Justifying the design and selection of literacy and thinking tools

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Abstract

Criteria for the design and selection of literacy and thinking tools that allow educators to justify what they do are described within a wider framework of learning theory and research into best practice. Based on a meta-analysis of best practice, results from a three year project designed to evaluate the effectiveness of a secondary school literacy initiative in New Zealand, together with recent research from cognitive and neuro-psychologists, it is argued that the design and selection of literacy and thinking tools used in elementary schools should be consistent with (i) teaching focused (ii) learner focused, (iii) thought linked (iv) neurologically consistent, (v) subject specific, (vi) text linked, (vii) developmentally appropriate, and (viii) assessment linked criteria.

Key words: Literacy, thinking, tools, justifying criteria.

Most of the literacy and thinking tools I used as a beginning elementary school teacher were copied from my colleagues. When de Bono (1976) and his CoRT thinking program was published we were caught up in the hype, but we failed to apply our knowledge of learning theories, let along any criteria specific to the design of his tools, to justify why we were using PMI (positive, minus, interesting) or CAF (consider all factors), other than they struck us as clever. Likewise, data from interviews, observations and questionnaire (Wright, May, Whitehead, & Smyth, 2005, 2006) suggests that school teachers in New Zealand who use Concept Frames and other literacy and thinking tools (Whitehead, 2001) (see Figure 1) are hard pressed to justify their use of those tools. This article suggests that it is important to establish criteria for the design of literacy and thinking tools because, as professionals, elementary school teachers need to justify what they do (Whitehead, 2006).

What is a literacy and thinking tool?

The intermediate Concept Frame is a literacy and thinking tool. This formative tool provides a four sector frame with a heading in each sector that prompts learners to think about what a specified concept can do, attributes and examples of that concept, and to what class of things the concept belongs. Additionally, the tool prompts learners to order what they record as an indication of how this information might be used in a report. The Concept Frame will be used to exemplify the design and selection criteria described in this article.

Links to learning theory

The design of literacy and thinking tools are related to particular learning theories and unrelated to others. For example, there is little evidence that behaviourism can provide either justification for the design of, or explanation for the effects of using literacy and thinking tools. In contrast, cognitive theories (Ashcraft, 2007) that seek to explain learning as information processing dependent on memory, attention, and task, provide useful explanatory frameworks for justifying the use of these tools. These theories explain the effects of tools designed to engage working and longer term memory, and assist learners to attend to tasks that present more or fewer degrees of challenge. Similarly, theories of social cognition (Vygotsky, 1978) provide an explanation for the effect of using literacy and thinking tools. These theories foreground the role of culture in providing the content for thinking (the 'what to think'), the tools of intellectual adaptation (the 'how to think'), and the dialogic setting in which literacy and thinking tools are used to solve problems. Further, the use of these tools as *teaching tools* is consistent with Vygotsky's zone of proximal development, and the formative structure of tools that are described at three levels of challenge is consistent with understandings about how we learn. Likewise, constructivist theories which seek to explain learning in terms of the active construction of ideas or concepts based upon current and past knowledge are consistent with the use of literacy and thinking tools, because they accept that a teachers' role is to help learners construct knowledge by working together.

Identifying design criteria

In addition to this broad explanatory framework are more specific criteria that can be applied to justify the design and selection of literacy and thinking tools. These criteria, described in this article, were identify from reviews of research describing the characteristics of effective pedagogy (Hipkins et al., 2002; National Institute of Child Health and Human Development, 2000), together with recent research about learning from educational and cognitive psychologists (Hattie, 2003; Sadoski & Paivio, 2001), and neuroscientists (Shaywitz & Shaywitz, 2007; Willis, 2007a, 2007b; Wolfe, 2001).

These criteria emerged, in particular, from a meta-analysis 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 this analysis were based on five characteristics including whether the research indicated (i) quantitative evidence of increases in learner understanding and performance on authentic tasks, and (ii) qualitative evidence of improved learner understanding, and attitudes in the classroom.

Finally, the criteria emerged from an analysis of data obtained from a three year evaluation of the New Zealand Secondary School Literacy Initiative (SSLI) (see a special issue of *Language and Education* edited by May and Smyth, 2007; Wright, Whitehead, May and Smyth, 2007) that involved a group of 60 pilot secondary schools. A quasi-ethnographic, multi-locale methodology was employ for this evaluation which involved detailed case studies in four schools a year, together with visits to classrooms and interviews with teachers and administrators in non-case study schools. The methodology engaged school principals, Heads of Department and Heads of Faculty, literacy leaders, and teachers, in semi structured interviews. These 'conversations with a purpose' (Burgess, 1988) were transcribed an analysed thematically. Additionally the researchers administered and analysed responses to a questionnaire designed to gauge the impact of the SSLI, and analysed artefacts (resources provided to teachers, memorandums and language policy statements) that provided some indication of cross-curricular sharing of literacy and thinking tools, the embeddedness of literacy principles and practices in departmental/faculty programmes, policies and professional goals.

A key outcome of this research was that schools that benefited most and sustained the initiative were characterised by literacy leaders and regional facilitators who lead learning (rather than just adopting the role of literacy 'master teacher'). They provided what Schoenbach et al. (1999) describe as 'highly-designed' professional development and mentoring sessions that focused on theoretical understandings about teaching and learning, or what one respondent called 'the head space stuff up front'. This focus provided staff with a theoretical basis for justifying their use of literacy and thinking tools.

Criteria for the design of literacy and thinking tools

The eight research-based design criteria that emerged from these analyses and research projects were that tools should be consistent with 1) teaching and 2) learner focused criteria, connected by virtue of their pedagogical focus; 3) thought linked and 4) mind compatible criteria, connected by virtue of their cognitive focus; 5) subject specific and 6) text linked criteria, connected by virtue of their literacy and epistemological focus; and 7) developmentally appropriate and 8) assessment linked criteria, connected by virtue of their formative focus. Justification for the inclusion of the teaching focused, learner focused, developmentally appropriate and assessment linked criteria stem,

primarily, from the research of educational and developmental psychologists (Alton Lee, 2003; Hattie, 2003; Hipkins et al., 2002; Neisser, 1976). Research by functional systemic and critical linguists (Gee, 1990; Halliday, 1985; Martin, 1985) and psychologists (Pinker, 2002) provide justification for the text linked and subject specific criteria. The thought linked and mind compatible criterion reflect recent research from cognitive and neuro-psychologists (Ashcraft, 2007; Gazzaniga, Irvy & Mangun, 2002; McComas, 1998; Willis, 2007a; Wolfe, 2001). Each of these criterions will now be detailed.

1) The teaching focused criterion

According to a meta-analysis of research describing the characteristics of best practice conducted by Hattie (2003), teachers account for about 30% of the variance in learner achievement. What elementary teachers know, their pedagogical content knowledge, is crucial to learner achievement. In addition, what they do, such as provide feedback and quality instruction including direct instruction, and what they care about, for instance that learners should have high expectations, is crucial to learner achievement.

Tools, including the intermediate Concept Frame, that align with this criterion are consistent with the characteristics of best practice. It can be used as a teaching tool 'at the board' or through a data show when adopting direct instruction or transmission approaches. It allows teachers to scaffold learners (Alton Lee, 2003; Hattie, 2003) from dependence on them to independent literate thinkers. The tool acknowledges prior learning by eliciting first lesson recordings on the frame, and provides teachers with opportunities to model different types of questions associated with conceptual inquiry (Alvermann & Hayes, 1989; Brooks & Brooks, 1993; Goldenberg, 1993; Hipkins et al., 2002; Martin, Sexton, Wagner & Gerlovich, 1997; Ruddell, 2002).

The use of a teaching focused criterion ensures that the design and selection of literacy and thinking tools used by elementary school teachers is consistent with the characteristics of best teaching practice.

2) The learner 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 because they equip learners with a means of becoming life-long, literate thinkers. The reason why elementary school teachers need to use tools consistent with a learner focused criterion is because democratic societies need literate critical thinkers who can use a range of literacy and thinking tools independently.

The Concept Frame can be used by learners, independently, to record and then critique information from a report text, or as a note making frame prior to writing a report text.

3) The thought linked criterion

One general reason for proposing a thought linked criterion is because learning evoked through the use of literacy and thinking tools is an active cognitive process. Given the focus on the teaching of thinking in curriculums internationally a second reason is that literacy and thinking tools are designed to differentially evoke different types of thinking. It is important that teachers identify those different types of thinking. And it is important that they are able to align those types of thinking with the way disciplines construct knowledge (Paul, 1987). A third reason for proposing a thought linked criterion aligns with the claim that elementary school teachers should reconstruct knowledge as a verb (Gilbert, 2005, Lyotard, 1984). Literacy and thinking tools consistent with the thought linked criterion assist learners do something with what they know.

A fourth reason for proposing a thought link criterion aligns with another claim that elementary teachers and students need a language to objectify thinking. Teachers need a range of (i) generic labels such as creative, critical, reflective and caring, and (ii) taxonomic thinking labels such as remembering, understanding, applying, analyzing, evaluating and creating, and labels that stem from an information processing perspective such as (iii) conceptual thinking (associated with the representation of concepts about objects, animals, events and ideas) and (iv) episodic thinking (that help us think about information that has a temporal dimension). These four types of thinking will be outlined below. In essence, the thought linked criterion is premised on the supposition that elementary school teachers should identify the types of thinking evoked by the tools they use.

(i) Generic types of thinking (creative, critical, reflective and caring)

Labels objectifying generic types of thinking are well established in the literature about teaching and learning. For example, the [Australian] Curriculum Council (1998) notes that when students' plan science investigations, (although this clearly applies to other subjects), they engage in critical, creative and metacognitive (reflective) types of generic thinking. Others highlight the role of caring (and ethical) thinking (Lipman, 1977; Millett, 2003; Pohl, 2000) and memory thinking (Whitehead, 2004). These types of thinking are also explicitly stated in the Victoria (Australia) and New Zealand Curriculum documents.

More specifically, creative thinking is listed in the Hong Kong curriculum and defined as the ability to generate *original* ideas and solve problems in *appropriate* contexts. Others see creative thinking as offering new perspectives, generating novel and meaningful ideas, raising new questions, and proposing solutions to problems (Sternberg & Lubart, 1999).

Critical thinking, listed in most curriculum documents, is fundamental to philosophical inquiry. It is a type of thinking that results in 'deeper' and 'broader' thinking, abstract thinking (stemming from concrete examples), and higher order thinking about 'big issues' (Wilks, 1992). Other research notes that critical thinking in authentic contexts results in learners '...asking questions, trying to answer those questions by reasoning them out and believing the results of their reasoning' (Nosich, 2005, p. 5). The intermediate Concept Frame engages students in critical thinking by prompting them to ask and answer four or more questions (implied in the subheadings) about a concept.

Likewise, reflective or metacognitive thinking is listed in most curriculum documents internationally. In Dewey's (1933) view the development of reflective thinking is the most important goal of education because it enables learners to take responsibility for their learning. This type of thinking is significantly associated with learner achievement (Scott, Asoko, & Driver, 1992). Indeed, literacy and thinking tools that evoke reflective thinking have, arguably, the largest impact on learner achievement (Donovan, Bransford, & Pelligrino, 1999; Georghiades, 2000). The independent and appropriate use of a Concept Frame implies learners can think metacognitively.

Caring thinking, often disguised as values, has affective and ethical dimensions. Together they help us establish value systems from which to make compassionate value judgments. Affective thinking is about being mindful of self and others, about appreciating the intrinsic worth, beauty or value of objects such as the sensory/aesthetic appeal of a painting, or an idea, or a person's attitude. According to Goleman (1995) affective thinking encompasses and strengthens what he calls emotional intelligence and includes self-awareness, self regulation, resilience, empathy and social skills.

Haidt (2007) sees moral intuitions and emotions as the foundation of ethical behaviour. Traditionally, ethical thinking has been seen as helping us decide what is 'right' and 'wrong'. There are at least five types of ethical thinking that inform the design of ethical thinking tools and that support the inclusion of a thought linked criterion. These are (i) ends-based, (ii) fair and just, (iii) rule based, (iv) care based, and (v) common good thinking.

i. Ends-based thinking helps learners select actions that result in the greatest good for the greatest number (a utilitarian principle).
ii. Fair and just thinking helps learners select actions that favour or discriminate against others, that is, assists them to decide how fair an action is, whether it treats everyone the same way or whether it favours some people without justifiable cause.
iii. Rule based thinking helps learners decide what to do based on a rule. These rules may be legal, religious, or particular to a social group or personal.
iv. Care based thinking helps learners decide what to do based on the idea that this is what they would want others to do to them.
v. Common good thinking is consistent with the belief that actions should be linked to the common good of society.

Implicit in the adoption of the thought linked criterion is the need for teachers to understand different types of generic thinking, and the need, ultimately to decide whether these types of thinking have a place in their programmes, and if so, when and to what extent.

(ii) Taxonomic types of thinking

Of all the types of thinking consistent with the thought linked criterion, taxonomic classifications are perhaps the most significant. They have driven the design of educational documents and teacher planning for many years. Most notable is the classification provided by Bloom and subsequently revised by Anderson & Krathwohl (2001).

(iii) Conceptual thinking

Concepts include our knowledge about objects, events and ideas/beliefs. Humans appear to have an innate ability to represent direct experiences as concepts. Indeed, every human society classifies plants and animals into species-like conceptual groups represented in the brain as connected attribute and classification 'meaning nodes' (Blaut, Stea, Spencer & Blades, 2003; Farah & McClelland, 1991). Tools, such as the Concept Frame that differentially evoke conceptual thinking are designed to reflect the way evolutionary and cognitive psychologists think concepts are stored in memory and the way we use these representations (Collins & Loftus, 1975; Pinker, 2002).

(iv) Episodic thinking

Episodic thinking is associated with the comprehension of events/episodes that occur over time. Tools that support the composition of narrative and recount texts are thought linked because they differentially evoke episodic thinking. Indeed, tools that evoke narrative thinking seem to be consistent with the default setting of the mind to construct reality through narrative (Tulving, 2002). Other researchers claim that '…narrative is universally basic to conversation and meaning making', and that '...humans appear to have a readiness, from the beginning of life, to hear and understand stories' (Read & Miller, 1995, p. 143). Their argument here is that reality is narrative linked.

The thought linked criterion reflects the ability of literacy and thinking tools to differentially evoke generic, taxonomic, conceptual, and episodic types of thinking and prompt teachers to identify the types of thinking evoked by the tools they use. However, it would be unwise to apply this criterion as a means of defining types of thinking as mutually exclusive. Likewise, despite the imperative implied by this criterion, it would be unwise to assume any single association between a specific tool and a specific type of thinking. The potential for tools to evoke multiple types of thinking render popular classifications such as 'creative thinking' or 'creative thinking' as problematic. But the fact that tools evoke different types of thinking should neither deter elementary school teachers from the professional responsibility to understand these types of thinking, nor

be used to dismiss the thought linked criterion as a means of justifying the design and selection of literacy and thinking tools.

4) The mind compatible criterion

Types of thinking associated with the thought linked criterion have their genesis in the mind (which is what the brain does). It is reasonable, therefore, that the design of literacy and thinking tools should be consistent with a mind compatible criterion; that they should be brain-friendly (Gazzaniga, Irvy & Mangun, 2002; Willis, 2007a, 2007b; Wolfe, 2001). But given the development of understanding about the brain, and brain-to-practice links, we should proceed with caution. Clearly, if the brain were so simple we could understand it, we would be so simple that we couldn't.

The mind compatible criterion should serve to remind us that when we teach we operate on learners' brains as assuredly as neurosurgeons. The neural circuitry of the brain is re-structured or pruned every time we teach; the very structure of our brain, the relative size of different regions, the strength of connections between them, even their functions reflects the way we teach. Like sand on a beach, the brain bears the footprints of the decisions we have made, the tools we have used, and the instructional conversations we have conducted.

Some links between this criterion and types of thinking described under the thought linked criterion are used below to provide further justification for the inclusion of this criterion.

Creative (metaphoric) thinking

There are functionally specialised and connected systems that engage, bilaterally, in the brain when we construct or comprehend novel metaphors like 'The doctor was a butcher'. These include an area in the temporal lobe (Brodmann area 37) which is also implicated in verbal creativity, and areas in the pre-frontal lobes (Brodmann areas 44/45 and area 46) involved in thinking (Mashala, Fausta, Hendlerc & Jung-Beemane, 2007).

Critical thinking

There is ample evidence that areas of the left pre-frontal lobes (Brodmann areas 45 /46 / 9) are crucial to critical thinking and problem solving. However, given that a major component of reasoning seems to be nonverbal, it is unsurprising that the right side of the brain should play a significant part (Whitaker et al., 1991). This seems to be true in respect to our ability to comprehend the theme of a story, generate inferences and establish story coherence.

Caring thinking (affective and ethical thinking)

The saying 'I was so mad I couldn't think straight' is true, and universal. Emotions interrupt thought. The primary function of an area above the eye balls (Brodmann area 47), and the amygdala, a small walnut shaped body at the top of the brain stem, is to process emotion. These areas form a key part of the system that turns emotion into feelings and allow readers to form factual memories that have an emotional content.

There are also systems in the brain linked to moral/ethical thinking. These involve pre-frontal areas (Brodmann areas 9, 45, 46, and 10). The front part of area 9 is especially active when we think about impersonal moral dilemmas, and an area in the upper back section of the temporal lobe (Brodmann area 39) is active when we make personal moral judgments such as recognising a sad face or an aggressive gesture.

Reflective thinking

Reflective thinking refers to any process that involves planning, monitoring, regulating or evaluating the way we think. Reflective thinking includes knowledge we have about our cognitive abilities ('I have a bad memory'), about our cognitive strategies ('to remember a phone number I should rehearse it'), and about tasks ('categorized items are easier to recall'). A review of brain imaging studies focused on reflective (meta cognitive) thinking reveals that the brain circuitry associated with attention, monitoring, and regulating behaviour is located in the upper front sections of the brain, (Brodmann areas 8 and 9), and the middle and lower pre-frontal areas, (Brodmann areas 46 and 47) (Fernandez, Baird & Posner, 2000; Shimamura, 2000).

Episodic thinking

There is research suggesting that our brains have a pre-wired default setting that pre-disposes them to construct understandings about the world in narrative form, which explains why story telling is found in every culture (Troiani, Ash, Reilly & Grossman, 2006). It appears that there is no single area or circuit responsible for episodic narrative thinking, however, several studies indicate it is associated with an area in the upper back part of the parietal lobe (Brodmann area 7) which is key to recalling events, along with upper frontal areas (Brodmann areas 8 and 9) which help us to organize information into connected narrative form and think about what has been recalled (Ash et al., 2006; Rugg, Otten &Henson, 2007).

A key component of episodic narrative thinking is the ability to infer the feelings and predict the intentions of characters. This ability is called 'theory of mind'. Most of us have an innate ability to deceive, cooperate, empathize, and read the body language of others. These abilities operate out of the prefrontal sections of the brain (areas 45, 46 and 9) (Baron-Cohen et al., 1985; Geary, 2005; Gallagher & Frith, 2003; Rizzlatti et al., 2001; Siegal & Varley, 2002).

Conceptual thinking

Concepts or facts about objects, events and ideas are stored in many different and connected parts of the brain. Concepts seemed to be stored in systems along the middle and lower parts of the temporal lobe (Brodmann areas 37, 38, 20, 21 and 22). Conceptual categories such as objects, peoples' names, verbs, and animals are stored in separate areas. For example, it seems our concepts for people (autobiographical memories) are stored in Brodmann area 38, animals in Brodmann area 20, and tools at the bottom of Brodmann area 37. A small area at the top of the brain stem called the amygdale has a specific role in memory for emotionally disturbing concepts. Together, these are the areas differentially engaged when learners use an intermediate Concept Frame.

5) The subject specific criterion

The subject specific criterion and the following text linked criterion are relevant because they are both concerned with literacy and with how language facilitates the construction of knowledge. The intermediate Concept Frame can be used across curriculum areas. In contrast, Flow Diagram tools align with the subject specific criterion because they are well suited to the explanatory discourse of science.

National curriculum documents are typically divided into subject domains. What we know about each subject is the outcome of subject specific, disciplined types of thinking. For example, the American Association for the Advancement of Science (1996) has identified three types of subject specific 'scientific thinking': systemic, temporal-causal, and model thinking. Systemic thinking helps learners comprehend how a water cycle (a system) works, or how actual or fictional social systems work. The two components of temporal-causal thinking are change and scale. Science involves thinking about how things change over time and how much they change. This type of thinking also applies to the comprehension of narrative plots or historical recounts. Model thinking allows us to represent ideas, objects and events, often unavailable to direct inspection, as metaphor, analogies, and visual mental images (Coll, 2005; Gilbert & Boulter, 2000; Taylor, 2000). Clearly model thinking also has a place in English, mathematics, and other subjects.

Together, these arguments give support for the inclusion of a subject specific criterion that might be applied to justify teachers' use of literacy and thinking tools.

6) The text linked criterion

Support for a text linked criterion is based on the claim that specific subjects evoke certain types of thinking, and the key additional claim for links between types of

thinking and text types. Indeed, Pontecorvo (1993) suggests that 'forms of discourse become forms of thinking' (p.191). For example, the thinking associated with writing a report, is both a response to subject specific ways of knowing, and to the type of text linked thinking evoked by subjects that use report texts. Writing a report about birds is both a response to science specific or ornithological ways of knowing about birds, and a response to the type of thinking evoked by the form and function of report texts. As, Lemke (1990) notes, a hallmark of engaging in learning is the opportunity to acquire subject specific discourse. This position is consistent with that of functional systemic linguists (Halliday, 1985; Martin, 1985) who make links between the social construction of knowledge and text forms. Literacy and thinking tools that evoke types of thinking similar to that evoked by a text learners are required to read, write, or talk are probably best used when they read, write, or talk those texts.

The subject specific and text linked criteria assist teachers to justify the literacy dimension of literacy and thinking tools.

7) The developmentally appropriate criterion

One reason for designing tools consistent with a developmentally appropriate criterion is linked to the professional responsibility of teachers to meet the needs of diverse learners. A second reason is linked to a principle that signals the need to scaffold students' learning. A further reason is that tools should provide a challenge to learners. This justification, consistent with research by Locke & Latham (1992), suggests achievement is enhanced to the degree that learners are set challenging goals; the greater the challenge the higher the probability of learners seeking, receiving, and assimilating feedback information.

Curriculum documents internationally, with the notable exception of the [Australian] Victorian curriculum, rarely include a developmental dimension in their description of literacy and thinking tools. In addition to the reasons outlined above, the inclusion of a developmentally appropriate criterion appears warranted because it is consistent with calls from educational psychologists for differentiated instruction (Brophy, 2001). Tools consistent with a developmentally appropriate criterion are designed to meet the needs of students at different levels of social, academic, and cognitive maturity. Thus this criterion reflects beliefs about variation in students' attention spans, ability to work in groups, motivation, learning styles, and in the types of text-related intellectual tasks they encounter in classrooms.

The developmentally appropriate criterion does not signal that tools should be age linked. If eight-year-old learners are capable of using an intermediate level Concept Frame rather than a simple level Concept Frame, they should be encouraged to do so. However, the more abstract thinking evoked by some 'complex level' 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 learners opportunities to think.

8) The assessment linked criterion

One reason for the inclusion of an assessment linked criterion is the need to recursively, monitor, plan, and teach when using tools. Another reason relates to the observation that forms of assessment have a powerful influence on the kinds of instruction learners' encounter, and the kind of learning they can accomplish. A further reason is based around the belief that there is nothing inherently wrong with assessing the content we teach, as long as we concurrently and regularly assess in ways that reflect how that content was taught. The assessment linked criterion is, therefore, consistent with the use of literacy and thinking tools that engage learners' in formative assessment (Black & Wiliam, 1998). The Concept Frame can be used as an assessment tool, thus enabling teachers to test as they taught, that is, in an ecologically valid way.

Conclusion

The importance of research linked criteria for the design and selection of literacy and thinking tools lays in the responsibility of elementary school teachers to justify what they do. These criteria described and justified in detail in this paper, provide guidance and understanding; guidance when it comes to selecting tools appropriate to learners needs and task demands, and understanding in respect to the impact of these tools on learning.

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