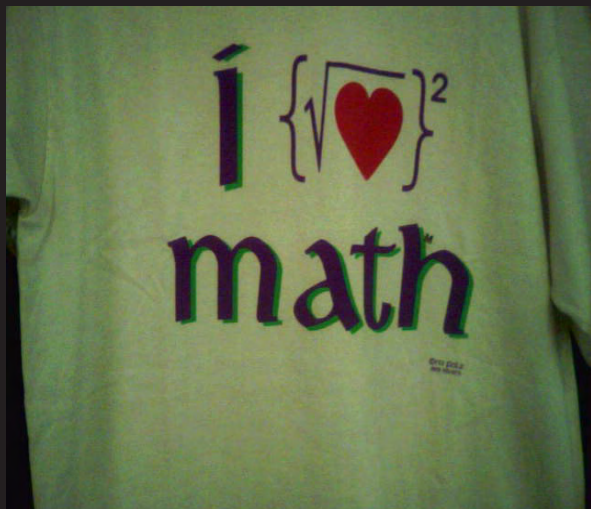
The Adult Numeracy Review...

Continued from page 5

instruction.” (Ibid. p. 61) the authors suggest research investigate five areas:

1. Evaluate instructional frameworks and theories of adult mathematics learning.
2. Identify and evaluate specific instructional practices.
3. Study how adults learn mathematics in class.
4. Explore the role of learner attitudes, affect, and experience
5. Examine ESL learners and students with learning disabilities.

Assessments can be improved through better alignment with instructional standards and frameworks. (See “Improved Assessment” article on this page bar for more detailed information.)



Improved Assessment

The following characteristics were outlined in the Review as a means of establishing a “set of high expectations regarding both the desired breadth of the curriculum and the richness of the teaching and learning process in adult numeracy education.” (Condelli, et. al, 2006, pp. 64-65) We quote the authors below:

- Offer balanced coverage of key numeracy domains: number, algebra, geometry and shape, measurement, statistics and probability.
- Provide information about learners’ problem-solving, reasoning and communication skills, as well as their understanding of connections between different mathematical and statistical ideas and their ability to explain and justify their reasoning.
- Include types of items and stimuli that provide information about ability to:
 - Provide information about learners’ ability to demonstrate confident numerate behavior in life and work contexts
 - Document beliefs, attitudes, or habits of mind that may affect both learning in class and numerate behavior outside the classroom
 - Enable teachers and programs to identify the pre-existing mathematical experiences and strategies that adults bring to the ABE classroom
 - Ensure they are appropriate for adults with special or particular learning needs
- Provide information about learners’ ability to demonstrate confident numerate behavior in life and work contexts
- Document beliefs, attitudes, or habits of mind that may affect both learning in class and numerate behavior outside the classroom
- Enable teachers and programs to identify the pre-existing mathematical experiences and strategies that adults bring to the ABE classroom
- Ensure they are appropriate for adults with special or particular learning needs.

Early Development of Number and Why Fractions Are So Challenging

Excerpt from:

Brown, A. L. and Cocking, Rodney R., Eds., "How children learn," *How People Learn: Brain, Mind, Experience and School*, Chapter 4, National Research Council, Washington DC, downloaded 2/26/08 from www.nap.edu/html/howpeople1/ch4.html

An ever-increasing body of evidence shows that the human mind is endowed with an implicit mental ability that facilitates attention to and use of representations of the number of items in a visual array, sequence of drumbeats, jumps of a toy bunny, numerical values represented in arrays, etc. For example, Starkey et al. (1990) showed 6- to 8-month-old infants a series of photographic slides of either 2- or 3-item displays. Each successive picture showed different household items, including combs, pipes, lemons, scissors, and corkscrews that varied in color, shape, size, and texture and spatial position. Half of the infants saw a series of two-item displays while the other half were shown a series of three-item displays. When they became bored, their looking times dropped by 50 percent (they habituated). At this point, they were then shown displays that alternated between two and three items, and if the displays showed a different number of items from what they had seen before, the infants began to show interest by looking again. The only common characteristic within the two-item and three-item displays was their numerical value, so one can say the infants habituated to the set of two or three things and then recovered interest when they were shown a different number of things. The infants could have focused on perceptual attributes of the items such as their shapes, motion, textural complexity, and so on, but they did not. This is an important

clue that they are able to process information that represents number at a rather abstract level.

Other researchers have shown that infants pay attention to the number of times a toy rabbit jumps up and down, so long as the number of jumping events they have to keep track of is kept between two and four jumps (Wynn, 1996). An especially interesting demonstration of infants' ability to notice abstract number information in the environment was reported by Canfield and Smith (1996). They found that 5-month-old infants used visual expectation (see previous section) to show that infants are able to distinguish three pictures presented in one location from two pictures in another.



Infants and Numbers

Young infants and toddlers also respond correctly to the effects of the arithmetic operations of adding and subtracting. Through their surprise or search reactions, young children are able to tell us when an item is added or subtracted from what they expected (Wynn, 1990, 1992a, b; Starkey, 1992). For example, 5-month-old infants first saw two objects repeatedly; then a screen covered the objects and they watched as an experimenter proceeded to add another object or remove one from the hidden display. The screen was then removed, revealing one more or one less item than before. In both the less and more conditions, infants looked longer at the numerically "incorrect" display--that is, the unexpected value that did not correspond to their initial training; if they saw one added, they expected three, not one, and

Continued on page 10

Early Development of Number...

continued from page 7

vice versa (Wynn, 1992a, b).

Experimental evidence of this kind implies a psychological process that relates the effect of adding or removing items to a numerical representation of the initial display. A similar line of evidence with preschool children indicates that very young children are actively engaged in using their implicit knowledge of number to attend to and make sense of novel examples of numerical data in their environments.

There are many other demonstrations of young children's interpreting sets of objects in terms of number. Together, the findings indicate that even young children can actively participate in their own learning and problem solving about number. This ability is why children often deal with novel conditions rather well, as when they tell puppets who are "just learning to count" if they are correct and if they are wrong or even invent counting solutions (Groen and Resnick,

1977; Siegler and Robinson, 1982; Starkey and Gelman, 1982; Sophian, 1994).

But just because children have some knowledge of numbers before they enter school is not to say that there is little need for careful learning later. Early understanding of numbers can guide their entry into school-based learning about number concepts. Successful programs based on developmental psychology already exist, notably the Right Start Program (Griffin and Case, 1997). Although making the entry levels easier, these early number concepts can also be problematic when it comes to the transitions to higher-level mathematics. Rational numbers (fractions) do not behave like whole numbers, and attempting to treat them as such leads to serious problems. It is therefore noteworthy that many children experience just these sorts of problems in mathematics when they encounter "fractions": They believe the larger number always represents a bigger quantity or larger unit.

Numeracy, Another Take

In the NCSALL (National Center for the Study of Adult Learning and Literacy) occasional paper The Components of Numeracy, authors Lynda Ginsburg, Myrna Manley, and Mary Jane Schmitt describe and analyze numeracy and the components of numeracy: context, content, and cognitive and affective.

They say of numeracy "the definitions recognize that mathematics and numeracy are related but are not synonymous. ...Pure mathematics is abstract and context-free, yet 'unlike mathematics, numeracy does not so much lead upward in an ascending pursuit of abstractions as it moves outward toward an ever richer engagement with life's diverse contexts and situations' (Orrill, 2001, p. xviii)" (Ginsburg, et. al. 2006, p. 1)

Components of Numeracy Link

www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/28/01/04.pdf

£ № Ω 7/8 ≈ ∞ ≠ √ % ‡ ∂ . € .. 1 2

Nine Definitions of Numeracy

The term 'numeracy' enjoys increasing use in adult education circles. But what do we mean by the term? The *AIR Numeracy Literature Review* listed the following definitions in its Appendix A, p. A-1. We quote here:

AAMT, 1997

Numeracy "involves using some mathematics to achieve some purpose in a particular context."

Brown, M. 2002

Numeracy is the "competence and inclination to use number concepts and skills **to solve problems** in everyday life and employment."

Coben, D. 2000

To be numerate means to be competent, confident, and comfortable with one's judgments on whether to use mathematics in a particular situation and if so, what mathematics to use, how to do it, what degree of accuracy is appropriate, and what the answer means in relation to the context.

Evans, J. 2000

The "limited proficiency" vision of numeracy prevails. Against this vision, (Evans) offers a "provisional working definition for a reconstituted idea of numeracy" as meaningful social practice: the ability to process, interpret, and communicate numerical, quantitative, spatial, statistical, even mathematical, information, in ways that are appropriate for a variety of contexts, and that will enable typical members of the culture to participate effectively in activities that they value.

Gal, I. 2000

(Gal) characterizes numeracy as a semiautonomous area at the intersection between literacy and mathematics. He describes three different types of "numeracy situations:" "generative," "interpretive," and "decision." Generative situations require people to count, quantify, compute, and otherwise calculate. Interpretive situations demand that people make sense of verbal or text-based messages that may be based on quantitative data but require no manipulation of num-

bers. Decision situations "demand that people find and consider multiple pieces of information in order to determine a course of action, typically in the presence of conflicting goals, constraints or uncertainty."

Johnston, B. & Tout, D. 1995; Yasukawa, K., Johnston B., & Yates, W. 1995

"We believe that numeracy is about making meaning in mathematics and being critical about maths. This view of numeracy is very different from numeracy just being about numbers, and it is a big step from numeracy or everyday maths that meant doing some functional maths. It is about using mathematics in all its guises – space and shape, measurement, data and statistics, algebra, and of course, number – to make sense of the real world, and using maths critically and being critical of maths itself. It acknowledges that numeracy is a social activity."

Johnston B. and Yasukawa, K. 2001

Numeracy is "the ability to situate, interpret, critique and perhaps even create mathematics in context, taking into account all mathematical as well as social and human complexities which come with that process."

O'Donoghue, J. 2003

"Numeracy and mathematics are not interchangeable terms; numeracy is seen as encompassing some elements of mathematics rather than vice versa: Mathematics and numeracy are not congruent. Nor is numeracy an accidental or automatic by-product of mathematics education at any level. When the goal is numeracy, some mathematics will be involved, but mathematical skills alone do not constitute numeracy."

McDevitt, E. 2001

"Numeracy has been defined as the kinds of math skills needed to function in everyday life – not one fixed set of skills but rather a continuum of skills that an adult draws from to meet different needs. And it's numeracy that we want for our learners, not just math."