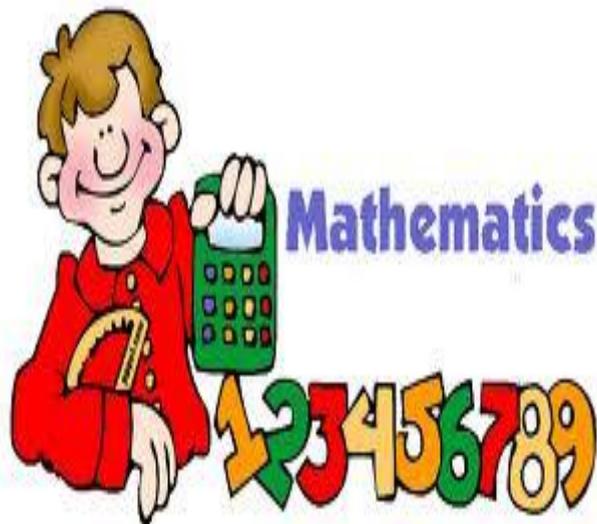


NUMERACY
SEAMEO QITEP in Mathematics
Yogyakarta, 8 - 9 October 2013



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Numeracy

A. What is numeracy?

Numeracy means different things to different people. Some see numeracy as the foundation of mathematics, the concepts learnt in school and necessary for understanding more advanced mathematics. Some see numeracy purely as the ability to perform simple number calculations - a subset therefore of wider mathematics. Others define numeracy in terms of its purpose or its function: numeracy skills are those you need to do a job, for example: using spreadsheets, calculating invoices; or to be an engaged citizen, for example: making sense of statistics reported in the media (Evans, 2000). In this section I will describe that numeracy is multiple layered arithmetic that requires the ability to integrate math, situated and contextual problem solving, and communication skills.

The term numeracy was created in 1959 by a committee on education in the United Kingdom which said that 'numeracy' should 'represent the mirror image of literacy'. Just as the early definitions of literacy have progressed from 'reading and writing', numeracy is more than 'numbers and measurements'. In the eighties, the British Cockcroft Committee developed a definition of numeracy. It stated that a numerate person should understand some of the ways mathematics can be used for communication, and this required the possession of two attributes:

1. being 'at-ease' with all those aspects of mathematics that enable a person to cope with the practical demands of everyday life
2. the ability to understand information presented in mathematical terms.

According to the British Cockcroft Committee numeracy involves the functional, social, and cultural dimensions of mathematics. Numeracy is the set of math skills needed for one's daily functioning in the home, the workplace, and the community. Beyond daily living skills, numeracy is now being defined as the mathematical knowledge that empowers citizens for life in their particular society (Westwood & Peter, 2008).

Such a definition is limiting as it does not take into consideration spatial perception, symbolic reasoning, or graphical representation. In order for today's students to be prepared to succeed as productive members of a society that is profoundly influenced by technology and mathematics it is essential that they have some

competence in the area of mathematics. Hughes, Desforjes, Mitchell, & Carre (2000) consider numeracy as more about the ability to use and apply rather than just knowing.

The term numeracy is understood in many ways. Regardless of the source and difference, however, there exists a common theme in all the definitions, namely, the ability to think in quantitative terms in order to complete tasks, and the inclination to solve problems using number in context. Numeracy is therefore more accurately measured by looking at what people actually do with numbers in their daily lives than by assessing their mathematical ability. Simply put, numeracy is “math in action”.

Everyone needs to be numerate to maximise their life chances and to make a positive contribution to society. The effect of poor numeracy on people’s lives is often much less obvious than poor literacy. But there is substantial evidence that low numeracy skills are associated with poor outcomes for many people. This has a negative impact on them and their families – and on society as a whole.

B. Numeracy Across the Curriculum

NCTM released the *Principles and Standards for School Mathematics in 2000*. The Standards describe what mathematics instruction should enable students to know and do. According to the *Principles and Standards for School Mathematics*, mathematics is one of the greatest cultural and intellectual achievements of human kind, and citizens should develop an appreciation and understanding of that great achievement, including its aesthetic and even recreational aspects” (p. 4). The NCTM 2000 document advocates a broader and more meaningful mathematics curriculum that is responsive to changing societal priorities and to changes in instructional practice that meet the needs of a far greater proportion of the student population than has been true in the past.

They specify the understanding, knowledge, and skills that students should acquire from pre-kindergarten through grade 12. These Standards are divided into two groups titled Content and Process. The five Content Standards (Number and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability) explicitly describe the curriculum or the content students should learn in their mathematics classes. The five Process Standards (Problem Solving, Reasoning and Proof, Communication, Connections, and Representation) are interwoven throughout the curriculum to provide a context for learning and teaching mathematical knowledge.

The NCTM *Principles and Standards* calls for a common foundation where students are able to understand and use Mathematics:

- For life
- As part of a cultural heritage
- For the workplace
- For the scientific and technical community

Furthermore, partnerships need to be developed with families, other caregivers, and community members to promote numeracy and change societal attitudes towards mathematics to reflect the fact that mathematics is inherent in everyday living and it enables us to solve a variety of situated and contextual problems. NCTM's equity principle states that "equity does not mean that every student should receive identical instruction: instead, it demands that reasonable and appropriate accommodations be made as needed to promote and access attainment for all students" (NCTM, 2000, p. 12).

C. How are number concepts develop?

We form concepts as a result of engaging in, and interpreting, a variety of learning experiences. New information is assimilated and linked with prior knowledge as we categorise and make sense of our environment.

– The theories of Piaget, a developmental perspective:

Piaget's observations on children's cognitive development at various stages have greatly influenced our views on developmentally appropriate practice. His notion of 'schema' helps us understand how new learning is linked with prior knowledge and how concepts are formed.

– The contributions of Lev Vygotsky:

His contributions are the zone of proximal development that means the importance of scaffolding children's learning and learning as a social activity.

– Bruner's views on learning:

Learners must be actively involved in the learning process. Most learning progresses from concrete to abstract.

We owe much of our understanding of how children develop number concepts from the work of the late Jean Piaget (1942; 1983). Piaget's theory of cognitive development was derived from his close observation of children (mainly his own children) as they engaged in various tasks, including many involving quantitative and

spatial relationships. Piaget argued that children must continually construct and modify their own understanding of phenomena through their own actions and reflection. In Piaget's theory, children's active exploration of their environment, coupled with their increasing physical and neurological maturation, play the most important role in influencing conceptual development.

Bruner (1960; 1966) was instrumental in raising educators' awareness of the important role that learners themselves must play in constructing knowledge. In the domain of mathematics for example, he stressed the need for students to think mathematically for themselves instead of having a deconstructed and decontextualised version of mathematics presented formally to them by the teacher and textbook. However, Bruner sees the role of the teacher to be more than simply a facilitator. Children do need opportunities to explore and discover on their own but they also need to interact positively with more knowledgeable adults and peers who can support their efforts, challenge them, and assist them in interpreting and assimilating new discoveries.

It is believed that some children begin to experience difficulty in learning mathematics because they have been taken too quickly from the concrete stage to the abstract symbolic level of recording. A gap is created in children's understanding if they are forced to operate too soon with symbols and mathematical notation. The use of structural apparatus such as Dienes MAB, Cuisenaire Rods, or Unifix can help bridge this gap by providing a visual link between real objects and the symbols that can eventually represent them.

Bruner's views are not incompatible with those of Piaget; but like Vygotsky, he is much less concerned with issues such as readiness and maturation. Instead, Bruner supports the view that young children can be taught many things if the quality of instruction is good and the teaching follows the sequence of concrete, through the semi-concrete, to the abstract levels. His claim is that any subject can be taught effectively in some intellectually honest form to a child of any stage of development – if the method is right. More recently, there is an argument againsts denying some students a right to a challenging and interesting maths curriculum because of poor ability, has echoed Bruner's view, stating, 'It is possible to engage nearly all students in some form of abstract and conceptual understanding.'

D. Assessing Numeracy Skill

Assessment enables teachers to modify their numeracy program when teachers have precise information about students' current knowledge and skills they can match their instruction and learning tasks more accurately to students' ability. In order to monitor the development of numeracy in an individual student, in a whole class of students, or in all schools across an education system, it is necessary to conduct regular assessments. These assessments take many forms, ranging from the informal minute-by-minute observations that a teacher makes while conducting a lesson, through to large-scale testing projects such as the national assessment program.

It has become popular to identify three main purposes of assessment in schools and else where as assessment for learning, assessment as learning, and assessment of learning :

1. Assessment *for learning* refers to using assessment data to improve the teaching program by finding out exactly what students know, where they are having difficulty, and how best to support their development. This form of assessment guides a teacher's decision making and leads to action that will enhance learning.
2. Assessment *as learning* refers to assessment that causes students to monitor their own performance and think more deeply about their own learning needs. It causes them to examine more closely their thinking processes and strategies as they endeavour to construct knowledge and reflect upon their results. Students become more effective learners if they can self-assess and identify their own learning strengths, weaknesses and needs.
3. Assessment *of learning* refers mainly to assessment of students' overall achievement relative to the goals, objectives or standards for the curriculum.

E. Numeracy for Upper Grades

Here are some of the skills that should be owned by students in upper grades level:

- Integers
- Fractions
- Percentages
- Decimals
- Proportions

- Approximations
- Rounding off numbers

Understanding Integers

The main number systems of arithmetic are (a) the *whole numbers*, (b) the *integers* (i.e., the positive whole numbers, their negative counterparts, and zero), and (c) the *rational numbers*—positive and negative ratios of whole numbers, except for those ratios of a whole number and zero. Thinking in terms of number systems helps one clarify the basic ideas involved in arithmetic.

Understanding Fractions

Fractions provide one of the biggest challenges for many children (and adults!) in understanding mathematics. Often the problem is a lack of understanding of the fraction notation (people commonly interchange $\frac{1}{3}$ and $\frac{3}{4}$) or not recognising the relative values of fractions (some consider that because 4 is greater than 3, so $\frac{1}{4}$ is greater than $\frac{1}{3}$).

In terms of representations, it is reported that although diagrams sometimes help with the solution of fractions problems or were used as a checking procedure, the actual process that children used with diagrams did not necessarily support conceptual understanding.

Calculating with fractions is also outside the intuitive thinking of many – multiplying fractions turns on its head the common view that multiplying makes numbers bigger, also the rules for adding fractions are regularly forgotten, so learners resort to adding both numerator and denominator.

Division is the most challenging of operations with fractions (Ma, 1999). Errors made in division of fractions have been classified as falling into three broad categories. Pupils make algorithmically based errors (with mistakes made in the computation process); intuitively based errors due to misconceptions associated with division; and errors based on formal knowledge about the nature of fractions. In terms of algorithmic errors, the most common ‘bugs’ include inverting the dividend instead of the divisor or inverting both (i.e. applying the rule ‘turn upside down and multiply’, but not remembering what to turn upside down).

Understanding Percentages

With percentages, things are a little more straightforward because a percentage is easily converted to a fraction with a denominator of 100 (a power of 10 already). Therefore, the decimal 0.175 is $\frac{175}{1000}$ or $\frac{17.5}{100}$ if we divide top and bottom by ten. Therefore, 0.175 is 17.5%. Going the other way from percentages to decimals, 12.5%, for example, is $\frac{12.5}{100}$ or $\frac{125}{1000}$ which is 0.125.

Understanding Decimals

The first challenge pupils have is with recognizing decimal numbers. A number of researchers have noted that pupils are confused by the range of symbols in mathematics. Students similarly confuse fractions and decimals identifying 1.5 as being the same as $\frac{1}{5}$. The observation of this inappropriate ‘conversion’ between decimals, argued that the main reason for this is that pupils struggle to make sense of the decimal point.

When asked to order decimals, two main patterns of error occur which can be broadly identified as ‘longer is larger’, where the more decimal places there are the larger the number is thought of (so 0.325 is identified as larger than 0.48), and ‘shorter is larger’ where the fewer the number of decimal places the larger the number is believed to be (so 0.6 is identified as larger than 0.75). The ‘longer is larger’ misconception is more prevalent, but declines with age. The ‘shorter is larger’ is rarer, but more persistent.

Understanding Proportions

Proportions in upper grades involve reasoning and calculating with direct proportions. It is important that students recognize situations where proportions are being used. Calculating with proportions often has the aim of making situations comparable. In this respect they are closely related to fractions, percentages and decimals in a more specific way. Proportions are everywhere and students already have a lot experience with proportions by the time they reach the upper grades of primary school, although the assignments in this earlier years usually did not call them ‘proportions’.

Understanding Approximations

Approximations are a process that is used constantly by mathematically capable adults, and that can be mastered easily by children. It involves an educated guess about a quantity or a measure, or an intelligent prediction of the outcome of a computation. The growing use of calculators makes it more important than ever that students know when a computed answer is reasonable; the best way to make that decision is through estimation. Equally important is an awareness of the many situations in which an approximate answer is as good as, or even preferable to, an exact answer.

Understanding Rounding Off Numbers

Measurement results obtained from measuring tools are not always written as what is read on the gauge. By type, there are three possible rounding off: lower rounding off, upper rounding off and closest rounding off. According to the value of the place referred to, there are many kinds of rounding off are possible, three of which are: rounding off to the closest ones, rounding off to the closest tens and rounding off to the closest hundreds. When asked to round to the closest ones - your rounding digit is the first number to the left (one's place). When asked to round to the closest tens - your rounding digit is the second number to the left (ten's place). When asked to round to the closest hundreds - your rounding digit is the third number to the left (hundred's place), etc.

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