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ABSTRACT

The numeracy abilities of adults is now part of the 2002 International Life Skills Survey (ILSS) to be administered to representative samples of adults aged 16-65 in participating countries. The Numeracy Working Group has spent more than two years developing a conceptual framework based on the premise that numeracy is the bridge between mathematical knowledge and the real world. Since one cannot assess numeracy directly, the framework focuses on five facets of numerate behavior, which involve: (1) managing a situation or solving a problem in a real context; (2) responding to numeracy situations; (3) having information about mathematical ideas; (4) representing numeracy in a range of ways; and (5) enabling knowledge, behaviors, and processes. A scale that estimates the complexity of numeracy tasks uses the following five factors: complexity of mathematical information or data; type of operation/skill; expected number of operations; plausibility of distractors; and type of match/problem transparency. A pool of 80 assessment items has been developed that satisfies the conceptual framework and facets. Feasibility studies have resulted in 68 "good" items. A problem is that the assessment must be done through a less than ideal paper-and-pencil test. (YLB)

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Numeracy Up Front: Behind the International Life Skills Survey

by David Tout

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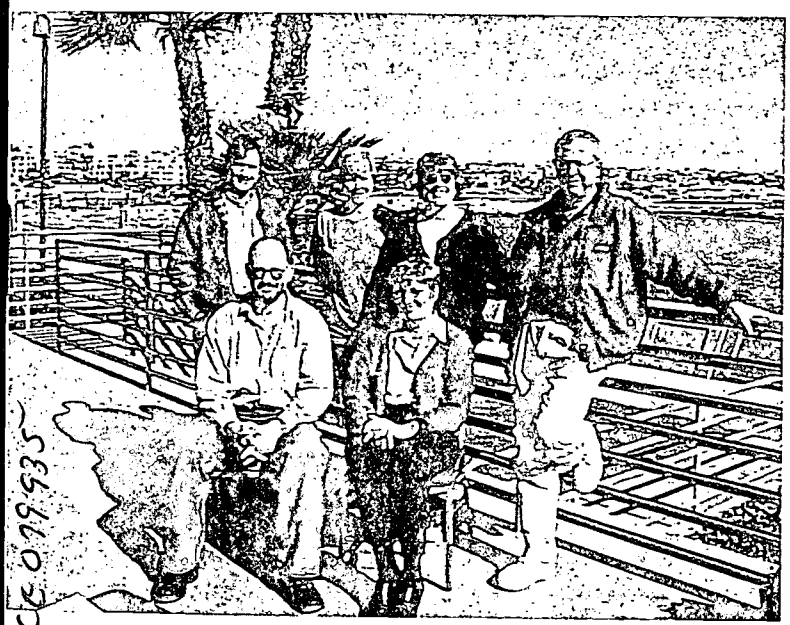
Numeracy Up Front: Behind the International Life Skills Survey

*by **Dave Tout**, Language Australia, who is a consultant on the Numeracy Working Group[1] of the ILSS*

In an important step forward for the new field of adult numeracy, numeracy was given the opportunity to be part of the International Life Skills Survey (ILSS[2]) planned for the year 2002. But to make it through to be part of the final survey was no simple task. It is required of all domains of the survey to first develop a conceptual framework or construct for their domain and prove that this construct is sound and can produce a range of assessment tasks that fit the construct, and that these tasks will stand thorough statistical analysis in a number of trial surveys. Only then is the 'new' domain able to take its place in the final survey.

It seems that the Numeracy Working Group has achieved this result, and that the domain of numeracy will be part of the main assessment of ILSS. I believe the inclusion of a Numeracy scale in the ILSS offers a significant opportunity to develop an international and new conceptual framework of adult numeracy, which will be of interest to educators and researchers interested in the development and application of mathematical knowledge in purposeful contexts. To date the Numeracy Working Group has spent most of its time developing the conceptual framework and a set of assessment items that fit the framework. Two feasibility studies involving possible tasks from the Numeracy scale have been held in both the United States and the Netherlands.

In this article I want to present some of the results of the Working Group's endeavours, and show that behind such surveys as the ILSS and it's predecessor, the International Adult Literacy Survey (IALS), there is a wealth of ideas and concepts that can be of interest to the wider educational sector. These surveys are not just about the final statistics that are released that show that x.y million people are at such and such a level, and that (yet again) we fall well behind Sweden. Too often I feel we focus on these public statistics, and rarely look behind the data, or do more detailed analyses. The statistical methodology used in these International Surveys is unique in that an individual respondent



The ILSS Numeracy Working Group. Back row (L. to R.): Yvan Clermont, Mieke van Groenestijn, Mary Jane Schmitt, Iddo Gal. Front row: Dave Tout, Myrna Manly.

INSIDE

The ***ARIS Resources Bulletin*** is the quarterly journal of the Adult Education Resource and Information Service (ARIS)

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is NOT given a score or a mark - different respondents actually do different assessment tasks - it is the items themselves that are scored and get placed on a continuum of difficulty or complexity. There are data, concepts and theoretical works behind these surveys that should be of interest and use to researchers and teachers. Unfortunately in Australia there seems to have been little of that sort of analysis or research undertaken on the IALS framework or data. I would like to write about that here too, but that's another article for another time. For a recent response to the IALS data for Australia read Geraldine Castleton's article 'Adult Literacy in Australia: Reading Beyond the Figures' (Castleton, 2000).

BACKGROUND

As mentioned above, an international survey of the numeracy abilities of adults is now to be part of the International Life Skills Survey (ILSS) planned for the year 2002. This comparative survey is being jointly developed by Statistics Canada and by the United States' National Center for Education Statistics (NCES), in cooperation with the Organisation for Economic Cooperation and Development (OECD). The ILSS project is a follow-up to the International Adult Literacy Survey (IALS), the world's first large scale comparative assessment of adult literacy. The proposed survey will be administered to representative samples of adults aged 16 to 65 in all participating countries[3].

The study will directly assess performance in three skill domains:

- Prose and Document Literacy
- Numeracy
- Problem Solving.

The study will also indirectly assess two further skills through behavioural reports:

- Teamwork
- Information and Communication Technology.

A comprehensive background questionnaire will also be administered prior to testing.

Key motivations for conducting the overall ILSS are: to inform policymakers and educators regarding levels (distributions) of various skills, including of numeracy; to explore factors associated with observed skill levels (e.g., literacy); and to examine links between numeracy (or other skills) and important social variables, such as earnings, labor-force participation, unemployment, or health-related behaviors.

WHY INCLUDE NUMERACY?

Numeracy is becoming a growing concern for diverse education sectors. As countries increasingly attend to topics such as improving workplace efficiency and quality processes, to resulting lifelong learning needs, and to civic participation, it is seen as vital that nations have information about their citizens' numeracy, among other skills, if they want to plan effective education and lifelong learning opportunities.

The concept of numeracy is also specifically related to the dialogue about the goals and especially outcomes and impact of school mathematics education. More educators now encourage links between knowledge gained in the mathematics classroom and students' ability to handle real-life situations that require mathematical or statistical knowledge and skills. However, while numeracy may be a key skill area, its conceptual boundaries, cognitive underpinnings, and assessment, have not received much scholarly attention so far.

One of the scales of the International Adult Literacy Survey (IALS), the Quantitative Literacy Scale, was a measurement of the respondent's ability to apply arithmetic operations to numbers embedded in diverse texts. For an analysis of Australia's performance in the Quantitative Literacy (QL) scale, see Joy Cumming's article 'The Quantitative Literacy Performance of Australians: Implications of Low Skill Levels' (Cummings, 1997). While this scale produced useful data, survey developers recognized that it was limited in scope. The Numeracy scale of ILSS is designed to go above and beyond the QL Scale.

It might be thought unnecessary to undertake a full numeracy assessment for ILSS since the IALS included the Quantitative Literacy scale. While there is a clear connection and relationship between numeracy and the IALS measure called Quantitative Literacy, there are significant differences, with numeracy covering a much wider breadth of mathematical skills and purposes. This can be easily demonstrated by reference to the Certificates in General Education for Adults (CGEA) Numeracy and Mathematics stream. The IALS Quantitative Literacy scale parallels one of the four domains of the CGEA - Numeracy for Interpreting Society, which leaves the other three Numeracy and Mathematics domains of the CGEA untouched in the IALS. Hopefully the numeracy in the ILSS will in some way address the numeracy skills of the other three domains: Numeracy for Practical Purposes, Numeracy for Personal Organization and Numeracy for Knowledge.

THE FRAMEWORK/BACKGROUND PAPER

The Numeracy Working Group has spent over two years developing its conceptual framework, which has been published in a Background Paper (Gal et al, 1999). The Background Paper is still in a state of flux. Initially it's purpose was to describe the concept of numeracy that we wanted to incorporate into the ILSS and to explain how it could be assessed, and obviously to justify why numeracy should be included. But as mentioned right at the start, it had to include a conceptual framework or construct for numeracy and one didn't exist. Different members of the numeracy team brought different thoughts and different concepts about numeracy (and about it's relationship to mathematics) - and my ideas of different numeracies (eg. through the CGEA) were a bit foreign to the other members of the team. In fact, as one of the people responsible for putting together the framework document, I wasn't allowed to use the word "numeracies". I even had difficulty arguing

that there was a plural for literacy. (Mind you, my spell checkers often don't accept numeracy, let alone literacies or numeracies.)

We are currently working on about version 8 of the Framework! A number of factors have influenced and changed the content of the original Framework. These have included the results of the feasibility studies, feedback that has recently been received from 16 'expert' external reviewers of the Framework, as well as internal revisions made by the team itself. The 16 reviewers of the Framework have been quite positive about the Framework overall, whilst making many valuable, and sometimes contradictory, suggestions for improvements and modifications. Eventually all these factors and suggestions will lead to a revision of the current Framework document. Following the major Pilot study that is to be conducted in 2001, I'm sure even more revisions will take place as more empirical data becomes available. So the process is very much an evolutionary one, where we are able to review and reflect on both our framework and our assessment tasks.

So what follows is a description of some important aspects of the current numeracy Framework, but these will need to be reviewed again as more evidence becomes available.

FACETS OF NUMERACY

We view numeracy as a complex, multifaceted and sometimes slippery construct. Our basic premise is that numeracy is the bridge that links mathematical knowledge, whether acquired via formal or informal learning, with functional and information-processing demands encountered in the real world. An evaluation of a person's numeracy is far from being a trivial matter, as it has to take into account task and situational demands, type of mathematical information available, the way in which that information is represented, prior practices, individual dispositions, cultural norms, and more.

Because our notion of numeracy implies a bridge that links mathematics and the real world, our goal was to develop a conceptual framework of "numeracy" that is couched in assumptions about how adults "know" and "do" maths in the real world, using not only their formal knowledge (of mathematics, of literacy, and so forth), to the degree it exists, but also other, experience-based knowledge.

We have sought a view of numeracy that acknowledges the diverse purposes served by adults' mathematical knowledge, that encompasses the different suggestions regarding the skills adults need to effectively function in home, work, community, and other contexts, and that takes into account the cognitive, metacognitive, and dispositional processes that support or affect adults' numeracy.

However, one cannot assess numeracy, but behavior (broadly defined). We have thus chosen to focus on numerate behavior, which is revealed in how a person responds to mathematical information that may be represented in different ways. The nature of a person's responses to mathematical situations critically depends on the activation of various enabling knowledge bases, practices, and processes.

Numerate behavior involves managing a situation or solving a problem in a real context by responding to information about mathematical ideas that is represented in a range of ways and requires activation of a range of enabling knowledge, behaviors, and processes. Table 1 presents our elaboration of numerate behavior.

This description of numerate behavior distinguishes what we have called five facets, each with several components. The first facet is about the purpose or goal of the numeracy activity - a numeracy action takes place in some context. The framework describes four types of contexts: everyday life, work, societal, and further learning.

The second facet concerns the fact that in different types of real-life numeracy situations, people have to respond in some way. We suggest there are four different ways to respond or act (the first virtually always occurs; others will depend on the circumstances and the individual involved): identify or locate; act upon; interpret;

Table 1: Numerate behaviour and its 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 or locating
acting upon
interpreting
communicating about

to information about mathematical ideas
quantity & number
dimension & shape
pattern & relationships
data & chance
change

that is represented in a range of ways
objects & pictures
numbers & symbols
formulae
diagrams & maps
graphs
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.

and/or communicate about the activity or situation. Some activities may require only one type of response, others may require all types of response.

The third facet is about what type of mathematical information or ideas are embedded within the numeracy situation. Here we have described five areas of mathematics: quantity & number; dimension & shape; pattern & relationships; data & chance; and change. The fourth facet describes how the mathematics is represented. Mathematical information in an activity or a situation may be available or represented in many forms. It may appear as concrete objects (e.g. people, buildings, cars, etc.) or as pictures of such things. It may be conveyed through mathematical symbols, notations, or formulae. Mathematical information may be encoded in a diagram or chart or a map. Likewise, graphs and tables may be used to display statistical or quantitative information; further, a person may have to extract mathematical information from visual displays or text.

The way in which each person responds to the contexts, tasks, and mathematical representations discussed above will depend on the unique combination of existing mathematical knowledge, problem-solving skills and strategies, literacy skills, and dispositions that he or she brings to each situation. This is the fifth and final facet in our construct, and concerns people's enabling knowledge, behaviors, and processes.

Note that many of the components of the facets are not mutually exclusive, and that different numeracy activities can cover more than one of any of the components of the facets. The Background paper goes into much more detail for each of the facets.

This elaboration of facets of numerate behaviour has been used to guide development of the assessment items for the Numeracy Scale for the ILSS. We have attempted, within the restrictions of the assessment protocol, to try to cover as many of the facets and their components as possible. Unfortunately some, such as the last one, 'beliefs and attitudes' is one that can't be directly assessed, but it is one that we have attempted to address via the background questionnaire and that can be linked with respondent's success or otherwise on the numeracy scale.

COMPLEXITY FACTORS

As mentioned earlier, there were a number of requirements expected in the numeracy construct, one of which was to develop a scheme that would be able to predict the difficulty or complexity of a numeracy assessment task. The development of such a scale that attempts to predict the complexity/difficulty of numeracy tasks was one of the more exciting, and challenging, aspects of the project. A draft scheme of five factors was developed that attempted to account for the difficulty of different tasks, enabling an explanation of observed performance in terms of underlying cognitive factors.

These five factors are: (1) Complexity of Mathematical information/data; (2) Type of operation/skill; (3) Expected number of operations; (4) Plausibility of distractors (including in text); (5) Type of match/problem transparency. These factors have been used to attempt to estimate, separately and in interaction, the difficulty level of the numeracy tasks. Three factors address the mathematical aspects of tasks, and two factors address mainly textual aspects of tasks. These five factors are listed separately for clarity of presentation, but in actuality are not independent of each other and do interact in complex ways.

For each of these factors a detailed description was developed against a scoring system initially in the range from 1 through to 3 (although this is now under review). Based on these 5 factors a total "difficulty score" in the range 5-15 was pre-assigned by the team to each item before the data from the feasibility study were known.

THE ASSESSMENT ITEMS

Based on the conceptual framework, a pool of 80 items was developed that attempted to satisfy the conceptual framework and the facets described above. We attempted to be as realistic as possible, but there are restrictions on developing items for such a large scale survey that is to be delivered to 1000s of people in all participating countries (see comments below). Unfortunately, I cannot share with you the actual items as they need to remain under wraps for the survey. But all are based upon simulated texts such as advertisements, newspaper articles, maps, diagrams and plans, photos, etc. A ruler and a calculator are provided to all respondents. We even tried in our first set of items to use a real object (a tin can) where we asked questions about it's height and volume. However the result on this particular item was inconsistent statistically and also was impractical to deliver in a full scale survey, so our 'tin can' item has had to be dropped.

RESULTS SO FAR

The initial 80 items were tested in a feasibility study in the U.S. and the Netherlands in June 1999. Following that some items were discarded and new ones developed and submitted to the Numeracy Working Group by representatives from participating countries. These new items and some revised old ones were tested in another,

Table 2: Complexity Factors—Overview

Aspects	Category	Range
Mathematical aspects	1. Complexity of Mathematical information/data	Concrete/simple to abstract/complex
	2. Type of operation /skill	Simple to complex
	3. Expected number of operations	One to many
Textual aspects	4. Plausibility of distractors	No distractors to several distractors
	5. Type of match/ problem transparency	Obvious/explicit to embedded/hidden

smaller feasibility study, also held in the U.S. and the Netherlands in January 2000.

Overall, the feasibility studies have shown that the item pool includes tasks at diverse levels of difficulty and that they cover key facets of the conceptual framework for numeracy. The theoretical factors that are supposed to account for task difficulty were found to be highly correlated with actual difficulty of items. A key statistic to emerge from the first feasibility study was the correlation between this total "complexity rating" and the actual p-value (percentage correct on the item) of all items. This correlation was computed for the 68 "good" items and was found to be r=0.77. This high correlation indicates that the conceptual system of complexity factors proposed by the Numeracy Team can actually account for at least 50% of the performance on the numeracy items. This finding implies that the scores to be obtained on the numeracy scale can be interpreted quite well by using this 5-factor system, and thus that the distribution of ability levels on the numeracy scale can be meaningfully explained by reference to these factors. That said, the numeracy team is now exploring items whose actual p-value was quite different from the difficulty level predicted by the complexity factors, both as a way to identify problem items (or instructions) as well as a way to refine the understanding of the factors that make numeracy tasks vary in difficulty.

Preliminary results therefore provided initial support for the content validity and the construct validity of the numeracy scale, and have provided information on which to reflect and review the framework and the items.

ISSUES, PROBLEMS AND BENEFITS

In a large-scale survey such as the ILSS, tasks can be couched in realistic non-school settings, with limited usage of formal notations (unlike school-based assessments), and with a blend of either text-rich tasks or text-less tasks, as well as including some tasks where opinions rather than just computation are called for (e.g., when interpreting statistical messages). However, the assessment of numerate behavior in the ILSS can only be accomplished through tasks delivered in a sit down, pen and paper test. Even though it is done at home in a 1:1 situation, this is still not ideal and can only attempt to replicate real life situations. Therefore, while the scale we propose may cover a broad mathematical terrain, it may still fall short of encompassing the full scope of numerate behavior espoused in our conceptual framework, due to such pragmatic considerations. Some aspects of people's numeracy skills, such as those pertaining to problem-solving strategies, or to interpretive responses and their underlying reasoning processes, cannot be fully reliably and validly assessed with the methodology presently available in the ILSS.

There are many other issues that have needed to be addressed, and are still being addressed, many in preparation for the full scale pilot study to be held next year. An example is about what background questions should be included that ask about the person's maths history and attitudes. What are possible useful indicators of their performance in numeracy? Would a person's dispositions and attitudes towards numeracy tasks or mathematical activities be important? Preliminary findings so far suggest that there would be merit in including in the ILSS background questionnaire a factor composed of at least three items centering around an adult's confidence and comfort with everyday mathematical demands.

So there are many areas that are still being worked on, and therefore much to do over the coming years. I personally feel it is a pity that Australia does not want to be involved in this survey, as there will be much of interest not only to those involved in adult education and training, but also to school maths educators.

The work in getting numeracy up front in the ILSS has had many benefits already, many of which are world firsts. Amongst these are having an internationally developed conceptual framework for numeracy and a theoretical scheme that attempts to show what makes a numeracy task easy or difficult. These can be used as the basis for other researchers to refine, to criticise, or to come up with alternatives. The survey itself will also have many benefits, including data on background characteristics that influence a person's success in numeracy; and of course, the actual data and statistics on the performance of a population over a range of numeracy tasks.

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NOTE: *For more information about the ILSS visit their Website at: http://nces.ed.gov/ilss/*

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2 Note: The final title of the survey is still undecided.

3 Note: At this stage Australia has not become involved in the ILSS.

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