Higher order

thinking skills

By Margaret Forster

Margaret is the Research Director of ACER's Assessment and Reporting research program.

In today's world it is necessary, but not sufficient, for students to achieve minimal competence in areas such as reading, writing and numeracy. Beyond the achievement of minimal competence, students also need to develop what are often called 'higher order' thinking skills including critical literacy, critical numeracy and cross-curricular competencies.

A useful conceptualisation of higher order thinking skills distinguishes two contexts in which these skills are employed: contexts where the thought processes are needed to solve problems and make decisions in everyday life; and contexts where mental processes are needed to benefit from instruction, including comparing, evaluating, justifying and making inferences (Wheeler & Haertel, 1993). The ability to employ higher order thinking skills in both these contexts is seen as essential in a rapidly changing world and the first context in particular is being adopted as a starting point for international assessment programs.

Higher order literacy and numeracy skills are now adopted as a starting point in most international assessment programs.

International Adult Literacy Survey

Reading literacy is no longer defined merely in terms of a basic threshold of reading ability which everyone growing up in developed countries is expected to attain. Rather, literacy is now equated with an individual's ability to use written information to function in society.
(Kirsch, 2001, p.4)

Programme for International Student Assessment

Reading literacy is an individual's capacity to understand, use and reflect on written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society.
(OECD, 2003, p.15)

International Life Skills Survey

Numeracy involves abilities that include interpreting, applying and communicating mathematical information in commonly encountered situations to enable full, critical and effective participation in a wide range of life roles.
(ETS, 2004, p.14)

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Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage in mathematics in ways that meet the needs of that individual's life as a constructive, concerned, and reflective citizen.
(OECD, 2003, p.15)

In Australia, school systems are increasingly focusing attention on higher order thinking skills. For example, the curriculum in Tasmania is organised around five cross discipline constructs or 'essential learnings'. The 'learnings' are intended to culminate in the lifelong outcomes of inquiring and reflective thinkers, effective communicators, self-directed and ethical people, responsible citizens, and world contributors. They are also intended to be future-oriented and connected to the real world, to focus on depth rather than breadth, to focus on connections and transfer of learning, and to reflect and embody values and purposes'. In the Tasmanian framework, higher order *thinking* is situated in the broader context of higher order *learning* with the five 'essential learnings' listed as: communicating, personal futures, social responsibility, world futures, and thinking.

It is easy to articulate a commitment to the development of higher order thinking skills but more demanding to translate this commitment into action. How do we develop a curriculum that both addresses subject knowledge and emphasises higher order thinking? And how do we monitor and assess the development of students' higher order thinking ability? In the case of assessment, the first challenge is to define exactly what it is we wish to focus on (how we define higher order thinking), the second is to select an appropriate method for gathering evidence of students' skills (what form of assessment we use).

Two areas of work undertaken at ACER provide two different approaches to the assessment of higher order thinking skills through paper and pen tests: tests of performance 'beyond the school curriculum', and tests of 'general academic abilities'. These approaches reflect two different contexts in which higher order thinking skills are employed.

Performance beyond the school curriculum

Tests of performance 'beyond the school curriculum' assess the thought processes that are needed to solve problems and make decisions in everyday life. At ACER these skills are addressed in the Programme for International Student Assessment (PISA), an international study of the skills of 15-year-olds in 46 countries[2]. Here the approach to assessing the higher order thinking skills is based on a dynamic model of *lifelong learning* in which new knowledge and skills necessary for successful adaptation to a changing world are continuously acquired throughout life. Rather than assessing 'school' knowledge, PISA aims to measure how well students perform beyond the school curriculum.

Although the domains assessed in PISA so far (reading literacy, mathematical literacy and scientific literacy) are closely related to subjects learned at school, PISA concentrates on the value of the skills acquired, through applying them in real-life situations[3]. The definitions of the assessment domains make this clear.

Reading literacy is defined as 'an individual's capacity to understand, use and reflect on written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society'. Mathematical literacy is defined as 'an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen'; and scientific literacy is defined as 'the capacity to use scientific knowledge to identify questions and to draw evidence-based conclusions in order to understand and to help make decisions about the natural world and the changes made to it through human activity' (OECD, 2003, p15).

In the case of 'reading literacy' students perform a variety of tasks with different kinds of text selected to reflect the range of written forms that individuals will encounter in adult life. Written forms include both continuous prose and 'non continuous' text such as lists, forms, graphs, and diagrams. The range of texts also samples texts constructed for different purposes such as a novel, personal letter or biography written for people's 'private' use; official documents or announcements for 'public' use; a manual or report for 'occupational' use; and a textbook or worksheet for 'educational' use.

Students are not assessed on the most basic reading skills. Rather, they are expected to demonstrate their proficiency in retrieving information, forming a broad general understanding of the text, interpreting it, reflecting on the content and form of texts in relation to their own knowledge of the world, and arguing their own point of view.

In the case of mathematical literacy, tasks address three dimensions. First, the *content* of mathematics, as defined mainly in terms of broad mathematical concepts underlying mathematical thinking (such as chance, change and growth, space and shape, reasoning, uncertainty and dependency relationships), and only secondarily in relation to 'curricular strands' (such as number, algebra and geometry).

Second, the *process* of mathematics as defined by general mathematical competencies. These include the use of mathematical language, modeling and problem-solving skills. The idea is not, however, to separate out such skills in different test items, since it is assumed that a range of competencies will be needed to perform any given mathematical task. Rather, questions are organised according to the type of thinking skill needed (simple computations or definitions; connections to be made to solve straightforward problems; mathematical thinking, generalisation and insight).

Third, the *situations* in which mathematics is used, ranging from private contexts to those relating to wider scientific and public issues.

In the case of scientific literacy, tasks address three dimensions also. First, *scientific concepts*, which are needed to understand certain phenomena of the natural world and the changes made to it through human activity. Second, *scientific processes*, focusing on the ability to acquire, interpret and act upon evidence. Third, *scientific situations* selected mainly from people's everyday lives rather than from the practice of science in a school classroom or laboratory, or the work of professional scientists. As with mathematics, science figures in people's lives in contexts ranging from personal or private situations to wider public, sometimes global issues.

Examples of a PISA scientific literacy task and a PISA mathematics literacy task are provided on the facing page.

An example of a PISA Mathematics Unit with one of the unit questions[4]

For health reasons people should limit their efforts, for instance during sports, in order not to exceed a certain heartbeat frequency.

For years the relationship between a person's recommended maximum heart rate and the person's age was described by the following formula:

Recommended maximum heart rate = 220 – age

Recent research showed that this formula should be modified slightly.

The new formula is as follows:

Recommended maximum heart rate = 208 – (0.7 x age)

Example question

A newspaper article stated 'A result of using the new formula instead of the old one is that the recommended maximum number of heartbeats per minute for young people decreases slightly and for old people increases slightly.'

From which age onwards does the recommended maximum heart rate increase as a result of the introduction of the new formula? Show your work.

An example of a PISA Science Unit with one of the unit questions[5]

Another way that Peter gathers information to improve road safety is by the use of a TV camera on a 13 metre pole to film the traffic on a narrow road. The pictures tell the researchers such things as how fast the traffic is going, how far apart the cars travel, and what part of the road the traffic uses. Then after a time, lane lines are painted on the road. The researchers can then use the TV camera to see whether the traffic is now different. Does the traffic now go faster or slower? Are the cars closer together or further apart than before? Do motorists drive closer to the edge of the road or closer to the centre now that the lines are there? When Peter knows these things he can give advice about whether or not to paint lines on narrow roads.

Suppose that on one stretch of the narrow road Peter finds that after the lane lines are painted the traffic changes as below.

Speed	*Traffic moves more quickly*
Position	*Traffic keeps nearer edges of road*
Distance apart	*No change*

On the basis of these results it was decided that the lane lines should be painted on all narrow roads. Do you think this was the best decision? Give your reasons for agreeing or disagreeing.

Agree

Disagree

Reason

General academic abilities

The second approach to the assessment of higher order thinking skills focuses on the mental processes needed to benefit from instruction (such as comparing, evaluating, justifying and making inferences). At ACER these skills are assessed in tests of general academic abilities. These tests aim to measure how well students *reason*.

Two broad domains are sampled in these tests: reasoning in the 'natural world' (mathematics, science and technology); and reasoning in 'human world' (humanities, arts and social sciences). While these broad domains reflect a basic division in school curricula, the tests focus on the styles of thinking elicited when we reason in the two domains rather than the kinds of material that are considered, or school knowledge.

These styles of thinking can be seen as two ends of a continuum. Reasoning in the natural world elicits styles of thinking that typically can be described as 'objective' or 'scientific'. They include problem solving, and using logical analysis to draw inferences. Categorisation, representation, transformation of information, relationships and objects are important. Reasoning in the human world elicits styles of thinking that typically can be described as 'subjective'. They include the interpretation of subjective human constructs, and holistic judgements about meaning. Vocabulary and socio-cultural understandings are important.

At the extreme ends of the continuum the styles of reasoning elicited are clearly differentiated. For example, at the human world end 'interpretive reasoning' is elicited (see Example A), whilst thinking typical of the 'natural world' (mathematics, science and technology) elicits styles at the other end of the continuum (see Example B).

Of course, the separation of styles of thinking within contexts is not watertight. For example, reasoning in both the natural and the human world includes 'critical thinking'; and a single piece of stimulus can address both the natural and human world and can elicit objective and subjective styles of reasoning.

And, of course, the assessment of higher order thinking skills can occur at different levels of specificity. The two examples illustrate the measurement of skills at a broad level of generality that samples a

Example A

The image above suggests that we:

A **cannot escape conformity.**

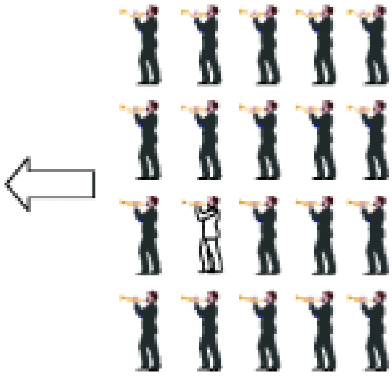
B **can effectively disguise ourselves.**

C **appear to be anonymous but are unique.**

D **appear to be unique but are anonymous.**

The finger-print is known around the world, and its suggestions and significance can be interpreted from a range of different cultural perspectives. The image plays the apparent anonymity of a faceless, nameless human figure against the unique personal identity embodied by the fingerprint. Identifying the correct response depends on the candidate's ability to perceive this paradox within the image and then work out its most likely meaning. Distractors A and B are wrong because neither captures this central feature of the image; in fact, the uniqueness of a fingerprint suggests rather the opposite of conformity or disguise. D is wrong because the relationship between uniqueness and anonymity is reversed; it is the uniqueness that is fundamental and real rather than the anonymity.

Example B



In this parade, Alfonzo (white uniform) is second from the front, third from the right. Bartholo is in another, similar parade. He is fourth from the front, third from the back, second from the left and third from the right.

How many people are there in Barthollo's parade?

A 20 ***B*** 24 ***C*** 28

D 42 ***E*** more than 42

The correct response to this item is B.

In this item, the stimulus describes how a person's position in a group is designated. Then a description is given of a person's location in another group. The problem is to determine the size of this second group. There is enough information for the candidate to see that if the person is fourth from the front and third from the back, then there must be six rows marching forward. The other information shows that there are four columns. Thus there are twenty-four people in all.

range of skills. For example, a test of reasoning in the human world might draw on 'understanding' (recognition of explicit and implicit meanings through close reading of words and phrases, and global interpretations of text); 'interpretation' (interrelating, elaborating and extending concepts and ideas and drawing conclusions); and 'critical thinking' (making discriminations and judgements in the realm of plausible reasoning and/or making assessments and value judgements).

These general academic abilities could be conceptualised, measured and reported at a greater level of specificity. For example, it would be possible to measure and report students' ability in the specific area of 'empathy' (narrowly defined) rather than the more general area of 'interpersonal understandings', or 'socio-cultural understandings', or the still more general area of 'reasoning in the human world'.

The two different approaches to the assessment of higher order thinking skills described here – PISA tests of performance 'beyond the school curriculum', and tests of 'general academic abilities' – reflect two different contexts in which higher order thinking skills are employed. Ongoing challenges for work in this area include continued refinement of our understanding of higher order thinking and continued exploration of the contexts in which higher order thinking might be developed, assessed and monitored. ■

References:

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[1] For further information on essential learning see the Tasmanian Education Department website: www.education.tas.gov.au

[2] For further information on PISA see www.pisa.oecd.org

[3] Competencies more obviously across disciplinary boundaries also have a growing importance in PISA. PISA 2000 analysed students' approaches to learning and beliefs in their own abilities, motivation and engagement and other aspects of student attitudes, under the heading "self-regulated learning" and in 2003, PISA assessed students' ability to solve problems.

[4] OECD, 2003, p.64

[5] OECD, 2003, p.144