Numeracy: A Challenge for Adult Education

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In adult education, we are often confronted with adults who once learned mathematics in school but who have developed insufficient skills to use mathematics efficiently in real-life situations. This problem is seen very clearly in surveys such as YALS, NALS, and IALS,[1] and PISA.[2] Although awareness of the importance of mathematics is increasing because of technological developments in western societies, numeracy has not yet received the priority it requires in educational settings. One reason for this may be that it is not yet clear what kinds of knowledge and skills are necessary to become numerate and what should be taught in school to help learners develop numerate behavior.

The first part of this paper addresses the concept of numeracy in general and the way in which it was operationalized in the Adult Literacy and Lifeskills (ALL) survey to develop items for numeracy assessment.[3] In the second part I make a few suggestions for implementation of numeracy in educational settings based on my own study of numeracy in adult basic education (van Groenestijn 2002).

What's in the Name?

The initial problem we encounter is confusion about the definitions of quantitative literacy, numeracy, and mathematical literacy. The three terms originally came from different perspectives but today have the same intention and cover almost the same areas.

The YALS, NALS, and IALS are based on three components of literacy: prose, document, and quantitative literacy. In these surveys, familiarity with numbers and quantities has been defined as part of literacy because it is often embedded in spoken words and written texts in real-life situations. In this context, the original definition of quantitative literacy was:

> The knowledge and skills required to apply arithmetic operations, either alone or sequentially, to numbers embedded in printed materials, such as balancing a checkbook, figuring out a tip, completing an order form, or determining the amount of interest on a loan from an advertisement. (OECD 1997; Dossey 1997; Houtkoop 1999)

In this original definition, quantitative literacy covered only a small part of mathematics. In *document* literacy, however, we also find some mathematical aspects that we now consider to be part of numeracy, such as reading and understanding tables, graphs, and charts and understanding and interpreting data.

As a follow-up to the IALS, the ALL project is planned for the years 2002 and 2003.[4] In the ALL study, the term "quantitative literacy" has been replaced by numeracy. An international numeracy team[5] was established to develop numeracy assessment items. The ALL numeracy team has ex-

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panded the original quantitative literacy (QL) definition to a broader concept of numeracy: "The knowledge and skills required to effectively manage the mathematical demands of diverse situations."

The word "manage" indicates that being numerate encompasses more than just knowing mathematics. It implies that to organize their lives as individuals, as workers, and as citizens, adults need to feel confident of their own mathematical capacities and be able to make effective decisions in mathematical situations in real life. The word *numeracy* was chosen for the ALL study because this concept was originally introduced as a parallel for literacy (Cockcroft 1982), whereas quantitative literacy is seen as part of literacy. Further, numeracy is more commonly used in adult education in English-speaking countries. It signals a difference from school mathematics, which often reminds adult learners of negative school experiences. Numeracy courses focus on the use of mathematics in real-life situations.

In the PISA study, a closer link was created between school mathematics and the application of mathematics in real life by introducing the concept of mathematical literacy:

> Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments, and to engage in mathematics in ways that meet the needs of that individual's current and future life as a constructive, concerned, and reflective citizen" (OECD 1999, 41; de Lange, see p. 76).

According to de Lange, "ML is less formal and more intuitive, less abstract and more contextual, less symbolic and more concrete. ML also focuses more attention and emphasis on reasoning, thinking, and interpreting as well as on other very mathematical competencies or skills" (see p. 77).

Although there are differences in wording, these definitions have a common intention. All three focus on the competencies of individuals to make sensible use in real-life situations of the mathematics they learned in school. Attention to this need is based on the alarming results of, in particular, the YALS, NALS, and IALS surveys (Dossey 1997; OECD 1997). The IALS results, for example, showed that on average about 40 percent of the adult population of the participating western countries functioned at levels 1 and 2 of the IALS quantitative literacy scale. This means that these adults have not acquired the "walking around skills we would expect of almost any citizen" (Dossey 1997). Another 40 percent of the population functioned on a medium level and only about 20 percent on the higher levels of 4 and 5. These results show clearly that quantitative literacy is of *international* concern (OECD 1997; Dossey 1997; Houtkoop 1999).

With the increasing international awareness of the importance of numeracy, the concept of quantitative literacy also has expanded. In particular, *Mathematics and Democracy: The Case for Quantitative Literacy* (Steen 2001) pioneers an effort to broaden the perspective of quantitative literacy by showing its role and influence in the changing world and its place in education. In addition, the Forum background essay "Data, Shapes, Symbols: Achieving Balance in School Mathematics" (Steen, see pp. 53–74) develops a strong link between mathematical literacy, quantitative literacy, and numeracy. Hence the three labels— quantitative literacy, numeracy, and mathematical literacy—now can be used more or less interchangeably, at least in English-speaking countries. My personal preference, however, is to use the word numeracy as a parallel to the concept of literacy.

Numeracy Assessment in the ALL Study

It is the opinion of the ALL team that numeracy itself cannot be tested; rather, "numerate behavior" can be observed. With this in mind and to create items for the numeracy assessment, the team operationalized the definition in a working form, emphasizing five facets: "Numerate behavior involves *managing* a situation or solving a problem in a real context by *responding* to mathematical *information* that is *represented* in a range of ways and requires the *activation* of a range of enabling processes and behaviors" (Gal et al. 1999).

These five facets offer the possibility to link recognizable mathematical information in real-life situations with expected required mathematical actions. This is shown in Figure 1, adapted from Gal et al. (1999). (See also Manly, Tout, van Groenestijn, and Clermont 2001; Manly and Tout 2001.)

By choosing one element from each of these five facets, we can develop a definition for specific situations, for example:

> Numerate behavior involves managing a situation or solving a problem *in everyday life* by *making an estimation with money* (*acting upon*) using information concerning *quantity and number* that is represented by *pictures and numbers in an advertisement in a door-to-door leaflet* and requires the activation of *computational and estimation skills*.

These facets make the definition applicable to almost all situations in which people have to manage a mathematical problem.

Figure 1: Numerate Behavior

Numerate behavior involves

— *managing a situation or solving a problem in a real context*
- everyday life
- work
- societal
- further learning

— *by responding*
- identifying or locating
- acting on (order/sort, count, estimate, compute, measure, model)
- interpreting
- communicating

— *to information about mathematical ideas*
- quantity and number
- dimension and shape
- pattern and relationships
- data and chance
- change

— *that is represented in a range of ways*
- objects and pictures
- numbers and symbols
- formulas
- diagrams and maps
- graphs and tables
- texts

— *and requires activation of a range of enabling knowledge, behaviors, and processes*
- mathematical knowledge and understanding
- mathematical problem-solving skills
- literacy skills
- beliefs and attitudes

The ALL team also identified five complexity factors:

1. *Problem transparency,* varying from obvious/explicit to embedded/hidden. How difficult is it to identify the mathematical problem and decide what action to take? How much literacy proficiency is required?

2. *Plausibility of distractors,* from no distractors to several distractors. How many other pieces of mathematical information are present? Is all the necessary information there?

3. *Complexity of mathematical information/data*, from concrete simple to abstract complex. How complex is the mathematical information that needs to be manipulated?

4. *Type of operation/skill,* from simple to complex. How complex is the mathematical action that is required?

5. *Expected number of operations,* from one to many. How many steps and types of steps are required?

Based on the five facets and five complexity factors, the ALL team set up a grid and developed a bank of about 120 items on five levels for the numeracy domain of the ALL survey. Each item received an individual identity. The ALL team thought that this way of working also could serve as a framework for the development of mathematical content and actions for numeracy programs in educational settings (van Groenestijn 2002).

Implementation of Numeracy in Education

For the implementation of numeracy in educational programs, however, it is not sufficient only to determine mathematical content and actions. It also is necessary to look for components that help develop numerate *behavior,* for now and in the future. In my own study of numeracy in adult basic education (van Groenestijn 2002) I started from the ALL definition but added a second part to include attention to the future:

> Numeracy encompasses the knowledge and skills required to effectively manage mathematical demands in personal, societal and work situations, in combination with the ability to accommodate and adjust flexibly to new demands in a continuously rapidly changing society that is highly dominated by quantitative information and technology (p.37).

To make this definition operational for the implementation of numeracy in educational settings, four components were identified:

- *Functional mathematical knowledge and skills,* recognizable in real-life situations;
- *Management skills* for managing mathematical situations;
- *Skills for processing new information* in out-of-school situations; and
- *Insight into one's own learning skills* to be able to keep up with new developments in the future and to acquire new mathematical knowledge and skills independently in real-life situations.

As for the first component, we can distinguish a general, basic set of mathematical knowledge and skills that everybody should have acquired and that can be the basis for further learning, in combination with an individual set of knowledge and skills required to function in specific personal, work, and social situations. Content for this mathematical component can be developed with the help of the ALL grid for numeracy items.

With respect to the second component, management skills, we can think of a broad range of skills such as:

- *Generative mathematical understanding and insight* to give meaning to and interpret numbers and to plan appropriate mathematical actions;
- *Literacy skills* to read and understand problems and to reason about them;
- *Communication skills* to be able to share problems with others, discuss information, learn from others how they would solve problems, and work cooperatively;
- *Problem-solving skills* to identify, analyze, and structure problems, plan steps for action, select appropriate actions, actually handle problems, and make decisions; and
- *Reflection skills* to be able to control the situation, check computations, evaluate decisions, and come to contextual judgments.

Such management skills often are assumed to evolve spontaneously in the course of life. We argue that it is necessary to pay explicit attention to teaching these skills in educational settings. Training enables adults to develop appropriate skills for different types of mathematical situations.

The same can be said concerning the third component, developing skills for processing new information in real-life situations. The way students learn in school differs from the way in which adults acquire and process new information in out-of-school situations, independently from teachers. Adults almost always process new information in the course of action (Greeno 1999). For this, people need to learn to:

- Read, watch, or listen to information;
- Identify key points in the information;
- Reflect on what is new (What is new to me?);
- Communicate and discuss with others;
- Reflect on possible implications for their personal life (What does it mean to me?); and
- Reflect on possible implications for society or work.

Concerning the fourth component, developing insight into one's own learning skills, we argue that in a rapidly changing and developing society, people need to have developed skills and strategies for lifelong learning to be able to accommodate and adjust flexibly to new situations in the course of life. To be able to do so, people need to have acquired insight into their own learning skills: in what way do they process information best? Where and how can they find more specific information needed for certain purposes? How can one learn from others? In everyday life situations, adults play different roles. They can be spontaneous learners, their own teachers, or teachers of others. Such learning often happens by means of learning by doing and learning in the course of action.

People need to be aware of situations in which learning takes place. In such situations, they must reflect on their own actions. To develop skills for lifelong learning, students need to have opportunities in school settings to discover their own best ways of learning. From this perspective, we identified the following points for attention:

- A general awareness of the need for lifelong learning;
- More emphasis on self-directed, autonomous, teacher-free, cooperative learning;
- More emphasis on problem-based learning environments and learning in contexts;
- Creating opportunities for learning in action;
- Creating facilities for lifelong learning and helping students learn how to benefit from them; and
- Encouraging creativity and curiosity.

For the development of numerate behavior, we argue that it is not sufficient to focus only on what mathematical knowledge and skills are necessary and should be taught in a numeracy program. We also must pay attention to the way in which they are taught. In fact, the emphasis should be on the way in which they are *learned*. Developing numerate behavior is a matter of acquiring and constructing functional knowledge and skills by solving real problems in the course of action in authentic real-life situations and learning how to reflect on this learning. The art of teaching is to create and facilitate learning environments in which such learning is possible and to guide learners in their learning activities. For life-long learning, people need to take the responsibility for their own learning in their own hands.

Conclusion

Becoming numerate is as essential as becoming literate for all citizens in all nations. The case for quantitative literacy, or numeracy, or mathematical literacy, by whatever name, therefore must be an important item on national and international policy agendas.

Achieving numeracy is a matter of learning how to *use* mathematics in real life and how to *manage* mathematical situations. "Citizens need a predisposition to look at the world through mathematical eyes" (Steen 2001, 2). This predisposition can best be acquired in real-life situations in which mathematics is functionally apparent. Hence, numeracy courses embedded in school programs must focus on problem-solving activities in which students can apply their acquired mathematical insights and skills and learn how to manage such situations. The role of teachers is mainly to encourage and reflect students' actions. Learning mathematics and becoming numerate go hand in hand and must start, in fact, in kindergarten.

Notes

1. The Young Adult Literacy Skills (YALS) study was conducted in 1986. The National Adult Literacy Survey (NALS) followed that study in 1992. The International Adult Literacy Study (IALS) in 1996, was a follow-up of the NALS. In the first phase of the IALS (1994, 1996), adults from 14 countries were tested based on methodology that combined household survey research and educational testing. A second cohort of 10 countries conducted surveys in 1998 and 1999 (the Second International Adult Literary Survey, or SIALS). In 1994 and 1996, participating countries were Canada, France, Germany, Ireland, the Netherlands, Sweden, Switzerland, and the United States; in 1996, Australia, the Flemish community in Belgium, Great Britain, New Zealand, and Northern Ireland participated. The second full round of data collection in 1998 and 1999 (SIALS) included Chile, the Czech Republic, Denmark, Finland, Hungary, Italy, Malaysia, Norway, Slovenia, and Switzerland.
2. The OECD Programme for International Student Assessment (PISA 2000) was an international assessment of 15-year-olds that looked at how well they were prepared for life beyond school and was fielded in 32 countries. Four types of skills were assessed: skills and knowledge that prepare students for life and lifelong learning, reading literacy, mathematical literacy, and science literacy.
3. The international Adult Literacy and Lifeskills (ALL) survey is the follow-up to the IALS and is planned for the years 2002 and 2003.
4. The ALL study is being organized by the National Center for Education Statistics (NCES) and Statistics Canada. Participating countries in the ALL pilot study are Argentina, Belgium, Bermuda, Bolivia, Brazil, Canada, Costa Rica, Italy, Luxembourg, Mexico, the Netherlands, Norway, Spain, Switzerland, the United States, and Venezuela.
5. The international ALL numeracy team is comprised of Yvan Clermont, Statistics Canada, Montreal, project manager; Iddo Gal, University of Haifa, Israel; Mieke van Groenestijn, Utrecht University of Professional Education, Utrecht; Myrna Manly, enjoying her retire-

ment; Mary Jane Schmitt, TERC, Cambridge, Massachusetts; and Dave Tout, Language Australia, Melbourne, Australia.

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