Functional Numeracy

Mieke van Groenestijn
Utrecht University of Professional Education,
Department of Education,
Utrecht, Netherlands

Abstract

Almost everybody is convinced of the importance of numeracy for everyday life, but almost nobody knows what exactly people need to know about mathematics to be “functional numerate”.

Nowadays, in a time that numbers play a big role in western technological societies, where almost everybody receives compulsory school education, we may wonder how it could happen that so many adults have serious problems with mathematics and cannot be mentioned “numerate”.

The results of IALS (Houtkoop, 1999) showed that about one-third of the adult population in western countries only achieved the lowest two levels of quantitative literacy, out of five levels. We may wonder how it could happen that all these adults achieve so low, though most of them received school education when they were young. The PISA study (PISA, 2000) shows a similar result: about one-third of the 15-years old youngsters score below average. Does this say something about their learning capacities, about the quality of school mathematics education or about the developments in society? What kind of mathematics do adults need in our contemporary western society to be numerate? Does school mathematics education lead to functional numeracy or to school numeracy?

In adult education we often meet adults who show partial knowledge and skills on mathematics and have developed un-sufficient skills to manage mathematical real life situations. They come to school because they have to or feel the need to learn more about mathematics. How can we help them learn what they want or need to know?

A main challenge here is: how can we organize mathematics courses in such a way that these adults experience mathematics as useful and inspire them to learn more and keep learning for the future?

Mathematics in real life

Mathematics in real life is always embedded in actual situations where people are supposed to respond to that situation in “some way”. Such may vary from just locating and identifying a number on a bus to doing complex computations in formal or informal ways. People mostly decide on the spot what to do in particular situations, often based on experiences. In many situations creative problem solving is required, including mathematical activities. It is often difficult to find out what type of school mathematics is used, but one thing is clear: the mathematics they use is “functional”.

However, in many everyday-life situations people are not challenged to think or reason mathematically or to do computations. Our technological society allows us to only do...
some counting, comparisons, some estimation, weighing, measuring, taking half of something, or a quarter, etc. But in many situations it is not necessary to act very precisely.

Many things people want to buy, for example in a supermarket, are packed in standard units that often only requires very simple counting or actions of consumers, like taking two cans of juice, one container of milk, a bag of rice, 2 packs of coffee, 3 boxes with cookies, taking pre-packed meat or cheese, and other things, weighing 4 bananas. People don’t need to bother whether they have one pound of tomatoes or 400 grams. They are packed in plastic boxes with six or four tomatoes in it, already labeled with the price on it. Cucumbers, sealed in plastic, can be bought per piece, not per kilo. The only thing people have to do in a supermarket is taking such packed items and put them in their trolleys. Sometimes people are allowed to do some weighing on the scales, push the button for the price label and stick the label on it. In the end, they pay with plastic cards at the counter.

Also, people don’t need to think about measures or conversion of measures, for example 800 grams is equal to 0.8 of one kilo, or 800 meters is equal to 0.8 km. People only “use” kilos, meters, centimeters, kilometers, liters as measures of their own. They often don’t know the interrelationship between these measures as part of the metric system. The metric system is often a big puzzle for adults. The same with percent. And since we work with the euro in the European Union we also don’t need to bother anymore about differences in currencies like Dutch guilders, Belgium francs and Austrian shillings.

Similar problems occur in work situations where a big part of the job is computer-directed. Cashiers at a cash-desk of a supermarket, for example, don’t need to think anymore about how much change they have to hand to the customer, because the cash-register shows them in the display how much to give.

On the other hand, our technological society requires us to do a lot of advanced mathematics in all kinds of high technological environments, like enlarging a print on a photo-copier, using mobile phones, reading the manual of a television, programming a video, setting an alarm clock, using internet, using timetables, processing quantitative information in news bulletins, operating all kinds of machines in work situations, using spreadsheets in work situations …….. etc.

In work situations adults often need to know more specific and more complex mathematical procedures. Whereas the consumers don’t need to know how to measure length or to determine the volume of a bottle of wine (often 0.75 liters), producers will have to be able to measure very precisely, to compute a bill without any mistakes, to do computations with percents, etc. At the work floor people are often required to know more about measurement systems, proportions including percents, doing computations with decimals.

The contradiction between the simple actions required for everyday-life situations on the one hand and the more complicated actions on the other hand is increasing. The gap between under-schooled and high-schooled adults, (often the people who find out new technological things) becomes bigger and bigger. High-schooled adults may be better able to keep up with new developments in society and to adjust flexibly to new situations.
**Definitions: differences and similarities**

In 1970 UNESCO introduced the term “functional literacy”:

“A person is functional literate who can engage in all those activities in which literacy is required for effective functioning of his/her group and community and also enabling him/her to continue to use reading, writing and calculation for his/her own use and the community’s development.” (Jones, 1997)

This definition was introduced to make clear and to emphasize the problem of illiteracy in developed countries. It shows the distinction between real illiterate adults who never went to school and adults who received school education in their youths but cannot profit from that in real-life situations and cannot maintain their literacy skills. The latter are “functional illiterate”. Consequently, they may not be capable to manage their own lives effectively. This may hamper them in their societal life.

Functional literacy was placed as a broad concept, including calculation. It indicates that the three “R”-s are inextricably bound up in real life and are the basis for effective functioning in society. Being capable to do calculations was seen as part of literacy. From 1970 important developments took place in our society. The focus moved to mathematics as a growing important part of our technological and information society.

Cockcroft (1982) was the first person who signaled the problem of “innumeracy” in his report “Mathematics Counts” and introduced the concept of “numeracy” as a parallel of literacy. He describes adult numeracy as “an ability to cope confidently with the mathematical needs of adult life”. (page 10, art. 35).

In 1986 a national survey was done between youngsters (YALS) in the United States of America. This survey was the precursor of the National Adult Literacy Survey (NALS) and the International Adult Literacy Survey (IALS). These studies basically had the intention to measure literacy skills. Therefore three scales were developed: prose, document and quantitative literacy. Quantitative literacy was seen as part of literacy and was defined as:

“the knowledge and skills required to apply arithmetic operations, either alone or sequentially, using numbers embedded in printed material” (e.g. balancing a checkbook, completing an order form). (Gal et al, 1999)

Since then “numeracy” and “quantitative literacy” have been in use in English-speaking countries, to indicate that mathematics in real life differs from school mathematics. In the nineties many programs on adult literacy started in several countries. From the beginning there was also attention for mathematics. Since many adults in adult education have no good memories of school mathematics, “numeracy” courses were started, in particular in the USA, Australia and Great Britain, to indicate “practical mathematics”. The emphasis in numeracy courses was mainly on how to use basic mathematics in real-life situations and to feel comfortable with numbers. This, in fact, reduced the broad meaning of the concept of numeracy to doing simple operations and computations with numbers and measurement.

In the Adult Literacy and Lifeskills Study (ALL), the follow-up of IALS, quantitative literacy was replaced by numeracy, used in its original broad meaning as a parallel of
literacy and focusing on numbers as they appear in various real-life situations (Cockcroft, 1982). Numeracy was defined as:

“The knowledge and skills required to effectively manage the mathematical demands of diverse situations.” (Gal et al, 1999)

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. Since numeracy of its own cannot be assessed in a survey, but only numerate behavior can be observed, the ALL Numeracy Team (Gal et al, 1999) created a working definition in order to develop items for the ALL assessment. This working definition emphasizes five facets:

“Numerate behavior involves managing a situation or solving a problem in a real context (everyday life, work, societal, further learning) by responding (identifying, interpreting, acting upon, communicating about) to mathematical information (quantity & number, dimension & shape, pattern & relationships, data & chance, change) that is represented in a range of ways (objects & pictures, numbers & symbols, diagrams & maps, graphs, tables, texts, formulae) and requires the activation of a range of enabling processes and behaviors (mathematical knowledge and understanding, mathematical problem solving skills, literacy skills, beliefs and attitudes).” (Gal et al, 1999).

This working definition can be adjusted to every individual situation. Based on this definition over hundred items on five levels were created for the ALL survey.

In the PISA study (PISA, 2000) a closer link was created between school mathematics and the application of mathematics in real life by using 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)

The accompanying description says:

“mathematical literacy is less formal, less abstract, more contextual, less symbolic, and more concrete than mathematics. It also focuses more attention and emphasis on reasoning, thinking, and interpreting as well as on other very mathematical competencies or skills”

Though numeracy and mathematical literacy have much in common, there is a difference.

For numeracy the starting point is trying to find mathematical situations in real life and to find out what mathematics people should know to be able to manage such situations. This is in particular the case in work situations where sometimes very specific mathematical knowledge is required, almost always very different from school mathematics. Such became clear in recent publications. See for example Bessot and Ridgway, (ed),(2000) and Coben, O'Donoghue, and Fitzsimons, (ed), (2000).
For mathematical literacy the starting point is the application of school mathematics in real-life situations. The basic idea of PISA is to analyze how well-prepared students are for real life when they leave school. It entails the use of mathematical knowledge and skills at several levels, ranging from performance of mathematical standard operations to mathematical thinking, insight, reasoning and communication. In fact, it measures the flexibility of students in the application of school mathematics in further learning, work, societal and individual situations.

Despite this difference it can be said that numeracy and mathematical literacy have a core intention in common: awareness of the importance of mathematics in real-life situations and improvement of mathematical actions of adults.

**Functional Numeracy**

As said, the concepts described in previous section mainly developed in English-speaking countries. This may differ from other countries. In other languages, like in French and in Norwegian, there even is no word to indicate “numeracy”. In Norway the English word “numeracy” is used. In Denmark the word ‘numeralitet” was created by Lindenskov and Wedege (2000).

In the Netherlands the concept of quantitative literacy is not known at all. Mathematical Literacy [in Dutch “Wiskundige geletterdheid”] is only used in scientific papers and situations and does not indicate “practical” use of mathematics in everyday life. It refers to capability in advanced and more complex mathematics, mathematical reasoning and communication. The concept of numeracy [in Dutch: “gecijferdheid”] is, in fact, a general goal of school mathematics education since the eighties when Realistic Mathematics Education (RME) conquered our school system and replaced traditional mathematics education. Van der Blij (1987) was the first person who discussed this subject in the context of new developments in mathematics education in the Netherlands. The starting point of RME is that mathematics is all around in real life. The objective of RME is to start from there and to result into “mathematics for life”. Mathematics courses in adult basic education, that started as an organized system in 1987, were mainly based on the RME starting points and focused on mathematics in contexts and on the practical use of mathematics in real-life situations. However, in Dutch we cannot use terms like a “numeracy course”. This does not exist in the Dutch language. Numeracy has only been used as a concept in parallel of literacy. Hence, UNESCO’s concept of “functional literacy” can easily be adapted in the concept of numeracy, namely “functional numeracy”.

Since numeracy is a general goal for school mathematics in the Netherlands nowadays, we could make a further distinction between school numeracy and functional numeracy. In general, the mathematics we learn in school is basically meant to enable students to study in further education and university. We may call it *school numeracy*. This type of mathematics may differ from the practical mathematics we need in real life situations. *Functional numeracy* is the result of mathematics education that focuses on *how to use* mathematics in real-life situations and how to keep up with new developments in society. Functional numeracy also implies the capability to adjust and adapt mathematical procedures to individual situations. Therefore students need to learn to be “creative” with the mathematics they learn in school by solving context problems.
Numeracy, a dynamic Concept

The mathematics we learn in school heavily relies on the legacy from the past. It mostly focuses on learning traditional subjects like number, measurement, geometry, algebra, doing traditional algorithms, computations with formulas, standard procedures. But to be equipped for the future, learning mathematics should prepare young learners for new mathematical situations that require new mathematical actions, even still to be invented and developed. Therefore learning mathematics in real-life contexts and doing creative problem solving in school situations is essential.

To be numerate means more than only being familiar with numbers. In the ALL definition it was stated that people need to be able to “manage mathematical situations”. However, the mathematics we use in real life may change over the years. For that reason it can be said that people also must be able to keep up with societal, economical and technological developments and to maintain and further develop their own mathematical knowledge and skills. They must have developed an open mind for further learning and for acquiring new knowledge and skills, often in an informal way through learning in practice and from experiences. It also implies some creativity in problem solving to be able to manage new situations. Therefore, we may state that numeracy is a dynamic concept. The content may change over the years. My own definition of numeracy is the following:

“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.”(van Groenestijn, 2002, p. 37)

The first part of this definition is derived from the ALL definition, the second part describes the necessity to keep up with societal and technological developments and to maintain and further develop one’s own mathematical knowledge and skills. In my study on functional numeracy I have tried to come to make this definition operational for adult education. (Van Groenestijn, 2002)

Functional Numeracy in Adult Education

In adult education we often meet adults who have acquired partial and situational mathematical knowledge and skills, misconceptions and half-forgotten procedures, often not appropriate and usable in practical situations.

Zeki for example, a 28 year old man who got eight years of school education, shows in the bus item that he does not refer his computation to the length of a bus in reality. He only transfers the number of centimeters to meters. Probably he is not capable to use the scale indication 1:150. (see figure 1)

Zebiba, a 24 year old woman with 12 years of school education, learned about scale and shows a bit of her thinking in her computation. She assumes that 1 cm is 100 meters. Thereby the length of the bus is 800 meters. She realizes that this is a bit long and deletes one zero in the answer.
Working with dimension in a two-dimensional presentation also appears to be difficult. Jing (23) got only three years of school education. She only counts the visible boxes in the front and on the side of the pile in the picture. The result is 26. She counts the three boxes on the corner two times. We may wonder whether she would also do this when she would count a real pile of boxes. However, it indicates that she is not used to working with three-dimensional constructions visualized on paper. This will have consequences for her way of learning in a school setting.

Nadia (21) learned something about cubic centimeters and meters and knows that it has something to do with 3 zeros. Probably she knows that 10x10x10 = 1000. She applies this in her computation but made some errors. She computes 4x4=8. Then she multiplies by 1000 (to make it volume), and subtracts one box (the one on the corner). Then her answer is 79000.

Here too, we may wonder if Nadia would fail counting this pile of boxes in reality.
These four adults show that school mathematics does not mean much to them. They learned something about mathematics but cannot use it in real-life tasks. They show innumeracy in these examples. Though, we still may wonder how they function in real-life situations and how they use the math they learned in school in reality. In these tasks only Zebiba shows some practical knowledge.

Nowadays there are many numeracy courses for adults all over the world, often as part of a well-planned system of adult education for lifelong learning. Such courses may differ from traditional math courses to very experimental courses in which teachers really try to teach their adult learners how to deal with everyday-life problems, for example in courses like “Mathematics on the work floor” where people learn about the mathematics they need in their own work-situation. Since numeracy in adult education has no tradition yet, many teachers look for the right content and the right way how to “teach” or “facilitate” or “help learn” adults. To not remind their learners to often negative school memories, courses may have all kinds of fancy names, like “budgeting”, “shopping”, “using math in home and garden”, “help your children with their homework”, etc. However, the content of such courses is still often based on traditional mathematics, like learning algorithms for addition and multiplication. Though, these courses all have one intention in common: it is all about how to use mathematics in real life.

Discussions about what adults should learn in a numeracy course and how to teach adult learners, are still going on. There is still little knowledge about this issue. Clear is that a numeracy course should not only focus on learning mathematics. There is more. In my publication “A Gateway to Numeracy” (van Groenestijn, 2002) I have created a framework for numeracy courses based on the four following components:
- 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
- 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

These components show that learning mathematics, the first component, is only a small part of a numeracy course. The other three components, of which often is assumed that people acquire these skills from their own, deserve as much attention. For managing a mathematical situation, for example, adults need to be able to locate a mathematical situation, identify the mathematical problem in it, analyze and structure the problem, give meaning to the problem, plan, discuss, do computations if necessary, apply contextual judgment, make decisions and reflect on their own actions in this process of problem solving.
Many adults are not aware of all these details. In my opinion it is part of a numeracy course to spend a lot of attention on problem solving. Such is based on a basic pattern of a plan-do-review process by which adults learn to systematically solve mathematical problems. This plan-do-review process also helps the learners to discover their own best way of learning by which they get grip on their own learning processes. (see Van Groenestijn, 2002, chapter 5).

For acquiring new knowledge and skills in out-of-school situations adults need to be able to read about or listen to information, identify key points in the information, reflect
on “what is new”, communicate with others and reflect on possible implications for personal life, for society or work. These are also the ingredients for the fourth component. Teachers in a numeracy course can help their learners learn how to go through this process of acquiring new knowledge and skills step by step. By this they acquire insight into their own thinking and learning. (see Van Groenestijn, chapter 5)

Last but not least: for the mathematical component we may state that a program for numeracy should anyway include:
- A basic set of general mathematical knowledge and skills everybody should have acquired and that can be the basis for further learning (could be learned in courses, classroom settings)
- A set of individual knowledge and skills required to function in specific personal, work and societal situations (could be learned in real-life situations, e.g. at work, at home, etc.)

Of course it is discussable what mathematical content should be in a basic set of general mathematical knowledge and skills in a numeracy course. Such may depend on programs planned in a well-thought system for adult education. It also depends on the level and the goal of a course. However, it is advisable to also include computations that require the use of technological aids on all levels, like using advanced measurement instruments, a calculator and computer programs, e.g. working with spreadsheets, a budgeting program or programs for specific jobs like supply administration. This way numeracy courses may help learners to discover new ways of doing math and experience that math is really useful. Together with the other three components this may lead to functional numeracy.

Conclusion

In many societal situations people are not challenged to use or to improve the mathematical knowledge and skills they have acquired in school, because they don’t need it and don’t see where the mathematics is in real-life situations. In addition, many of these people are also not encouraged to use mathematics on the job, often by technological developments. This means: “when you don’t use it … you’ll loose it.” Maybe this is the reason why the number of “functional illiterate” and “functional innumerate” people is not decreasing, but even maybe increasing.

On the other hand, people who are engaged in activities in which reading, writing and mathematics are required, are enabled to maintain and to further develop their mathematical knowledge. These are often the people who can easily adjust to new developments in society and by this, help work on further societal, economical and technological development of communities and societies. This may lead to the undesired situation that the gap between functional innumerate and functional numerate people is growing wider.

In adult numeracy education the focus should not only be on learning mathematics, but also on learning how to manage mathematical situations and on acquiring new knowledge and skills in out-of-school situations.
References:


Gal, Iddo, Mieke van Groenestijn, Myrna Manly, Mary Jane Schmitt, Dave Tout, (1999). *Numeracy Framework for the International Adult Literacy and Lifeskills Survey (ALL)* http://nces.ed.gov/surveys/all Ottawa, Canada, Statistics Canada (internal publication)

Groenestijn, Mieke van (2002). A Gateway to Numeracy; A Study of Numeracy in Adult Basic Education. Utrecht, CD-β Press, nr. 40, Netherlands


---

1 This paper was published in: Maasz, Juergen & Wolfgang Schloeglmann (2003). *Learning Mathematics to Live and Work in our World. ALM10. Proceedings of the 10th International Conference on Adults Learning Mathematics (ALM) in Strobl (Austria).*

2 Parts of this section are derived from “A Gateway to Numeracy”, Van Groenestijn, 2002, chapter 2.

3 The three “R”-s in English are Reading, Writing and Arithmetic.