16
Research based criteria for the design and selection of literacy and thinking tools

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Abstract
This paper describes criteria for the design and selection of literacy and thinking tools. The criteria are that tools should be: (i) teaching focused (ii) learner focused, (iii) thought linked (iv) neurologically consistent, (v) subject specific, (vi) text linked, (vii) developmentally appropriate, (viii) culturally responsive, and (ix) assessment linked.

Introduction
The importance of establishing criteria for the design and selection of literacy and thinking tools (Whitehead, 2001; 2004a) lies in the need for teachers to justify what they do. The reason for using literacy and thinking tools might be very general, for example 'the need for literate, future-focused thinkers who can create new knowledge and ensure the survival of society', or 'the need for a populace that understand how views are socially constructed and not always based on evidence'. Alternatively, the reason might be very specific, for example, 'the need to meet the evidence based reading comprehension needs of students'. Whatever reason we adopt, embedding a selection of literacy and thinking tools into an already over-crowded, over-specified, subject focused curriculum is problematic. It is made even harder in some institutions, notably secondary schools and universities, characterised by unproductive, hermetically-sealed silos of subject specific discourses that too long ago created intellectual no-fly zones, and that too long ago closed down the kinds of interdisciplinary dialogues crucial to the development of a literate and thoughtful population. But the question: "Which tools should we use in our classrooms?" inevitably leads us to

consider criteria against which we might design and select those tools, and ultimately, justify what we do.

I use the 'tool' metaphor, rather than the more common term 'strategy', to emphasise the instrumental nature of these pedagogical aids, and I describe the tools illustrated in this paper in terms of both 'literacy' and 'thinking' because, as Guthrie and Wigfield (2001) note, the processes of inquiry learning [in science] are similar to text comprehension strategies recommended by the US National Reading Panel (National Institute of Child Health and Human Development, 2000) and the types of thinking outlined by the [Australian] Curriculum Council (1998).

A bird is ... ***Before*** 1. An animal that can fly ***During*** 2. Linked to dinosaurs ***After*** 3. An avian	**A bird can …** ***Before*** 1. Fly ***During*** 2. Crush seed in its beak ***After*** 3. Migrate
Examples of birds are … ***Before*** 1. Crow ***During*** 2. Parakeet ***After*** 3. Humming bird	**Birds have …** ***Before*** 1. Feathers ***During*** 2. Bills and beaks ***After*** 3. Webbing and talons

Figure 16.1. A simple *Concept Frame* tool about birds.

Literacy and thinking tools are construction tools for the mind. Just as carpenters use tools to construct houses, literate thinkers use tools to construct and use knowledge. Just as hammers are built to drive in nails, some literacy and thinking tools are purpose-built to evoke specific types of thinking and for use with specific subjects and text types. Like the range of tools used by carpenters, literacy and thinking tools can be, procedurally and cognitively, more or less sophisticated. For example, the simple *Concept Frame* tool (see Figure 16.1) assists students to record and use their conceptual understandings. More specifically, this tool, discussed in greater depth later in this paper, engages students in recording words evoked by four generic headings (A xxx is …, A xxx can …, xxx have, Examples of xxx are …). The recorded information can then be used to write or critique a report or description text.

Identifying design and selection criteria

The focus of this paper is not to describe tools for use in the classroom but rather to provide examples of tools that are consistent with criteria that allow us to justify what we do. The method used to identify nine criteria that allow us to justify the design and select literacy and thinking tools, involved the use of meta-analyses and literature reviews. These describe the characteristics of effective research-based pedagogy (Hattie, 1992, 2003; Hipkins, 2002; National Institute of Child Health and Human Development, 2000), and the application of recent understandings about learning from educational and cognitive psychologists (Ashcraft, 2007; Brophy, 2001; Sadoski & Paivio, 2001), and neuroscientists (Shaywitz & Shaywitz, 2007; Willis, 2007a, 2007b; Wolfe, 2001).

In part, the criteria emerged from a 2002 New Zealand Ministry of Education (MOE) literature review of significant New Zealand and international research published as the *Curriculum, Learning and Effective Pedagogy: A Literature Review in Science Education* (Hipkins et al., 2002). The selection of studies for inclusion in the 2002 MOE review was based on five characteristics, including whether the studies indicated (i) quantitative evidence of increases in student understanding and performance on authentic tasks, and (ii) qualitative evidence of improved student understanding, and attitudes in the classroom. The researchers who compiled this review defined 'effective pedagogy' in relation to student achievement.

Broadly, this literature review recommends that students might experience more success where pedagogy and curriculum are characterised by:

- learning experiences that are couched in meaningful contexts

- learning experiences that include sharing the purposes for learning with students
- student conversations with teachers that include explicit modelling of the type of discourse needed to achieve learning intentions
- the use of literacy strategies (or tools) that help students cope with the text features.

Findings from this review, together with those from other researchers referenced above, are used to identify criteria that might be used to justify each of the literacy and thinking tools described in this paper.

Criteria for the design and selection of literacy and thinking tools

The literacy and thinking tools described in this paper are consistent with nine research-based criteria. The criteria, derived from and supported by the literature reviewed in association with each tool, are that tools should be:

1. teaching focused
2. learner focused
3. thought linked
4. neurologically consistent
5. subject specific
6. text linked
7. developmentally appropriate
8. culturally responsive
9. assessment linked.

The use of each of the tools described in this paper can be justified in terms of more than one criterion. From a research paradigm perspective, justification for the inclusion of the teaching and learner focused, developmentally appropriate, thought linked and assessment linked criteria stem, primarily, from the research of cognitive, educational and developmental psychologists (Block & Pressely, 2001; Brophy, 2001; Neisser, 1976). The research paradigms of functional systemic linguists (Halliday, 1985; Martin, 1985), evolutionary psychologists (Pinker, 2002) and the epistemological studies of philosophers (Russell, 1912) provide justification for the text linked and subject specific criteria. Justification for the inclusion of the neurologically consistent criterion reflects recent research from neuropsychologists (Gazzaniga, Irvy & Mangun, 2002; Willis, 2007a; Wolfe, 2001).

1. Justification for a teaching focused criterion

The difference between tools consistent with the teaching focused criterion and tools consistent with the learner focused criterion is like the Chinese proverb: Give a family a fish and they will eat for a day; give them a fishing line and they will eat for a lifetime. Tools consistent with the teaching focused criterion are like fish. Tools consistent with the learner focused criterion are like the fishing line.

A justification for the inclusion of a teaching focused criterion lies in the claim that literacy and thinking tools should align with what excellent teachers do. Excellent teaching is associated with student achievement. In this respect, a meta-analysis of research describing the behaviours of excellent teachers conducted by Hattie (1992; 2003) noted that teachers account for about 30 per cent of the variance in student achievement. What teachers know, do, and care about is crucial to student achievement. More specifically, Hattie reports that teachers' feedback (effect size 1.13), instructional quality (effect size 1.00) and direct instruction (effect size .82) are key 'quality of teaching' variables.

A characteristic of excellent teachers identified by Alton-Lee (2003) that relates to Hattie's 'instructional quality' variable is 'teacher responsive to student learning processes'. This responsiveness is expressed when teachers scaffold learning, provide feedback on students' task engagement, encourage reflective thinking and engage students in goal oriented assessment.

Additional characteristics of excellent teachers identified by Hipkins et al. (2002) are again that they (i) scaffold conversations and investigative skills with explicit modelling of the type of text appropriate to the type of learning to be achieved, (ii) engage students in the co-construction of meaning that acknowledges their existing ideas (Ruddell, 2002), (iii) model different types of questions associated with inquiry and (iv) engage students in types of rich instructional dialogue that support critical and logical thinking (Alvermann & Hayes, 1989; Brooks, 1993; Goldenberg, 1993; Martin, Sexton, Wagner & Gerlovich, 1997).

Together these research findings point to excellent teachers as having a significant influence on student achievement. To be consistent with the teaching focused criterion, literacy and thinking tools must be shown to facilitate these characteristics of excellent teaching.

Teaching focused tool

The *concept cartoon* (see Figure 16.2) is designed to assist teachers who use co-construction pedagogy to restructure students' existing conceptual knowledge. It facilitates scaffolding through dialogue that models how we reason. *Concept cartoons* enable teachers to model different types of questions associated with inquiry learning and, through these questions, involve students in types of subject specific argumentation that, combined with responsive feedback, serve to modify the known and link to the new (Naylor, Keogh, & Downing, 2001).

The visual format and minimal written text of the *concept cartoon* tool together with their potential to help students express diverse and complex viewpoints make them effective teaching focused literacy and thinking tools. Best of all, the user-friendly cartoon format removes any potential embarrassment that might occur when students justify their own views to their peers.

As illustrated in Figure 16.2, *concept cartoons* take the form of cartoon styled drawings that illustrate students' subject specific conceptions (or misconceptions) and allow for the presentation of alternative ideas as a means of evoking ideas that don't fit comfortably with students' existing beliefs (cognitive dissonance).

Through discussion around a teachers' initial observation, ("Some birds have beaks curved at the end") and then through dialogue that evokes critical and reflective thinking, this teaching focused tool enables students to make intellectual leaps to a 'Big Scientific Idea'. The ideas beginning with 'BUT …' recorded in *concept cartoon* callouts take the form of pseudo-questions, and can come from either the teacher, who understands some common misconceptions students might have about the topic, or from students, with teachers taking a 'back seat'.

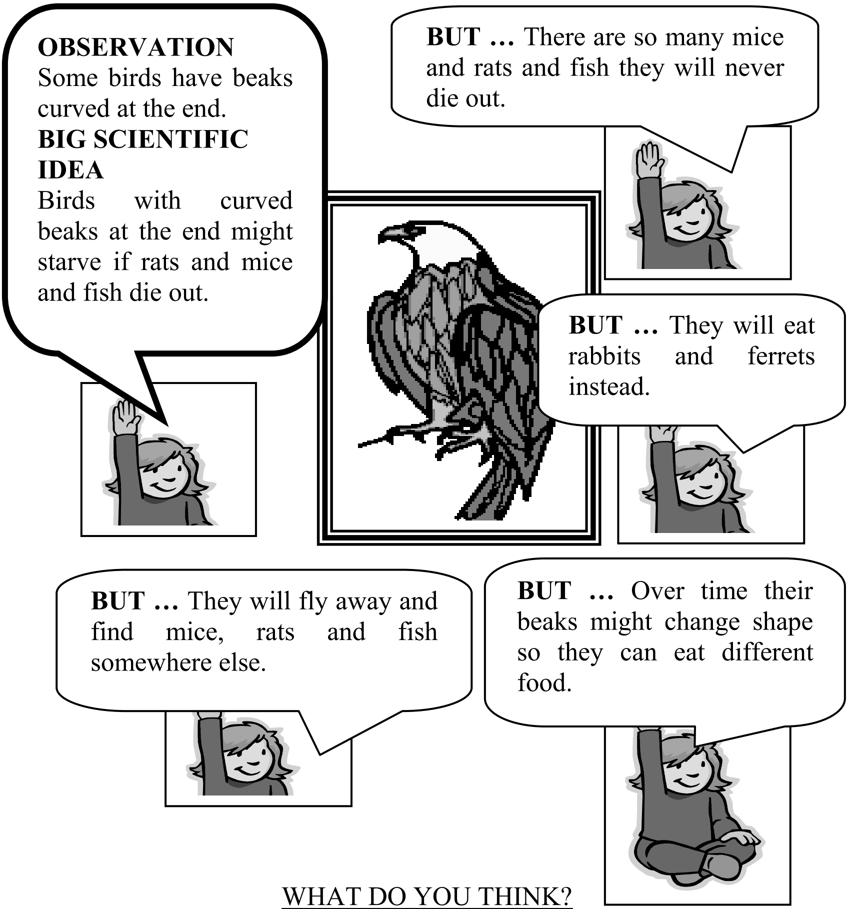

Figure 16.2. A completed *concept cartoon* tool.

This tool enables teachers to help students learn effectively by talking themselves to meaning and is consistent with many of the teaching focused criteria associated with excellent teaching.

The intermediate *acrostics* tool (see Figure 16.3) is consistent with both the teaching and learner focused criteria. A key word from a current topic is written down the left of the acrostic and words beginning with each letter recorded mid-way (top word) and at the end of a series of lessons on that topic. Students then select the best word associated with each letter and construct a sentence that uses that word. The *acrostics* tool is consistent with both the teaching and learner focused criteria because it can be used by the teacher, as scribe, with a class or used independently by students as a revision tool. It can also be used as an assessment tool, for example by students recording words beginning with each letter of a few key words associated with a topic selected by the teacher.

		Tough
T	}	(Thinking can be **tough**).
		Thrilling
		Help
H	}	(**Hyerle**'s thinking maps **help** me think).
		Hyerle
		Interesting
I	}	(Tools make learning **interesting**).
		Innovative
N New		(Using an *Acrostic* tool to think is **new** to me).
K Knowledge		(Tools turn information into **knowledge**).

Figure 16.3 An intermediate *acrostic* tool.

2. Justification for a learner focused criterion

Learning tools are like fishing lines because they equip students with a means of becoming lifelong, literate thinkers. Two broad reasons for the use of tools consistent with a learner focused criterion are that (i) democratic societies need literate thinkers who can use a range of literacy and thinking tools independently and (ii) tools that align with this criterion are consistent with our understanding of learning as an active and complex process. More specifically, research by cognitive psychologists (Ashcraft, 2007) and neuropsychologists (Willis, 2006) suggests that students learn when they (i) maintain attention on a task,

(ii) are motivated to learn, (iii) encounter vivid and interesting experiences and (iv) are able to repeat the same experience and apply their understanding. This research also explains how we represent and modify concepts. Tools consistent with the learner focused criterion should reflect these findings and, in consequence, assist students to learn.

A learner focused tool

The *concept frame* (see Figure 16.1) is designed to help students achieve deliberate and purposeful outcomes with texts, independently. It is consistent with the learner focused criterion to the extent that it reflects the way psychologists think concepts are represented in memory. For instance, research by evolutionary psychologist Steven Pinker (2002) supports the claim for an innate ability among humans to represent direct experiences of the physical and natural world as concepts. He notes that in every human society, people classify, (conceptualise) plants and animals into species-like groups. Cognitive psychologists suggest concepts are represented in memory as connected 'meaning nodes' (Blaut, Stea, Spencer & Blades, 2003; Collins & Loftus, 1975; Farah & McClelland, 1991). These include 'example', 'dynamic', 'classification' and two types of 'attribute' nodes. Similarly, each sector of a *concept frame* (see Figure 16.1) aligns with the way concepts are represented in memory by providing learners with 'example' (types of bird), 'dynamic' (A bird can ...), 'classification' (A bird 'is ...) and 'attribute' (Birds have ...) headings.

This tool is also consistent with the principles of formative assessment. The 'Before', 'During' and 'After' (a series of lessons) headings invite students to record their developing understandings and allow teachers to assess student progress.

3. Justification for a thought linked criterion

Tools that align with the teaching and learning criteria construct learning as an active cognitive process. They are consistent with a definition of literacy as language in use – use implying thought. The thought linked criterion justifies the design and selection of tools on the basis of the types of thinking they evoke. In part, support for a thought linked criterion stems from research that describes the role of *generic* and *thematic* types of thinking in learning (McComas, 1998). For example, the [Australian] Curriculum Council (1998) notes that when students plan science investigations, (although clearly this applies to other subjects), they engage in at least three distinctive *generic* types of thinking. These include (i) critical thinking ('exploring ideas and materials, reviewing background information, identifying variables'), (ii) creative thinking ('thinking laterally, making predictions, inventing strategies for investigation'), and (iii) metacognitive thinking ('clarifying purposes, reflecting on their knowledge and experiences') (Curriculum Council, 1998, p222). Other researchers highlight the role of caring (and ethical) thinking (Lipman, 1977; Millett, 2003; Pohl, 2000).

There are overlaps among these types of *generic* thinking. For example, critical thinking requires principled reasoning, a critical spirit, and a rational and ethical passion (Eisner, 1985) – qualities also associated with epistemologically subversive students who are creative thinkers and who show creative curiosity, reflectivity and fascination in a subject. Metacognitive thinking is integral to all these types of thinking and significantly associated with student achievement (Scott, Asoko, & Driver, 1992). Literacy and thinking tools that evoke metacognitive thinking have, arguably, the largest impact on student achievement of any teaching practice (Donovan, Bransford, Pelligrino, 1999; Georghiades, 2000). However, it should be acknowledged that students' ability to engage in metacognitive thinking is not exclusively dependent on the use of tools designed to evoke this type of thinking. As Georghiades (2000) notes, short 'metacognitive instances' that involve brief discussions, thinking and writing tasks, and group activities can assist students to reflect on their own thinking using their own language.
In addition to these four *generic* types of thinking, justification for the inclusion of a thought linked criterion is provided by three common 'scientific themes' outlined by the American Association for the Advancement of Science (1996). These themes represent different types of *thematic* thinking, including (i) systemic, (ii) temporal-causal, and (iii) model thinking, all of which transcend disciplinary boundaries. First, systemic thinking allows learners to think about the 'whole' (for example the theme of a story) in terms of its parts (for example a narrative episode). System thinking also allows us to think about parts in terms of

how they relate to one another and the whole, for example how the relationships among episodes provides texture to the whole story.

Second, there are two components of temporal-causal thinking, which are (i) change and (ii) scale. For example, in respect to change, much of our comprehension of characterisation in narrative is concerned with comprehending how a character's psychological state changes, and the scale of that change. Change might be subtly signalled by a raised eyebrow, or dramatically signalled by a pique of rage. We also comprehend the rate at which things change, for example, the gradual development of abiding love and the instant onset of jealousy.

Third, model thinking allows us to represent ideas, objects and events (Gilbert & Boulter, 2000) as metaphor, analogies and visual mental images. I believe that model thinking should be made an explicit focus of learning because, as Coll (2005) argues, mental models, such as visual images, are central to our understandings of physical and psychological phenomena that may be unavailable to direct experience. In the form of analogies, metaphors or visual mental images, model thinking allows students engaged with the content of any subject to reflect on, discuss and critique both their understandings of concepts and those held by others (Taylor, 2000).

Evidence supporting the inclusion of a thought linked criterion acknowledges the need for tools that assist students to engage in generic and thematic types of thinking.

Thought linked tools

Literacy and thinking tools consistent with the thought linked criterion can, variously, evoke *generic* and *thematic* types of thinking. For example, *generic* creative thinking and *thematic* modelling can be evoked by the use of visual imagery tools such as *RISE* (Read, Image, Share and Evaluate) (Whitehead, 2001; 2004a). This involves teachers reading to or with students, then asking students to construct visual images representing objects, events, settings or people described in the text. Next, students are asked to share their images and then evaluate their images against the author's description as the text is re-read, or the illustrations as they are revealed. Consistent with the learner focused criterion this tool can be used by students independently.

A range of tools can be used to evoke critical thinking, including the *concept frame* when used to critic the content of text. Ethical issues can be addressed using *y-chart* tools that evoke caring thinking (Whitehead, 2001). There are also tools described by Fogarty (1994) that assist us to think metacognitively. These include the use of questions that prompt students to ask, "Which tool should I use to think about that idea?" Systemic and temporal-causal types of *thematic* thinking can be evoked through the use of *flow diagram* tools (see Figure 16.5).

Just as it would be unwise to define generic types of thinking as mutually exclusive, so too it is unwise to assume a single, clear and certain link between tools and types of thinking. Tools may simultaneously evoke more or less challenging types of creative and critical thinking. Consequently, the multiple types of thinking evoked by any single tool render popular classification such as 'creative thinking tool' as unspecific and problematic. But the fact that tools might evoke multiple types of thinking should not deter teachers from their professional responsibility to understand the types of thinking associated with their practice. Nor should this be used to dismiss the thought linked criterion as a means of justifying the design and selection of literacy and thinking tools.

4. Justification for a neurologically consistent criterion

The types of thinking described in relation to the thought linked criterion have their genesis and residence in the brain. It is unsurprising, therefore, that a neurologically consistent criterion should emerge from a review of recent literature from neuropsychologists. This criterion emerges from research by cognitive neuroscientists (Gazzaniga, Irvy & Mangun, 2002; Willis, 2007a, 2007b; Wolfe, 2001) and stipulates that literacy and thinking tools should be brain-friendly, that they should align with the way the brain learns naturally. Visual (mental) images associated with model thinking are neurologically consistent and have a long tradition in thought experiments and education (Dagher, 1995; Gilbert, 2005; Gilbert & Boulter, 2000). Visual (mental) images can be used to understand objects, events and ideas that are unfamiliar to students (like starvation) or abstract, like time, or unavailable to direct inspection (sometimes because objects and events are hidden, like mental illness, sometimes because they are too small to see, and sometimes because they would take more than a lifetime to observe, such as fossilisation). Like any mental model, visual images are likely to be (i) wrong in some key respect, (ii) simple or complex, (iii) more or less understood as imaginary rather than real, and (iv) more or less representative of students' understandings of the things they are meant to illustrate (Dyche, McClurg, Stephans, & Veath, 1993). It should be also noted that some people cannot image (Treagust, 1993; Whitehead, 1995).

Justification for the inclusion of this criterion is, naturally, based on an understanding of the literate brain. At a general level the brain processes verbal language (words, mathematical and scientific symbols and formula), and non-verbal language (illustrations and mental visual images) in two separate but connected systems (Sadoski & Paivio, 2001) – reading and writing are not exclusively verbal. These systems provide at least two ways of knowing. The verbal system provides one way of knowing about a person, for example, stating in a sentence: "Stanley Yelnats was persistent." The non-verbal system provides another way of knowing about Lord Rutherford, for example, by forming a visual mental image of him walking across a dried up lake bed eating onions.

At a specific level, neurological justification for the use of visual imagery tools comes from findings which show that functionally specific areas of the cerebral cortex permit the generation and manipulation of images (see Figure 16.4). Areas at the back of the brain in the occipital lobe which are crucial for sight (visual perception), are also crucial to the representation of mental models as images (Kosslyn, Ganis, & Thompson, 2001). These areas work in concert with areas on the left side of the brain that associate images with words, and areas on the right side of the brain that allow us to think about the spatial extent of images. The motor cortex area on the left side of the brain is implicated in the rotation of image (Tomasino, Borroni, Isaja, Rumiati, & Farah, 2005) and all these areas work under the direction of the prefrontal cortex that acts like an executive decision maker, allowing us to consciously image and engage in imagery thinking. Justification for the neurologically consistent criterion lies in understanding the parts of the neural network that facilitate modelling and other types of thinking.

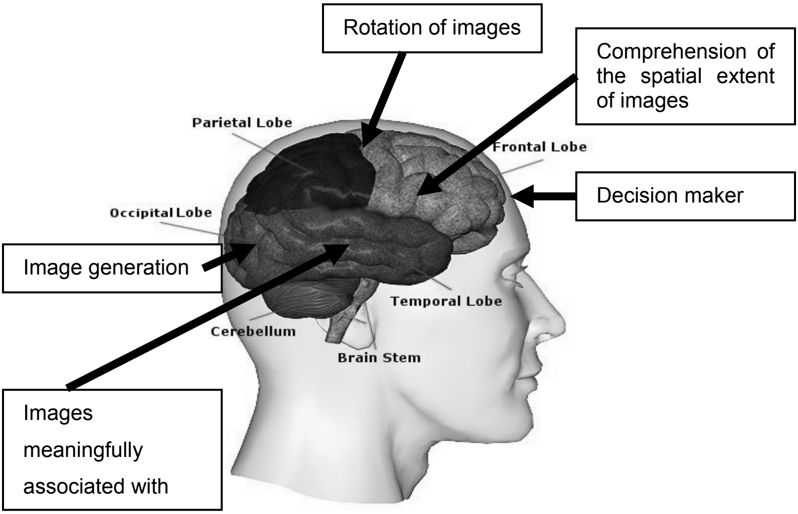

Figure 16.4 Areas of the brain involved in visual mental imagery

A neurologically consistent tool

Tools consistent with this criterion align with the way the brain learns. When teachers use tools and texts to engage students in different types of thinking, they operate on the brain as assuredly as neurosurgeons. The neural fabric of the brain is restructured or pruned every time a literacy and thinking tool is used. In this sense, the very structure of our brain – the relative size of different regions, the strength of connections between them, even their functions – reflects the pedagogy we use. Like sand on a beach, the brain bears the footprints of the decisions we have made, the tools we have used and the conversations we have conducted.

Visual imagery tools prompt students to generate and manipulate different types of visual mental images. For example, the use of a visual image to think about changes in a character's psychological state requires the generation of transformational images that represents those changes of state. Zooming in on that representation, or changing one's imaginary position in respect to that character can offer 'insight' into that character's psychological state and provide viable re-view and retrieval cues.

In a practical sense, during a lesson, teachers might ask students to make a static visual image, for example, of a character that is not moving. Then students might engage in imagery thinking by making their image move, allowing them to 'see' the character involved in a narrative episode. When students are asked to share the things they imaged (move from a non-verbal to a verbal representation) they are given the opportunity to express and further clarify what they know. At this point, and consistent with findings of behavioural indicators of expert model use (Coll, France, and Taylor, 2005), they should be provided with an opportunity to compare and critique their mental models with those of experts. These might be available by closely re-reading a text or examining illustrations that accompany a text. As a lesson closure designed to foster metacognitive thinking, students might discuss whether images and imagery thinking affected their understanding; whether the use of this type of neurologically consistent literacy and thinking tool helped them learn.

Tools consistent with the thought linked criterion serve as an interdisciplinary adhesive, as a super-set that connects disciplines. These tools have a unifying effect across the curriculum and allow teachers to redefine knowledge as a way of knowing. Visual imagery tools are whole brain tools, but justification for their design and selection lies in understanding the parts of the neural networks that facilitate the generation and use of the images. Like visual imagery tools, all literacy and thinking tools should be neurologically consistent because teaching and learning should align with how the brain learns naturally.

5. Justification for a subject specific criterion

While some literacy and thinking tools, like *thinking maps* (Hyerle, 1996) and cooperative learning tools such as *think-pair-share* (McTighe & Lyman, 1998) suit most subjects, other tools are more suited to specific subjects because they align with their language and epistemological characteristics (the types of thinking that underpin how those subjects construct knowledge). For example, scientists probably have more use for *flow diagram* tools than most other subject specialists because the reading and writing of explanations, and the cause and effect thinking inherent in their work and those literate tasks, are central to the traditional way scientists construct knowledge. However, note that creative thinking is a crucial antidote to the tyranny of empiricism.

A subject specific tool

The simple *flow diagram* illustrated in Figure 16.5 is well suited to science because it helps students explain changes in, for example, the states of matter. This tool also helps them acquire the verbal and visual language associated with these changes. Specifically, this tool assists students use 'causal link' words and visual text features associated with the academic language of scientific explanations ('because', 'so', 'when', etc). It is also formative, supporting conceptual development over time by requiring students to draw a series of sketches that represent and stretch their understandings, and to draft and re-draft their understandings as captions.

1. Sketches drawn over a series of lessons, explaining the process of water evaporating from the ocean.

Final draft caption explaining events in the pictures using 'because'.

Water evaporates from the ocean <u>because</u> warm air heats the water and molecules escape as water vapour.

2. Sketches drawn over a series of lessons, explaining the process of water vapour condensing into rain drops.

Final draft caption explaining events in the pictures using 'so'.

<u>So</u>, the warm humid air rises into the sky and begins to cool and turn into rain drops.

3. Sketches drawn over a series of lessons, explaining the process of water freezing.

Final draft caption explaining events in the pictures using 'when'.

<u>When</u> water gets cold enough, it becomes a solid called snow, or a solid called ice like in hailstones.

4. Sketches drawn over a series of lessons, explaining the process of snow melting into water.

Final draft caption explaining events in the pictures using 'when'.

<u>When</u> snow or ice heats up (or loses cold), it becomes a liquid again, and when it heats up even more, it becomes a gas or water vapour again.

Figure 16.5 A simple captioned *flow diagram* tool describing changing states of matter.

The three *flow diagram* sketches and caption in Figure 16.6 illustrate a student's developing understanding of evaporation, the subject specific language used to explain this process, and their ability to use the visual language of science. The student understands that the space between molecules of water vapour make it less dense than water, that scientists use schematic diagrams and that water vapour is better suited to an explanation of evaporation than steam.

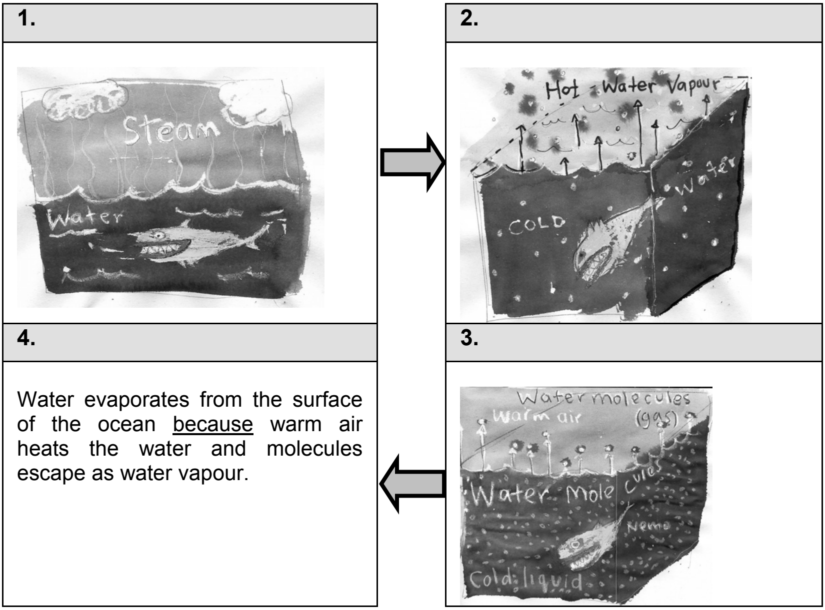

Figure 16.6 Sketches drawn over a series of lessons, exploring the process of water evaporation

6. Justification for a text linked criterion

Support for a text linked criterion is linked to the claim that specific subjects preferentially evoke certain types of thinking, and the additional claim for links between types of thinking and text types. Indeed, Pontecorvo (1993) goes so far as to suggest that "forms of discourse become forms of thinking" (p191). Implicit in this claim is that different types of thinking can be evoked through specific discourse practices (including reading and writing specific text forms). Additionally, the thinking associated with, for example, writing a factual report, is both a response to epistemology of the subject of the report, (that is, to subject specific ways of knowing) and to the type of thinking evoked by the type of text commonly used by that subject. These claims seem to underpin a key recommendation by Hipkins et al. (2002) that "students need to be coached in communication styles" (p179). Indeed, Lemke (1990) notes that a hallmark of engaging in learning is the opportunity to acquire subject specific discourse, a position consistent with that of functional systemic linguists (Halliday, 1985; Martin, 1985) who make links between the social construction of knowledge and text forms.

Further evidence justifying the inclusion of a text linked criterion comes from research that suggests comprehension is enhanced if readers make use of (i) text features associated with 'conventional' genre, and (ii) top level text structures including cause-effect, compare-contrast, and problem-solution structures typical of paragraph (Duke & Pearson, 2002; Goldman, 1997).

A text linked tool

Literacy and thinking tools that evoke types of thinking similar to that evoked by a text students are required to read, write or talk are probably best used when students read, write or talk those texts. This is because of the synergies generated between subject specific, thought linked and text linked criteria. These synergies are illustrated by the links between the *concept frame* tool (see Figure 16.1) and the report text about birds (see Figure 16.7). The tool is consistent with the text linked criterion because it is designed to help students comprehend or construct report texts and engage in the type of thinking associated with those tasks.

Specifically, the *concept frame* tool evokes, in part, attribute thinking – students are prompted to list (see 1–3 in the 'Can' and 'Have' sectors of the *concept frame*) the attributes of an object, event or idea. In turn, report texts represent the outcome of attribute thinking – they too record the attributes of objects, events and ideas. Given that both the *Concept Frame* tool and report texts evoke similar types of thinking they should, consistent with the text linked criterion, be used together.

From a linguistic perspective the *concept frame* tool is also consistent with the text linked criterion. Different parts of a *concept frame* reflect some of the 'conventional' structural features of report genre. One structural feature of a report, usually found toward the beginning, classifies the topic ("Birds are … animals that fly"). Students can use information from the unshaded sector of the *concept frame* (see Figure 16.1) to help them write this part of a report. Information from the shaded sectors of the *concept frame* can be used to write the body of a report (identified in the shaded area of Figure 16.7). This information might be written as in simple sentences ("Birds can chirp"), or as more complex sentences and paragraphs that reflect deeper understandings.

Title: Birds of a Feather

Engagement

Our parakeet, Wally, squawks and his cage sometimes smells. Wally is a bird and has a curved beak and beautiful feathers.

Classification

Most birds are animals that fly. But there are some birds, like emus and kiwis that don't fly. All birds have feathers. Some birds like parakeets have colourful feathers, and some like the bald eagle are mostly dark in colour. All birds are avian.

Body

Anatomy

All birds have feathers. Some feathers are long like the tail feathers of a peacock. Some feathers are colourful and others black like those of a crow. Feathers are hollow inside which makes them light.

All birds have beaks. Some are curved, others are long and thin, others are short and strong, and others are flat and wide. The type of beak a bird has and what it eats are related.

All birds have wings, but not all birds can fly. Some sea birds have wings up to two yards long. The emu has stumpy wings and can not fly.

Behaviour

Most birds can fly. Some birds like the humming bird fly very fast. Other birds like the eagle soar and glide and don't flap their wings as fast as a humming bird.

You might think that all birds can chirp, but the parakeet we have at home makes a loud screeching noise that doesn't sound like a chirp. Many small birds chirp, especially the ones with short strong beaks for eating grain.

But not all birds eat grain. Birds with different shaped beaks eat different things. For example, humming birds eat nectar from flowers and eagles eat meat and fish.

Figure 16.7 A short annotated report text about birds linked to a simple *concept frame*. Note: Underlined words are from the simple *concept frame* tool about birds (see Figure 16.1)

7. Justification for a developmentally appropriate criterion

The progression from the use of tools by teachers and later learners is consistent with the teaching focus and learner focus criterion signals that tools need to be developmentally appropriate. The justification for this criterion lies along at least three dimensions. The first is that the design and use of tools should scaffold students from a dependence on the teacher to an independence from the teacher. The second is that tools should provide a challenge to learners. This dimension is consistent with research by Locke & Latham (1992) that suggests achievement is enhanced to the degree that students and teachers set challenging goals, and that the greater the challenge the higher the probability of students seeking, receiving, and assimilating feedback information. The availability of developmentally appropriate tools at three levels of challenge reflects this research.

Third, and consistent with calls from educational psychologists for developmentally appropriate teaching and differentiated instruction (Brophy, 2001), tools consistent with this criterion need to be designed for use with students at different levels of social, academic and cognitive maturity. Thus the developmentally appropriate criterion reflects beliefs about variations in students' attention spans, and in the types of text-related intellectual tasks they encounter in classrooms. Consistent with these three dimensions, the tools used to illustrate criteria described in this paper have been designed at three developmental appropriate levels; simple, intermediate and complex. For example, the simple c*oncept frame* (see Figure 16.1) provides students with just four headings that assist them to gather and record information. In terms of Bloom's (1956) taxonomy this evokes little more than recall and understanding. In contrast, intermediate and complex c*oncept frames* (see Figures 16.8 and 16.9) require students to work with five headings and to further process information in each sector of each frame. In terms of Bloom's (1956) taxonomy this requires students to analyse and synthesise information.

What these three developmentally appropriate levels do not assume is that students' age should determine which tools they use. If eight-year-old students are capable of using intermediate rather than simple tools, they should be encouraged to use them. Many students in the early years of schooling are capable of abstract thinking even when presumed to be operating at a concrete operational stage. However, the more abstract thinking evoked by some complex tools might signal the need to scaffold their use, that is, to use them in ways consistent with the teaching focus criterion rather than the learner focus criterion. Teachers can plan to use tools at an appropriate level, but bear in mind that levels should never deny students opportunities to think.

A developmentally appropriate tool

The developmental appropriate levels of the three *concept frames* illustrated in Figures 16.1, 16.8 and 16.9 are designed to provide students with challenges appropriate to their intellectual development and experience. The simple level tool probably best suits 5–8-year-old students, or students using literacy and thinking tools for the first time. The intermediate level tool is designed to challenge the thinking of 8–12-year-olds and should suit students who can already use simple tools confidently and independently. The complex level tool is designed for use in secondary schools or with gifted and talented students, who will probably begin to use a range of tools in combination.

Is … / is a …		**BIRDS**	**Are …**	
Order	*Belongs to a group*		*Order*	*Things about them*
3.	Animals that fly		2.	Pets
2.	An avian		1.	Expensive to keep
1.	Animal with feathers		X	Colourful
X.	A noisy thing		3.	Meat eaters

Can …		**Has … /has a … /have …**		**Examples**	
Order	*Actions*	*Order*	*Things they have*	*Order*	*Examples*
4.	Chirp	1.	Feathers	2.	Eagle
2	Fly	2.	Claws	1.	Crow
1.	Eat grain	3.	Wings	3.	Sparrow
5.	Spread disease	4.	Curved beaks	4.	Chaffinch
3.	Dirty windows	5.	Stubby beaks	5.	Kiwi

Figure 16.8 An intermediate *concept frame* tool about birds.

For example, when used as a teaching tool, a simple *concept frame* (see Figure 16.1) can be used as a text-linked, pre-writing tool. This tool enables teachers to assess and record before, during and after a series of lessons, and to collaborate with students as they use each sector of their completed frames to write simple pattern sentences, for example, 'A bird can …, A bird has …, A bird is …, An example of a bird is …, or a more complete report text.

In contrast, students may find the intermediate and complex *concept frame* tools more challenging. At the intermediate level students are asked to further attend to what they know by ordering information in each sector of the *concept frame*. This order will be reflected in the structure of their written report texts. They might also decide that some information doesn't align with what they want to write in their report, and signal this with an 'X' beside the word (see Figure 16.8).

A complex level *concept frame* requires students to generate additional ideas by using the 'Examples' words (see right hand bottom sector in Figure 16.9) to construct and answer questions. To achieve this students would begin with a name of a bird listed in the 'Examples' sector, for instance 'Eagle', and add a sector header word ('is', 'are', 'can', or 'has') to 'Eagle' to construct their question. For example, 'An eagle is …?', or 'Eagles can …?' or 'An eagle has …?' Students then conduct further research and record answers to those questions in the appropriate sector of the *concept frame*. For example, 'Eagles can … catch rabbits' so 'catch rabbits' would be recorded under the 'can' sector heading of the *concept frame* (see point 6. '*Catch rabbits'* under 'Can' in Figure 16.9). In addition, the complex *concept frame* requires students to group information. Figure 16.9 illustrates how groups have been made for 'damaging' things birds can do, and for examples of birds that are 'meat eaters' and 'grain eaters'.

The developmentally appropriate criterion reminds us that literacy and thinking tools should be designed at three levels of 'challenge' that align with students' social and cognitive strengths.

Is … / is a … *Order* *Belongs to a group* 3. Animals that fly 2. An avian 1. Animal with feathers X. A noisy thing	**BIRDS**	**Are …** *Order* *Things about them* 2. Pets 1. Expensive to keep X Colourful 3. Meat eaters 4. *Threatened*
Can *Order* *Actions* *Groups* 4. Chirp 2 Fly 1. Eat grain 5. Spread disease 3. Dirty windows *6. Catch rabbits* (1, 5, 3 → Da maging)	**Has … /has a … /have …** *Order Things they have* 1. Feathers 2. Claws 3. Wings 4. Curved beaks 5. Stubby beaks	**Examples** *Order* *Groups* 2. Eagle 1. Crow (→ Meat eaters) 3. Sparrow 4. Chaffinch (→ Grain eaters)

Figure 16.9. A complex *concept frame* tool about birds.

8. Justification for a culturally responsive criterion

A further criterion that can be applied to justify the design and selection of literacy and thinking tools is cultural responsiveness. This criterion is aligned to the belief that students should think about their own and others' thinking, and more specifically, should reflect on the ways in which indigenous cultures construct knowledge.

<u>A culturally responsive tool</u>

The *universal perspective* tool (Whitehead, 2004b) is culturally responsive because it enables students to engage in a type of worldview thinking that has its genesis in indigenous cultures. The tool enables students to appreciate the perspective of people who see themselves as one within a connected universe (connected to nature, society and supernatural realms). First, this tool requires students to identify whether an author has constructed identities that were universally connected to, or separated from a culturally specific zeitgeist. It then requires them to appreciate the effect on meaning of a non-universal perspective, and finally to think critically about an author's text by asking why they adopted (or didn't adopt) a universal perspective. Literacy and thinking tools consistent with the culturally responsive criterion can assist us to communicate interculturally and appreciate the perspectives of others.

9. Justification for an assessment linked criterion

The forms of assessment teachers use have a powerful influence on the kinds of instruction students encounter, and the kind of learning they can accomplish. Underpinning the assessment linked criterion is the belief that there is nothing inherently wrong with assessing the content and processes we teach, as long as we concurrently and regularly assess in ways that reflect how that content and those processes were taught. The assessment linked criterion is, therefore, consistent with the use of literacy and thinking tools that engage students in formative assessment (Black & Wiliam, 1998).

The use of tools as concurrent and formative learning and assessment measures is consistent with Neisser's (1976) claim that assessment items should be constructed in such a way that students recognise and treat them as familiar and representative of the actual learning experience – that is, that they should be *ecologically valid* items. Thus, tools that align with the assessment linked criterion as assessment items, simultaneously assess both subject content and students' ability to use the tools employed to teach and learn that content. This criterion goes to the heart of how we teach and our understandings of how we learn.

The use of literacy and thinking tools as assessment items may require some teachers to change their pedagogical metaphors of 'knowledge-as-object', 'mind-as-container'. This pair of metaphors fails to reflect that knowledge, and especially the procedural knowledge associated with the use of literacy and thinking tools, which is something that does things, or makes things happen (Castells, 2000). If we accept that knowledge has what Lyotard (1984) calls *performativity*, it follows that the assessment of literacy and thinking should be consistent with Claxton's (2004) 'school as gymnasia', 'fit mind', and 'mental exercise' metaphors. When we work out at the gymnasium we don't look at the equipment, we use it, just as we use literacy and thinking tools to manipulate what we know and construct new meanings. Tools consistent with the assessment linked criterion should tell us how well a student can use what they know.

An assessment linked tool

The assessment item illustrated in Figure 16.10 can be used as a planned, formative, pre-test item to gauge students' prior knowledge of a topic, and as an ecologically valid summative post-test item (assuming the tool was used concurrently to learn the content). Assessment linked tools provides teachers with opportunities to test as they teach; to assess not only what is taught (about rocks), but also how it is taught.

A rock is ... 1 2 3	A rock can … 1 2 3
Examples of rock are … 1 2 3	A rock has … 1 2 3

Figure 16.10 A simple *concept frame* tool used as a pre- and post-test item

Instruction: Define the meaning of a rock as accurately as you can by completing the simple *concept frame*.

Conclusion

The use of literacy and thinking tools consistent with these nine design and selection criteria impact on how we plan and conduct our lessons, assess learning and view the role of education in society. For example, learning intentions and success criteria will identify tools linked to texts and types of thinking. Lessons will align more with co-construction than transmission models of teaching, and assessment will become more formative. The use of knowledge by a population of literate thinkers will be valued by society. Changes will occur to curriculum and teacher education programs, to the extent that tools for gathering, processing and reflecting are valued as part of our schools' culture along with content.

The use of literacy and thinking tools, justified against these nine research based criteria, provides a way of addressing a tendency among some teachers to rely on their pedagogy, a bit like a drunk uses a lamp-post – to support the way they teach rather than to shed light on alternative and justifiable pedagogies. Moreover, some teachers only use their lamp-post. Too often we seize on what we know and on historic precedent to support the way we teach without the justification of research based criteria. We resist looking for future directions because we have adopted comfortable labels. I believe the use of tools that align with these nine criteria should be an integral component of our programs, and should be prized, not only because their application leads to attractive learning opportunities, but also because the journey toward those destinations is extremely satisfying and motivating for both teachers and learners alike.

References

Alton-Lee A (2003). *Quality teaching for diverse students in schooling: Best evidence synthesis.* Wellington: Ministry of Education.

Alvermann D, Hayes D A (1989). Classroom discussion of content areas reading assignments: An intervention study. *Reading Research Quarterly*, 24: 305–335.

American Association for the Advancement of Science (1996). *Benchmarks for science literacy.* New York: Oxford University Press.

Ashcraft M (2007). *Cognition.* New York: Pearson.

Black P J, Wiliam D (1998). Assessment and classroom learning. *Assessment in classroom learning: Principles, policy and practice*, 5(1): 7–74.

Blaut J M, Stea D, Spencer C, Blades M (2003). Mapping as a cultural and cognitive universal. *Annals of the Association of American Geographers*, 93(1): 165–185.

Block C C, Pressely M (Eds), (2001). *Comprehension instruction: Research-based best practices.* New York: Guilford.

Bloom B (1956). *Taxonomy of educational objectives.* New York: Longman, Green and Co.

Brooks J G, Brooks M G (1993). *In search of understanding: The case for constructivist classrooms.* Alexandria, VA: Association for Supervision and Curriculum Development.

Brophy J (Ed), (2001). Subject-specific instructional methods and activities. *Advances in Research on Teaching, Vol. 8*. New York: Elsevier.

Castells M (2000). *The rise of the network society, 2nd Edn.* Oxford: Blackwell.

Claxton G (2004). Mathematics and the mind gym: How subject teaching develops a learning mentality. *For the learning of mathematics*, 24(2): 27–32.

Coll R K (2005). The role of models, mental models and analogies in chemistry teaching. In P Aubusson & A G Harrison (Eds), *Metaphor and analogy in science education*. Dordrecht: Kluwer.

Coll R K, France B, Taylor I (2005). The role of models/and analogies in science education: implications from research. *International Journal of Science Education*, 27: 183–198.

Collins A, Loftus E (1975). A spreading activation theory of semantic processing. *Psychological Review*, 82: 407–428.

Curriculum Council (1998). *Curriculum framework for kindergarten to year 12 education in Western Australia.* Osborne Park, WA: Author.

Dagher Z R (1995). Analysis of analogies used by science teachers. *Journal of Research in Science Teaching*, 32(3): 259–270.

Donovan M S, Bransford J D, Pellegrino J W (Eds), (1999). *How people learn: Bridging research and practice.* Washington: National Academy Press.

Duke N, Pearson P D (2002). Effective practices for developing reading comprehension. In A E Farstrup & S J Samuels (Eds), *What research has to say about reading instruction, 3rd Edn,* (pp205–242). Newark, DE: International Reading Association.

Dyche S, McClurg P, Stephans J, Veath M L (1993). Questions and conjectures concerning models, misconceptions and spatial ability. *School Science and Mathematics*, 93(4): 191–197.

Eisner, Elliot W (1985). *The art of educational evaluation: a personal view.* London: Falmer Press.

Farah M J, McClelland J L (1991). A computational model of semantic memory impairment: Modality specificity and emergent category specificity. *Journal of Experimental Psychology*: *General,* 120: 339–357.

Fogarty R (1994). *How to teach for metacognitive reflection.* Arlington Heights, IL: Skylight.

Gazzaniga M S, Irvy R B, Mangun G R (2002). *Cognitive neuroscience, 2nd Edn.* New York: Norton.

Georghiades P (2000). Beyond conceptual change learning in science education: Focusing on durability, transfer and metacognition. *Educational Research*, 42: 119–139.

Gilbert J (2005). *Visualization in science education.* Dordrecht: Springer.

Gilbert J, Boulter C (2000). *Developing models in science education.* Dordrecht: Kluwer.

Goldenberg C (1993). Instructional conversations: Promoting comprehension through discussion. *Reading Teacher*, 46(4): 316–326.

Goldman S R (1997). Learning from text: Reflections on the past and suggestions for new directions of inquiry. *Discourse Processes*, 23(3): 357–398.

Guthrie J T, Wigfield A (2001). *Engaging in reading through science: Motivating strategies across the disciplines.* Paper presented at the Crossing Borders: Connecting Science and Literacy conference, Baltimore, MD.

Hattie J A (1992). Towards a model of schooling: A synthesis of meta-analyses. *Australian Journal of Education*, 36: 5–13.

Hattie J (2003). *Teachers Make a Difference: What is the research evidence?* Paper presented to the Australian Council for Educational Research, October 2003.

Halliday M A K (1985). *An introduction to functional grammar*. London: Edward Arnold.

Hipkins R, Bolstad R, Baker R, Jones A, Barker M, Bell B, Coll R, Cooper B, Forret M, Harlow A, Talyor I, France B, Haigh M (2002). *Curriculum Learning and Effective pedagogy: A literature review in science education.* Report to the Ministry of Education.

Hyerle D (1996). *Visual tools for constructing knowledge.* Association for Supervision and Curriculum Development: Alexandria, Va.

Kosslyn S M, Ganis G, Thompson W L (2001). Neural foundations of imagery. *Neuroscience,* 2: 635–642.

Lemke J L (1990). *Talking science: Language, learning and values*. Norwood, NJ: Ablex.

Lipman M (1977). *Philosophy in the classroom*. Montclair State College, Upper Montclair, NJ: Institute for the Advancement of Philosophy for Children.

Locke E A, Latham G P (1992). Comments on McLeod, Liker & Lobel, *Journal of Applied Behavioral Science*, 28: 42–45.

Lyotard J F (1984). *The postmodern condition: A report on knowledge.* Manchester: Manchester University Press.

Martin J (1985). *Factual writing: Exploring and challenging social reality.* Geelong: Deakin University Press.

Martin R, Sexton C, Wagner K, Gerlovich J (1997). *Teaching science for all children, 2nd Edn*. Boston: Allyn & Bacon.

McComas W F (1998). *The nature of science in science education*. Dordrecht: Kluwer.

McTighe J, Lyman F (1988). Cueing thinking in the classroom: The promise of theory-embedded tools. *Educational Leadership*, 45(7): 18–24.

Millett S (2003). Thinking tools for teaching ethics across the curriculum. *Critical and Creative Thinking*, March, 2–13.

Ministry of Education (2006). *Effective literacy practices in Years 5–8*. Learning Media: Wellington.

National Institute of Child Health and Human Development (2000). *Report of the National Reading Panel. Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. Washington: Author.

Naylor S, Keogh B, Downing B (2001). *Dennis likes a good argument: Concept cartoon, argumentation and science education*. Paper presented at the annual conference of the Australasian Science Education Research Association, 11–14 July.

Neisser U (1976). *Cognitive psychology*. New York: Appleton-Century-Crofts.

Pohl M (2000). *Learning to think, thinking to learn: Models and strategies to develop a classroom culture of thinking*. Highett, Vic: Hawker Brownlow Education.

Pontecorvo C (1993). Forms of discourse and shared thinking. *Cognition and Instruction*, 11(3&4): 189–196.

Pinker S (2002). *The blank slate*. New York: Penguin.

Ruddell M (2002). *Teaching content reading and writing, 3rd Edn*. New York: Wiley.

Russell B (1912). *The problems of philosophy*. Oxford: Oxford University Press.

Sadoski M, Paivio A (2001). *Imagery and text*. Mahwah, NJ: Lawrence Erlbaum.

Scott P, Asoko H, Driver R (1992). Teaching for conceptual change: A review of strategies. In R Duit, F Goldberg & H Niederer (Eds), *Research in physics learning: Theoretical issues and empirical studies* (pp310–329). Kiel: Institute for Science Education at University of Kiel.

Shaywitz S E, Shaywitz B A (2007). What neuroscience really tells us about reading instruction. *Educational Leadership*, 64(5): 74–76.

Taylor I J (2000). *Promoting mental model-building in astronomy education.* Unpublished PhD Thesis, University of Waikato, Hamilton.

Tomasino B, Borroni P, Isaja A, Rumiati R, Farah M (2005). The role of the primary motor cortex in mental rotation: a TMS study. *Cognitive Neuropsychology*, 22(3&4): 348–363.

Treagust D F (1993). The evolution of an approach for using analogies for teaching and learning science. *Research in Science Education*, 23: 293–301.

Whitehead D (1995). *The design and validation of a visual imagery ability questionnaire*. Unpublished PhD Thesis, University of Waikato, Hamilton.

Whitehead D (2001). *Top tools for literacy and learning*. Auckland: Pearson Education.

Whitehead D (2004a). *Top tools for teaching thinking*. Auckland: Pearson Education.

Whitehead D (2004b). *World-view perspectives*. Paper presented at the Language, Education and Diversity conference, University of Waikato, November, March 2004.

Willis J (2006). *Researched based strategies to ignite student learning*. Alexandria, Virginia: Association for Supervision and Curriculum Development.

Willis J (2007a). The gully in the 'brain glitch' theory. *Educational Leadership,* 64(5): 68–73.

Willis J (2007b). Toward a neuro-logical reading instruction. *Educational Leadership*, 64(6): 80–82.

Wolfe P (2001). *Brain Matters: Translating the Research to Classroom Practice.* Alexandria, VA: Association for Supervision and Curriculum Development.