

# **Sophisticated Numeracy Learning Materials \*)**

Kees Hoogland

*APS - National Center for School Improvement, Utrecht, the Netherlands*

[K.Hoogland@aps.nl](mailto:K.Hoogland@aps.nl)

\*) This paper is under construction

## **Introduction**

Connecting mathematics to the real world is often seen as a motivational tool to make mathematics more meaningful and mathematics education more enjoyable.

In other cases connecting to the real world is seen as an explicit goal of mathematics education. Not for motivational reasons, not to learn the mathematics from it, but to learn to use the mathematics in real life situations or to cope with quantitative aspects of the world around us. If this explicitly is the case one speaks of numeracy or mathematical literacy.

Concepts of numeracy (education) can be arranged along a continuum of increasing levels of sophistication. According to a review of AIR (2006) all of the most recent influential approaches to defining numeracy fall into the so called integrative phase of this continuum. In this phase numeracy is viewed as a complex multifaceted and sophisticated construct, incorporating the mathematics, communications, cultural, social, emotional and personal aspects of each individual in context.

A closer look however at lesson or test materials used in many different countries reveals that most materials consist of word problems or of exercises with formal arithmetic skills. One could say that the sophistication of the concepts runs way ahead of the sophistication of the learning and testing materials.

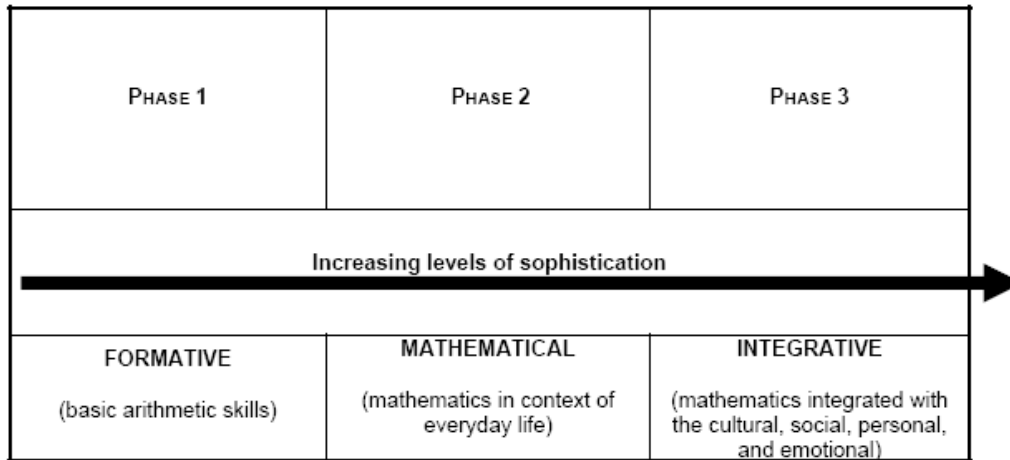
In this era of technological and multimedia possibilities a next step can and should be made to bring real quantitative problems – problems as individuals face them - into learning materials.

The new developed web based multimedia learning materials, presented at this conference, use real life situations in a multimedia environment to close as much as possible the gap between the educational setting and the real life use of numeracy.

## **Some background from research**

For creating the web based multimedia learning materials for numeracy we relied mostly on two sources. One theoretical source and one empirical source. The theoretical source is the framework of numeracy concepts, mentioned above, that is developed by O'Donoghue and Maguire (2002).

### Adult Numeracy Concept Continuum of Development



A continuum of development of the concept of numeracy showing increased level of sophistication from left to right (from Maguire & O'Donoghue, 2002)

Figure 1. Adult Numeracy Concept Continuum of Development

The different phases are described to more extent in the report “*A review of the literature in adult numeracy: research and conceptual issues.*” of the American Institute for Research (2006). In this paper this is summarised. In the *formative phase* the view is dominant that numeracy is a basic skill normally acquired in childhood; in some versions of numeracy, what adults are deemed to need is simple arithmetic. In the *mathematical phase* the view is dominant that “numerate” implies the possession of two attributes. The first of these is “at-homeness” with numbers and an ability to make use of mathematical skills, which enable an individual to cope with the practical mathematical demands of his everyday life. The second is ability to have some appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease. All of the most recent, influential approaches to defining numeracy fall into the *integrative phase*. In this phase, numeracy is viewed as a complex, multifaceted, and sophisticated construct, incorporating the mathematics, communication, cultural, social, emotional, and personal aspects of each individual in context. In this view being numerate is more than being able to manipulate numbers, or even being able to succeed in school or university mathematics. Numeracy is a critical awareness, which builds bridges between mathematics and the real world, with all its diversity. In this sense there is no particular level of mathematics associated with it: it is as important for an engineer to be numerate as it is for a primary school child, a parent, a car driver or gardener. The different contexts will require different mathematics to be activated and engaged in (AIR, 2006, p7).

The report concludes (AIR, 2006, p8) : Although integrative conceptions of adult numeracy dominate almost all current theorizing and thinking in adult numeracy, this view has only just begun to move beyond a limited core of numeracy researchers and practitioners. Most mainstream practice continues to reflect formative and mathematical approaches to numeracy.

The empirical source for the developing of the web based multimedia learning tool is the research carried out in the Netherlands with weak young adult learners (Hoogland,

2005). In this research we studied how young adults actually acted in quantitative situations.

In two cycles students were interviewed about products they had made in the job-oriented parts of their study. In these, they design and construct products in a way that is closely related to their future jobs. For example, they constructed a bicycle trailer for a surfboard, garden lights for a company, spotlights for the school, waste bins for the school shop, tomato soup for the school lunch, a rectangular flower bed, and so on. After finishing or almost finishing their products, they were asked to come and say something about the way they had designed and manufactured the product. The product was always at hand. The interviews were just general and inquisitive. When numeracy aspects arose, follow up questions were asked.

The results of the video's were

- When the artefact or device is at hand the students are involved in considerably more numeracy incidents than when the artefact is not at hand.
- When the artefact or device is at hand the students show more usage of gestures to support their numerate thinking than when the artefact or device is not at hand.
- The students use everyday language to describe mathematical concepts. They use quite a lot of non-distinct descriptions: 'what-d'you-call-it', 'something-like-that'. These non-distinct descriptions are much more prevalent than the use of mathematical language that could be relevant in the situation.
- Relevant technical language is used quite regularly; much more regularly than the use of relevant mathematical language.

This led to the following conclusions:

- The quality of the numeracy incidents is much higher for the students when they have an artefact or device at hand than when the product is not available.
- Respondents use gestures to support their numerate thinking. They use them more when a product is at hand.
- Students use a very limited mathematical vocabulary in numeracy incidents.
- Students regularly use technical language in numeracy incidents.

These conclusions are very important in combination. Without the artefact or device there is hardly any opportunity for gesture, and for these students that means that their opportunity to show their numerate thinking is very limited. These conclusions offer also a possible explanation for why these students score so poorly on written tests. Showing their numeracy thinking in writing only is a very limiting setting for these students.

### **Beyond Word Problems**

The results of the research and the conceptual frameworks is worked out into a set of criteria and examples for designing numerate problems that a much more sophisticated than the regular contextual word problems.

This is addressed in more detail in an upcoming publication *Beyond Word Problems* (Hoogland, 2009, in press)

### **Web based multimedia learning material**

Based on the research described, in 2007 and 2008 a web-based multimedia learning tools is developed. It deals with the basics in arithmetic, and numeracy concepts such

as the meaning of numbers, interpreting and deciding, division and dividing, area and volume, percentages and ratios.

The design principles for the learning tools were derived from the earlier mentioned research. These design principles are:

- Every problem posed must be directly related to a real situation, presented in photos or short video clips. Situations and contexts are not presented completely or mainly in text.
- Necessary information on the situation is presented in written and spoken (voiceover) text.
- Every question posed on the situation must be able to be conceived of by the student as a real and relevant question.
- Answering the questions posed demands some numerate thinking.
- The build-up is in the complexity of the situations and not in the complexity of the mathematical concepts.

On the basis of these design principles, the tools were developed in the spring of 2007. The first trials were conducted with three groups of students. Preliminary results seem to indicate that the students get absorbed by the material and focus on the numeracy and the posed problem, sometimes for more than an hour at a time.

Starting in September 2009, the material will be used on a larger scale by a few thousand students. In the summer of 2010 after a year of full use in a regular setting by a few thousand students more insight can be given on the effects of the material and the learning results of the students.

A demo of the material can be found on: [www.gecijferd.nl](http://www.gecijferd.nl) → demo's

### **Some more details of the material**

There is a complete feedback system behind every question that helps the student after he makes a mistake. This feedback is differentiating between plain wrong answers and understandable mistakes. The feedback is adaptive in that sense.

Both the time spent on the material by the students as well as all the keyboard inputs of the students are recorded and can be given as feedback to the assigned teacher or tutor. Every student can be connected to a teacher or tutor. The teacher or tutor has insight in the number of questions right or wrong by each of his/her students.

For designers the following technical specifications can be interesting.

It is a web based product and can be used with a variety of internet browsers like Internet Explorer, Firefox and Chrome. It is SCORM compliant. It works with licenses to get access to a personal surrounding (called Coach). All data handling and storage and history keeping takes place on the server of the manufacturer. This data collection will be used to improve the material in coming years.

The material can be quite easily transformed to other languages. There are already plans to translate the material in the English language. Please contact [K.Hoogland@aps.nl](mailto:K.Hoogland@aps.nl), when you are interested.

## References

(not complete yet)

- American Institutes for Research (2006). *A Review of the Literature in Adult Numeracy: Research and Conceptual Issues*. USA, Washington DC: IAR
- FitzSimons, G.E. (2002). *What Counts as Mathematics? Technologies of Power in Adult and Vocational Education*. Dordrecht: Kluwer Academic Publishers.
- Gal, I., M. van Groenestijn, M. Manly, M-J. Schmitt, D. Tout (1999). *Numeracy framework for the international Adult Literacy and Life Skills Survey (ALL)* <http://nces.ed.gov/surveys/all>
- Gal, I. (Ed.) (2000). *Adult Numeracy Development: Theory, Research, Practice*. Cresskill, NJ: Hampton Press.
- Gillespie, J. (2000). The Integration of Mathematics into Vocational Courses. In: Bessot, A. & Ridgway, J. (Eds.): *Education for Mathematics in the Workplace*. (pp. 53 - 64). Dordrecht: Kluwer Academic Publishers
- Groenestijn M. van (2002). *A Gateway to Numeracy*. The Netherlands, Utrecht: CD B press, University Utrecht
- Hoogland, K. & Jablonka, E. (2003) Wiskundige geletterdheid en gecijferdheid. In: *Nieuwe Wiskrant. Tijdschrift voor Nederlands Wiskundeonderwijs*, 23(1) , (pp. 31-37). Utrecht: Freudenthal Instituut. [Mathematical Literacy and Numeracy. English translation at [www.gecijferdheid.nl](http://www.gecijferdheid.nl)]
- Hoogland, K. (2005). Hoe gecijferd is een basisberoepsgerichte leerling in het VMBO?. In: Goris, T. & Wesker, L. (Eds.), *Nieuwe Wiskrant. Tijdschrift voor Nederlands Wiskundeonderwijs*, 24(3), (pp. 36-39). Utrecht: Freudenthal Instituut. [How numerate is a student in the basic stream of pre-vocational education. English translation at [www.gecijferdheid.nl](http://www.gecijferdheid.nl)]
- Jablonka, Eva (2003). Mathematical Literacy. In A.J. Bishop, M.A.Clements, C. Keitel, J. Kilpatrick, F.K.S. Leung (Eds.). *Second International Handbook of Mathematics Education* (pp. 75-102). Dordrecht: Kluwer Academic Publishers,
- Maguire, T., & O'Donoghue, J. (2002). A grounded approach to practitioner training in Ireland: Some findings from a national survey of practitioners in Adult Basic Education. In L. Ø.Johansen & T. Wedege (Eds.), *Numeracy for empowerment and democracy? Proceedings of the 8th International Conference of Adult Learning Mathematics - A Research Forum (ALM8)*. Danmark, Roskilde: Roskilde University, Centre for Research in Learning Mathematics.
- Maguire, T., & O'Donoghue, J. (2003). Numeracy concept sophistication - an organizing framework, a useful thinking tool. In J. Maaß & W. Schölglmann (Eds.), *Learning mathematics to live and work in our world. ALM-10. Proceedings of the 10th international conference on Adults Learning Mathematics in Strobl (Austria)* Austria, Linz: Johannes Kepler Universität Linz.
- Tobias, S. (1994). *Overcoming Math Anxiety*. New York: Norton, W. W. & Company, Inc
- Zevenbergen R. (2000). Ethnography and the situatedness of workplace numeracy. In: Bessot, A. & Ridgway, J. (Eds.): *Education for Mathematics in the Workplace*. (pp 208 - 224) . Dordrecht: Kluwer Academic Publishers
- Zevenbergen R. & Zevenbergen K. (2004). *The Numeracies of Boat Building*. Paper presented at ICME 10, Copenhagen.