

SABES Math Bulletin

●●●●●●●●●● Building Research Into Practice
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You might remember in the last issue of the *Math Bulletin* we zeroed in on information about research examining effective adult math teaching practices (a slim set of studies) as presented in *A Review of the Literature in Adult Numeracy: Research and Conceptual Issues*, published last year. We also promised to continue our examination of the literature review. In this issue we take a closer look at the *Review's* section on "Issues in Conceptualizing Adult Numeracy" where definitions, learning theories and affective concerns receive attention.

Does it matter how you define numeracy, what learning theories you subscribe to, or what attention you devote to affective issues in the classroom? According to the *Review* authors it matters deeply. How practitioners conceive of numeracy and what learning theories they embrace influences the problems they present to students, the type of discourse they develop in the class, and how they assess knowledge.

Speaking of discourse, we also take a brief look at research on classroom discourse that supports the development of students' mathematical communication. Throughout we include research tidbits meant to pique your thinking about the mathematics you teach and the connections you make. So welcome back to your adult math classes and programs!

We hope the information shared in these pages will trigger conversations and provoke thoughtful examination of your personal and program-wide theoretical assumptions and practices.

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Highlights from *A Review of the Literature in Adult Numeracy: Research and Conceptual Issues*

Definitions of Numeracy

Increasingly we hear the term 'numeracy,' but what do we mean by it? The AIR review of literature in adult numeracy acknowledge that "Numeracy is a deeply contested concept" with a host of related terms such as functional mathematics and math literacy used by various groups and individuals. "However, how numeracy is defined has profound implications...for what adults need to know, what should be taught, how students should be assessed, and what professional development teachers need. ... " (Condelli, et.al., 2006, p.5)

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Currently, the Integrative conception of numeracy dominates theorizing and thinking in adult numeracy fields, according to the AIR report.

Theories on Learning and Knowing Mathematics

Condelli, et. al. state that “Definition, pedagogy and instruction are ... tied together: one’s view of what numeracy is leads to a theory of learning, and this theory affects preferred approaches to instruction.” (p.11) However, they assert that “There remains controversy around the implication of theory to practice because there is little empirical research demonstrating the effects of instructional approaches implied by the theories on how adults know and learn about mathematics.” (Idem.)

In their literature review, they outline four recognized learning theories that have influenced mathematics instruction:

- Behaviorism
- Constructivist Theories of Learning
- Social-Cultural Perspectives on Mathematics
- Numeracy and Cognition: Experiences and Situations

Adoption of these four theories follows a somewhat chronological sequence.

Behaviorism ruled over math instruction for most of the 20th century. As the AIR report authors write:

In the behaviorist approach, learning is defined as a change in behavior observed when a stimulus results in a response. In behaviorist mathematics instruction, the teacher conveys knowledge ... (and) the students absorb it and produce a solution ... Learning is considered to have occurred when the correct solution is given consistently. Learning mathematics in this mode entails immediate recall, retention, and transfer, and understanding is equated with computation and operations as measured by achievement tests or performance tasks. (math is often seen as) a set of absolute truths determined by authority; doing mathematics means following the rules correctly. (11)

Since the 1990’s there has been a shift from behaviorist to constructivist perspectives. This shift “corresponds to the adoption of integrative definitions of adult numeracy.

...The keystone of constructivism is the notion that all knowledge is constructed by individuals acting upon external stimuli and assimilating new experiences by building a knowledge base or altering existing schemas. Learners actively construct knowledge by integrating new information and experiences into what they have previously come to understand, revising and reinterpreting old knowledge in order to reconcile it with the new. ... (Idem.)

Two constructivist schools are described in the report: one is led by Piaget, who focused on ways in which individual learners make sense of mathematics, and the other is led by Vygotsky, who saw learning as an activity in which shared meanings are constructed socially.

Piaget posited the theory that a child progresses intellectually from birth to adolescence, moving from the concrete level toward the formal operational level. The few studies on adults learning math that connect with Piaget’s theories “...refute, to varying degrees, Piaget’s conviction that the evolution to formal operations is complete by age 15; they also validate the use of concrete materials and manipulatives for adult students,” according to Condelli, et. al. (12)

Piaget’s theory of learning through assimilation, accommodation, and equilibrium, where new events are incorporated into students’ pre-existing cognitive structures (assimilation) or where those cognitive structures are changed because of new information (accommodation) to form schemata and where, eventually, a learner must balance his or her schemata and the environment or balance assimilation and accommodation (equilibrium) was used in one study of the problem-solving behavior of adults in Argentina with little formal education in work situations. The study highlighted the interactive and constructive nature of everyday knowledge and the social constraints that influence problem solving.

Vygotsky’s emphasis on social construction of knowledge, as opposed to individual construction,

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resulted in two development of two ideas: the Zone or Proximal Development (ZPD) which describes the distance between the actual developmental level and potential developmental level and ‘scaffolding,’ in which the student masters a skill under the guidance of an expert. The Review authors note that Vygotsky’s theories have been “referenced by advocates of cooperative learning and problem-solving activities.” (p.12)

Feminists posit that women learn mathematics differently from men (Becker 1995) and that women in a math preparation class for the building trades found it easier to learn math on the job than in a classroom setting (Crittendon, 2000).

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The authors conclude that “In constructivist epistemologies of mathematics education, mathematics education is viewed as a process whereby knowledge of mathematics is gained by doing mathematics.” (p. 13)

Socio-Cultural perspectives on mathematics hold that ideas are culturally based and

while they do not

negate the idea of universal truths in mathematics, they assert that the fact that we say a straight angle is 180° and not 100° supports the claim that math reflects cultural choices. Among the central influences on adult education from the socio-cultural camp we find ethnomathematicians and feminist scholars.

Ethnomathematicians often compare academic mathematics knowledge and local knowledge, as well analyze the power relations involved in the use of both kinds of knowledge. They discuss “whose knowledge counts.” (P. 13) One dissertation study by J. Masingila (1992) *Mathematics Practice and Apprenticeship in Carpet Laying: Suggestions for Mathematics Education*, and reported on in the *Review*, shows that “straightforward school problems did not prepare the novice carpet layers for the realities

of area, ratio and proportion, and measurement experienced on the job.” (p. 13)

Feminists posit that women learn mathematics differently from men (Becker 1995) and that women in a math preparation class for the building trades found it easier to learn math on the job than in a classroom setting (Crittendon, 2000).

The *Review* authors conclude that “Ethnomathematics and feminist approaches demonstrate that school mathematics and ‘street’ mathematics differ substantially (and) the affective environment of the traditional classroom setting can impede student learning despite the best intentioned efforts of the instructor.” (p. 14)

Cognition-based studies focused on adults learning math are rare, according to the *Review*. However, the research with children, which the authors claim is relevant for adults as well, indicates that “mathematical knowledge develops both in and out of school... and is profoundly influenced by experience and cultural practice.

...Such studies emphasize the ability of people to control and regulate their own behavior in relation to their experience in their environment, rather than react automatically to stimuli, as behaviorist psychologists predict. Adults bring this prior knowledge and life experience to the classroom and apply it to their use of mathematics in a wider range of situations. Effective instruction must be responsive to these experiences (p. 14)

A different approach to cognition, starting from the learner’s perspective, is forwarded by Iddo Gal. Gal contends that the cognitive load of mathematics stems from three types of numeracy situations that are “always embedded in the life stream with personal meaning to the individual involved:” 1) generative situations; 2) interpretive situations; and 3) decisions situations.

Simple operations, counting quantifying, computing or otherwise manipulating numbers are involved in generative situations. These situations, like how much you will need to buy

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several items, have clear right or wrong answers. Interpretive and decisions situations have no clear correct answers. Interpretive data do not always require number manipulations – one might look at a graph for instance. Decisions “require people to find an consider multiple pieces of information to determine a course of action.” Decisions not only have no clear correct answer, but may involve sacrifice of precision or accuracy “to save time or mental load when deciding on a response and may reach the response in an inefficient or nonstandard way.” (p. 16)

Affective Factors, Anxiety, and Learning Styles

Review authors examine several studies relating adult math performance and dispositional attitudes. Among the findings they report are:

Singh (1993) Found that abstraction and perceived lack of relevance are common reasons for dislike of mathematics and that fear of failure induced by instruction and testing in mathematics is a main anxiety trigger.

Tobias (1993) Found strong indications of math anxiety among adults and recommended that students need to take charge of their math learning, overcoming their history and the previous classroom cultures.

- Teachers must create environments where math anxiety is openly discussed and they must help students recognize their math strengths while providing growth opportunities within students’ zone of proximal development

- Math books are not easy reading, so teachers need to help students develop their reading skills

- Teaching styles must include methods that reflect gender and cultural differences

- Talking and writing about feelings and strategies must be part of classroom culture

Altieri (1987) found that anxiety and remembering were central learning problems for college developmental students.

Cook (1997) found a connection between anxiety level and perceptual learning style – those with audio and tactile/kinesthetic

learning styles were more likely to experience math anxiety, as were women. Age did not appear to be a factor.

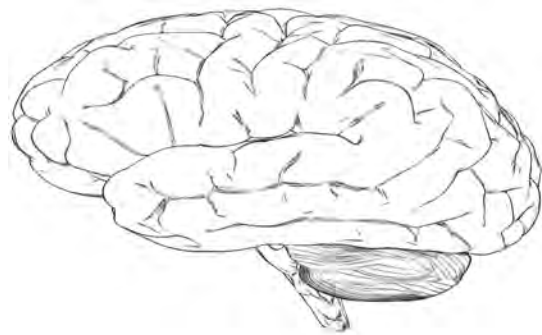
Jost (1997) found significant gender differences in computer experience, negative attitudes and higher computer anxiety in a computer assisted class of 40 students.

Peskoff (2001) found that low-anxiety math students use and value a wider variety of coping strategies than students with high math anxiety.

Brain-based research is still in its beginning stages. However, the authors report that recent research has shown that “when manipulating a number, a child does one of three actions, each involving a different region of the brain: Sees the number as a visual digit (ex. “3”) Hears or reads the number as word (ex. “three”), and Represents it as a quantity (ex. “3 is bigger than 1”).

If this is so, the authors contend, it may explain why some adults have difficulty in one or more of these areas: recognizing, manipulating, or representing numbers. It also tells us that we should not assume that an adult who can do one of these actions will be able to do the others and shows that language is deeply implicated in some, but not all arithmetical operations. (p.20)

The *Review* touched on definitions of numeracy, learning theories underpinning definitions and informing instruction/assessment, and affective domains of learning in this section.



Warning: US K-12 Math Programs Not Preparing Youth for Life

The Organization for Economic Co-operation and Development's (OECD) PISA survey (Program for International Student Assessment) 2003 study included the United States among 41 countries surveyed. The assessment covered reading, mathematical and scientific literacy, and problem solving, with a primary focus on mathematical literacy. "The United States ranked 28th ... in terms of the percentage of students at each level of proficiency on the mathematics scale in PISA 2003." (Condelli, et.al., 2006, p. 10) The assessment is given to 15 year-olds to test their 'readiness for life.'

The PISA defines mathematical literacy (numeracy) as "an individual's capacity to identify and understand the role that mathematics plays in the world, to make well founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a productive, concerned and reflective citizen." (PISA, p. 24)

This definition encompasses four domains:

1. Space and shape, which includes recognizing shapes and patterns
2. Change and relationships, which includes data analysis needed to specify relationships or translate between representations

3. Quantity, which focuses on quantitative reasoning and understanding of numerical patterns, counts and measures

4. Uncertainty, which includes statistics and probability

Everyone Does It!

We do not find all maths in all cultures. However, A. Bishop in *Mathematics Education in Its Cultural Context* identifies six cross-cultural activities:

- counting
- locating
- measuring
- designing
- explaining
- playing

Interested in the Details of the *Highlights*?

The American Institutes for Research (AIR) (2006). A review of the literature in adult numeracy: Research and conceptual issues, Office of Vocational and Adult Education, Division of Adult Education and Literacy, US Department of Education, Washington, DC, March. The full review is available online at: www.air.org/projects/

Next issue look for research review on assessment!

Student Talk = Student Understanding

A Brief Summary of "Adults' dialogic productive mathematical interactions in the classroom"

Overview

Researchers analyzed two case studies in which they observed a learning situation in which various adults worked on "the concept of proportions in a dialogic way." (Diez-Palmar, et.al., 2006, p. 97) They wanted to reveal how differences in discourse influence mathematical learning.

Research Process

The authors presented proportional problem/questions to two different groups of adult education students in Barcelona, Spain. They recorded the dialogue then examined it through several lenses in order to see the 'cognitive trajectory' or growth of understanding. In particular, they examined two different types of speech acts (Searle, 1980): perlocutionary (where a person 'convinces' or "produces an intended or unintended action or feelings"—where authority carries conviction) and illocutionary (act "performed in the saying, not explicitly intending to bring about change" – where information is simply put on the table and the receiver decides how to respond). (Ibid., p.99)

Conclusions

The researchers observed that discourse did lead to increased understanding of proportion. Most importantly: Egalitarian dialogue encourages participants' learning because they have to seek the correct arguments to justify the solutions that are proposed in the different problems. On the other hand, when the teacher directly provides the answer to the problem, without leaving room for dialogue in the classroom, adults are limited to agreeing without understanding the meaning of these reasonings.

It was also observed that egalitarian dialogue elicited the differences in meaning production for mathematics objects, in our case proportion. Such possibilities were successful because of the intentional position of introducing productive interactions, avoiding the figure of meaning being somehow worked into peoples' minds....(T)he inclusion of every voice from an egalitarian point of view contributes to breaking barriers that are encountered by adults from different cultures and education backgrounds... . p.103

Diez-Palmar, J, Giménez Rogrdiquez, J., and Garcia Wehrle, P. (2006) "Adults dialogic productive mathematical interactions in the classroom," *Connecting Voices*, Marj Horne & Beth Marr, Editors, proceedings of the Adults Learning Mathematics (ALM) 12th Annual Conference, Melbourne, July, 2005, Australian Catholic University, Melbourne, Australia

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Reading-Math Link
Numeracy is "often mediated through text." As a result, "difficulties in reading may impede numeracy development."
(Condelli, et.al., 2006, p. 10)