Components of Numeracy

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What is the nature of the components specific to adult numeracy that are inherent in numeracy practice and essential to frame a vision that can be used to inform and guide instructional practice, further research, and assessment development? That is the question Lynda Ginsburg, Myrna Manly, and Mary Jane Schmitt focused on as they considered the nature of numeracy. Their study highlights a critical area of adult education that has been largely ignored, under-funded, and under-studied. Their results can serve as a conceptual framework within which to situate research into both adult numeracy development and recommendations for instructional practices.

The term "numeracy" is used in the adult education community to include an array of mathematically related proficiencies that are evident in adults' lives and worthy of attention in adult education settings.

Pure mathematics is usually abstract and context-free. Numeracy, on the other hand, entails engagement with life's diverse contexts and situations. In some cases, being numerate is defined as being able to actively participate in civic activities. Others describe numeracy in more utilitarian terms — to function effectively in the workplace or as a family member. Numeracy requires the ability and inclination to explore situational mathematical content, thus is owned differently by each person. Unlike pure mathematics, numeracy has a distinctive personal element.

So, what does it take to be numerate? To act numerately? To acquire numeracy skills? We examined two sources of information: 1) International and US Adult Numeracy framework documents (both at the national and state levels) and 2) K-12 and Community College mathematics framework documents.

Three Components of Numeracy: Context, Cognitive, Content

Findings

We identified three components, along with their sub-components, that are intertwined to form the construct of adult numeracy:

The Context component—the uses and purposes within which mathematical activity is embedded

- **Family or Personal**—as a parent, household manager, consumer, financial and health-care decision maker, and hobbyist
- **Workplace**—as a worker able to perform tasks on the job and to be prepared to adapt to new employment demands
- **Further Learning**—as one interested in the more formal aspects of mathematics necessary for further education or training

- **Community**—as a citizen making interpretations of social situations with mathematical aspects such as the environment, crime and politics

The Cognitive and Affective component — the processes that enable proficient mathematical activity

- **Conceptual Understanding**—an integrated and functional grasp of mathematical ideas
- **Adaptive Reasoning**—the capacity to think logically about the relationships among concepts and situations
- **Strategic Competence**—the ability to formulate mathematical problems, represent them, and solve them
- **Procedural Fluency**—the ability to perform calculations efficiently and accurately by using paper and pencil procedures, mental mathematics, estimation techniques, and technological aids
- **Productive Disposition**—the beliefs, attitudes, and emotions that contribute to a person's ability and willingness to engage, use, and persevere in mathematical thinking and learning or in activities with numeracy aspects

The Content component —the essential concepts that form the basis for mathematical understanding and numeracy practice

- **Number and Operation Sense**—a sense of how numbers and operations work and how they relate to the world situations that they represent
- **Patterns, Functions and Algebra**—the ability to analyze relationships and change among quantities, generalize and represent them in different ways, and develop solution methods based on the properties of numbers, operations and equations
- **Measurement and Shape**—knowledge of the attributes of shapes, how to estimate and/or determine the measure of these attributes directly or indirectly, and how to reason spatially
- **Data, Statistics and Probability**—the ability to describe populations, deal with uncertainty, assess claims, and make decisions thoughtfully

The three components are unevenly treated in the U.S. adult education standards documents and frameworks. Computational procedures are addressed fully in most, but the Context component, the Cognitive and Affective component and other content strands often do not receive the attention they deserve. Our collective experience in adult education suggests that this neglect is mirrored in classroom practice.

Implications for Practice

Since all three components come into play during numeracy activities, they should all be part of meaningful adult numeracy learning and development. For example, instructional materials should foster real understanding of mathematical concepts, requiring students to reason and solve problems that go beyond typical exercises. And, the scope and sequence of the mathematical content should be restructured. The notion that mastery of whole numbers, fractions, decimals, and percents must precede algebra, geometry, and data analysis and statistics has been challenged by research and several of the frameworks. Therefore, teachers are challenged to devise a scope and sequence that integrates all four content strands at all levels, from Beginning ABE through transition to college, paying attention to how students' thinking develops within and across each content strand.

When possible, materials should arise from contexts wherein students use mathematics. Teachers would do well to devise a curriculum that strives to (1) begin with context and teach problem solving and procedures in service of solving real or realistic problems; (2) draw upon contexts that are important to adults and that are part of their experience and, at the same time, provide a variety of numeracy tasks that emerge from contexts that are less familiar to the learners, but are worthwhile to know.

Instructional practice should include attention to student attitudes toward mathematics and serve to develop confidence and agency to manage a real life numeracy situation. Practicing arithmetic computational procedures is a part of the process of being mathematically literate, but only one part. Take, for example, the topic of addition of fractions. At present, much class time is allotted to the procedural (e.g., finding common denominators when adding fractions). However, time and attention must be also paid to developing learners' conceptual understanding of the meaning of rational numbers, what the operation of addition means, what is a sensible answer, and how the numbers "look" with manipulatives, number lines, or diagrams.

Policy

The expanded definition of the components of numeracy developed in this paper demands that the assessments used to evaluate student progress and to review the quality of instructional programs be revised. In the revised assessments, all content strands should be included at all levels of proficiency. In addition, the test items should be constructed to evaluate the full range of cognitive aspects of numeracy.

Similarly, the broader definition of numeracy demands that professional development opportunities recognize the unique skills and knowledge that are required to teach numeracy – a deep understanding of the mathematics as well as the cognitive and affective processes involved in learning it. Additionally, staff development for numeracy should model contextualized instruction that supports meaning-making and draws out and builds upon the mathematics that is embedded in such contexts.

Implications for Further Research

Because the field of adult numeracy is young, the research base is thin. The field now requires a strategic research program to learn how numeracy develops throughout adulthood and how to foster that development. The components and subcomponents of numeracy proficiency could serve as a backdrop to explore research questions, such as:

- What are the characteristics of the various levels of proficiency in numeracy?
- How are the processes of adult learning the same or different from children's learning?
- How do prior learning experiences (both cognitive and affective aspects) affect current numeracy learning?
- What are effective classroom practices to facilitate numeracy development that addresses the components?
- How do age, gender, culture, and prior experience inform differentiated instruction?

Conclusion

When numeracy is considered as the interaction among the three components—context, cognitive and affective, and content—there can be no debate as to its value, both for an individual's full participation in today's society and for a nation's development of its democratic potential. Recognizing the critical value of numeracy carries a challenge for adult education practitioners and policymakers to take action at all levels—to expand the existing practices, frameworks, assessments, and research agenda to include the broader construct that is discussed in this paper. Incorporating context as a necessary component of numeracy challenges the field of adult education to understand where and when adults use mathematics. Acknowledging that numeracy content is more than arithmetic challenges the field to include elements from all content strands at all levels. Envisioning a confident, numerate adult challenges adult educators to develop learners' productive disposition, understanding of concepts, and ability to reason, solve problems, and carry out procedures. This vision of numeracy should revitalize instruction, making learning a more meaningful and lasting experience for adults.

About the Authors

Lynda Ginsburg is the Senior Research Associate for the National Science Foundation funded MetroMath project in the Center for Mathematics, Science and Computer Education at Rutgers University. Her own research projects focus on adult acquisition of mathematics knowledge and parent-child work on mathematics homework. Prior to this position, Lynda was Senior Researcher at the National Center on Adult Literacy (NCAL) at the University of Pennsylvania. In that capacity, she directed NCAL's activities on several adult numeracy and technology integration research and professional development projects and provided research and evaluation support for other projects. Lynda holds a Ph.D. from the University of Wisconsin, Milwaukee, in mathematics education.

Myrna Manly is an independent consultant who has conducted adult numeracy professional development activities around the country. She has experience teaching mathematics at many academic levels, most recently as a Professor of Mathematics at El Camino College. In that capacity, she developed curricula designed to adapt the foundation courses for the needs of at-risk students. She also is the author of *The GED Math Problem Solver,* a textbook that integrates all the strands of math into a coherent approach to test preparation. Myrna has been involved with the assessment of the mathematics proficiency of adults in various roles: as the Mathematics Specialist for the 1988 version of the GED test, and as a member of the numeracy team for the Adult Literacy and Lifeskills Survey (ALL).

Mary Jane Schmitt is co-principle investigator of the EMPower (Extending Math Power) Project and Project TIAN (Teachers Investigating Adult Numeracy) at TERC in Cambridge, MA. She has been in adult eduction for over 35 years, serving as mathematics teacher, coordinator, and supervisor. She has been active in helping to establish the Adult Numeracy Network. She is a recent recipient of the Kenneth J. Mattran Award from the Commission on Adult Basic Education (COABE) which annually honors an individual with a distinguished record of achievement in adult education. Her curriculum development work focuses on inquiry into the nature of adults' mathematical thinking.