A knowledge enhancement perspective on learning[1]

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The brief for this paper

The brief for this paper is to identify what would be for me the main elements and conclusions that could be highlighted in the framework for developing "models of learning" as part of the new project on Alternative Models of Learning for the OECD Centre for Educational Research and Innovation. The paper will identify

- the main elements,
- research support for the elements and
- the conceptual framework that synthesizes the various elements.

The structure for this paper : Learning and knowledge

The conceptual framework that synthesizes the various elements of learning is a consideration of knowledge and how it is enhanced or changed. During learning an individual's knowledge is changed or transformed in various way. A knowledge oriented focus describes these changes in knowledge as individuals learn more about a topic and explains them. The main elements identified in this paper refer to key aspects of phases of the change process. The research support for the elements is provided by sourcing them in earlier research.

Why a knowledge enhancement perspective ? Dialogue about learning can come from a range of perspectives. This focus sees knowledge both as a goal or an outcome for learning; individuals engage in learning to change what they know. Learning is the process or the set of activities by which the outcome is achieved. It can be achieved in multiple ways, in a variety of contexts and under differing conditions.

It is the knowledge change or enhancement perspective that teachers, schools, students or parents use, often implicitly, when they decide whether learning has occurred. It is also this perspective that is used by governments, educational policy makers and providers when they are planning for and evaluating the effectiveness of the provision. It is also the perspective that is used by the culture and community more generally when it engages in dialogue about the success of education.

The conceptual framework used in this paper describes learning in terms of the change in a topic as it is learnt. The knowledge enhancement involves three major phases:

1. activating what the person knows; the learner's existing knowledge
2. gradually changing one's knowledge; the learning of new knowledge and
3. consolidating and transferring the knowledge change.

The three phases of knowledge are shown in the following diagram:

| The learner's existing knowledge |
| The learning of new knowledge |
| consolidating and transferring the knowledge change |
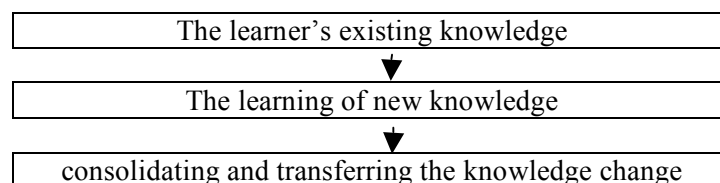
The paper uses this approach to identify what it sees as the key elements in a' model of learning". It examines

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- the notion of knowledge and its nature as a platform for learning,
- the conditions under which learning is likely to be initiated,
- learning as a process involving the gradual transformation of aspects of knowledge and
- the distinction between temporary understanding and permanent retention.

Learning begins with what the learner knows : The learner's existing knowledge

An individual's knowledge provides the starting point for learning. It provides the 'platform' for interpreting the teaching information at any time and for evaluating and using the feedback received. A main element in building a "model of learning" is an examination of how learners' knowledge is organised before, during and after learning. From a teaching perspective, teaching that takes account of how this in more likely to facilitate learning.

A main element of a model of learning is how it conceptualises each aspect of knowledge, how it sees the aspects linked and how each aspect contributes to learning. This paper examines the first two of these issues in this section and third issue in the section titled *The learning or knowledge change process*.

How the present model conceptualises each aspect of knowledge What does this paper mean by knowledge ? The term 'knowledge' can be interpreted in a range of ways. The present paper uses the term to refer to all that an individual or a group (a community, etc.) knows about one's self and one's world. It includes one's

(1) bank of stored experiences and a distillation of these, that is, experiential or episodic knowledge (Tulving, 2002; Gardner, 1995);
(2) abstract conceptual and propositional knowledge and the associated procedural knowledge or skills (Anderson,1982);
(3) attitudes and dispositions towards topics or phenomena (Krathwohl, Bloom & Masia, 1956).
(4) knowledge of self in relation to others and the cultures of which one is a member;
(5) knowledge of how to think and to learn, (Pressley & Harris, 1990), (for example, how to reflect, to think creatively and critically, to think about possibilities), to transfer and contextualize one's knowledge, motivational knowledge, including motivation to achieve, self efficacy (Nichols & Utesch, 1998) and
(6) beliefs and metaphors about one's world.

These aspects of knowledge can be indicated on the diagram showing the phases of learning as follows:

The learner's existing knowledge						
experiential knowledge	abstract conceptual knowledge	procedural knowledge	attitudes / disposition towards topics	knowledge of self in relation to others	knowledge of how to think and to learn	beliefs and metaphors about one's world
The learning of new knowledge						
Consolidating and transferring the new knowledge						
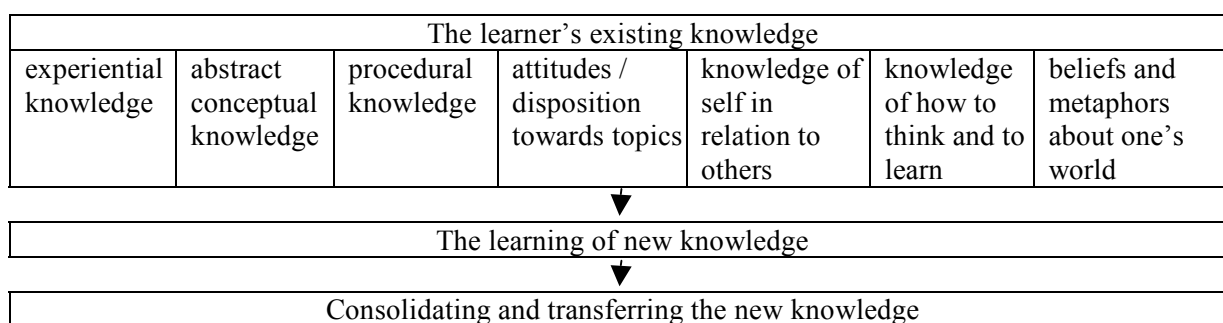
These types of knowledge have described in terms of a range of concepts such as learning and cognitive styles (for example, Riding & Cheema, 1991), dual and multiple information processing codes (for example, Paivio, 1991), memory (Baddeley, 1990) and intelligence (Wechsler, 2004).
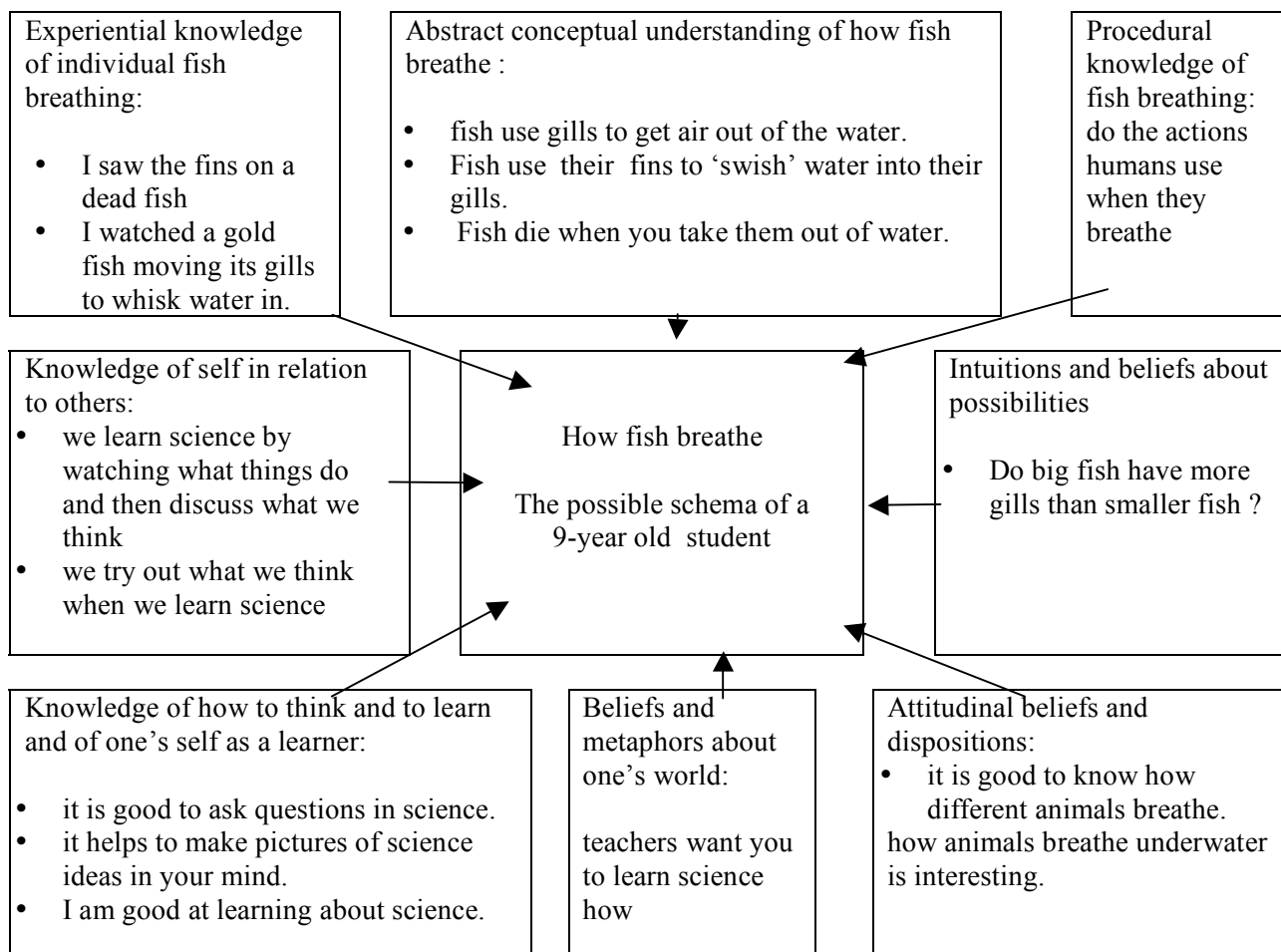
How does this paper see the aspects linked ? There are two components to this question:

- How are the aspects linked in knowledge ?
- How are the aspects linked during learning ?

How are the aspects linked in knowledge ? Individuals organize and link the above aspects of knowledge in complex 'topic-' or 'domain-' like ways. The topic does not necessarily refer to conventional subject

categories but rather the set of ideas an individual believes are linked with the topic. Learners link the relevant conceptual, procedural and experiential knowledge, their unique intuitions and beliefs about it, their attitudes and dispositions towards it and their knowledge of how to think and to learn it.

The notion of a 'schema' is used to describe the linked set of aspects (Perkins, Jay et al, 1993). The following diagram show part of the possible schema of a 9-year old student who is about to learn more about the topic *How fish breathe*.

| Experiential knowledge of individual fish breathing:

 • I saw the fins on a dead fish
 • I watched a gold fish moving its gills to whisk water in. | Abstract conceptual understanding of how fish breathe :

 • fish use gills to get air out of the water.
 • Fish use their fins to 'swish' water into their gills.
 • Fish die when you take them out of water. | Procedural knowledge of fish breathing: do the actions humans use when they breathe |

| Knowledge of self in relation to others:
 • we learn science by watching what things do and then discuss what we think
 • we try out what we think when we learn science | How fish breathe

 The possible schema of a 9-year old student | Intuitions and beliefs about possibilities

 • Do big fish have more gills than smaller fish ? |

| Knowledge of how to think and to learn and of one's self as a learner:

 • it is good to ask questions in science.
 • it helps to make pictures of science ideas in your mind.
 • I am good at learning about science. | Beliefs and metaphors about one's world:

 teachers want you to learn science how | Attitudinal beliefs and dispositions:
 • it is good to know how different animals breathe.
 how animals breathe underwater is interesting. |

While this is obviously a simplistic representation of what is a complex network of relationships, it shows, superficially at least, some of the aspects of knowledge that would influence the student's understanding at one point in time. These aspects would influence subsequent learning by the student.

The various aspects of knowledge are not mutually separate and isolated from each other in a 'silo' type model. Instead, they are intricately linked and interact. A person's knowledge of a topic can be thought of as being made up of 'microscopic' meaning units (McClelland & Rogers, 2003) that are linked into networks of meanings. The aspects of knowledge described above involve different types of links. At the risk of being overly simplistic, when individuals are making sense of information or thinking about a topic, they may draw on several types of links. They may

- link the ideas in time and place and think of how they occur in specific contexts, (experiential knowledge).
- think of how the ideas are linked in more abstract, decontexturalised' ways in propositions (abstract conceptual knowledge).
- link the ideas in action sequences (procedural knowledge).
- link the units of meaning with their values and feelings about the topic, for example, whether it interested them or was useful (attitudes and dispositions).
- link the ideas with the contexts in which they learnt similar ideas previously, for example, how the roles of 'teacher' and 'learner' operated in those situations (knowledge of self in relation to others).

- link the ideas with how they went about learning them, the learning actions they used, whether they were successful learners (metacognitive knowledge, self efficacy, motivational knowledge).
- link the ideas with beliefs and metaphors about their world.

In the above schema, examples of these units of meaning are 'fin', 'fish', 'science', and 'breathe'. The student may link a mental image with 'fin' and may also link it with a word description' and an action. The units of meaning or knowledge are linked into networks of relationships. The meanings 'fin', 'have' and 'fish' can be linked into the relationship "Fish have fins". As well, the student links their attitude and disposition with it, and may recall earlier contexts in which they thought about the ideas, how successful they were learning and using the ideas and significant others who were there.

These linked sets of ideas inform what individuals know or understand at any time (Anderson, 1994; Reed, 1993; Roth, 1990). One's knowledge comprises the linked set of topics. The topics differ in the extent to which they are represented by the various aspects. Some topics may be represented largely by experiences. Some may be represented more abstractly.

One's understanding of a topic or a phenomenon is determined by the totality of what one knows about it at that time. It is the synthesis of those aspects of knowledge that are in the person's consciousness or awareness at that time.

Individuals show evidence of representing aspects of their world from a very young age. By the second month of life, infants can recognise items they have seen earlier. By the fourth month they understand cause and effect in a simplistic action way; those who have learnt to kick a particular mobile to get a pleasurable outcome can transfer this to other mobiles.

Learning involves building increasingly more complex units of meaning. As individuals learn more about a topic or a subject,. These aspects of knowledge and how they are organised are acquired gradually over a developmental trajectory. Knowledge representation begins early.

These aspects of knowledge occur at both the social and the individual levels. Individuals learn concepts defined by the culture/s in which they interact (Cole 1998; Valsiner & van der Veer, 2000). Cultures value particular aspects of knowledge (Hodges,1998) and foster particular ways of learning (Munro, 2007). For any individual, each aspect is likely to have both culturally defined and idiosyncratic aspects.

One's culture influences how learners organise their knowledge. Cultural information indicates how ideas are linked and what is valued as salient experiential features to link with a concept. Cultures differ in
- how they define concepts and propositions,
- the typical experiences they foster and value,
- how they use knowledge to make decisions, to solve problems and to meet their range of needs,
- the symbolism they use to represent and to link ideas,
- the ways in which they scaffold learning and
- the beliefs they foster about learners and learning.

Nine year old students in different cultures may be expected to have quite different schemata about the topic *How fish breathe.*

How are the aspects linked during learning ? During learning, learners are thinking about part of what they know. Potentially, all of the aspects they have in their schema for the topic of the learning could be active. Nine year olds learning about how fish breathe might think about what they know from their experiences, and what they know more abstractly. Their earlier experiences learning about fish and science will have provided them with attitudes and dispositions to this topic and with ways of how to learn it. As well, they will have beliefs about whether they can learn this type of topic successfully, how to do this and what is expected of teachers and peers during this learning.

The set of ideas that is active during learning is referred to as the thinking space. This is the 'location of the learning'. Usually during learning, learners have to think consciously about the ideas; they 'invest learning or thinking attention' in the ideas. Some ideas need a lot of attention during thinking. Others, those the learner knows 'relatively automatically', need little attention. That is, they 'take up little thinking space'.

The amount of thinking space or learning attention is limited. Sometimes a person may think about two or more topics at once. These compete for the available attention. Learners need to prioritize how they allocate this. It is also affected by the learner's level of arousal and physiological conditions (such as poor diet, physical discomfort, pain and illness).

Sometimes, learners need to give attention to how they use or show what they know. They do this by saying, writing or 'doing' what they know. This display allows them to 'see how well their understanding fits' at any time and to receive corrective feedback that can shape their subsequent understanding. Some may not have automatized the accepted ways of doing this and need to give thinking attention to using them. This limits the attention they can invest in the knowledge they could show.

Another complicating factor is that humans can learn or think both consciously and unconsciously simultaneously (that is, without investing attention; thinking by 'incubation'). They may also use knowledge without being aware of it (tacit knowledge). This may include automatized actions, earlier experiences or beliefs and attitudes.

These factors can affect how well learners link ideas during learning. They lead to sources of individual difference in formal learning. Models of learning need to examine these phenomena.

The specific ways in which the ideas are linked during various phases of knowledge change during learning are described in more detail in the relevant section of the paper.

Learning and thinking in a virtual world Cultures influence how aspects are linked in knowledge and during learning. An example of this is shown in the differences in the knowledge and ways of thinking between students who play virtual reality games and those who don't. Compare the meaning networks of those who have played virtual reality games with those who have largely read written texts or played reality based games.

Virtual reality allows individuals to interact and think in contexts that distort and extend reality. They make decisions and solve problems in contexts in which the units have non-real life properties and are not constrained by real life rules. They can solve problems, for example, by standing 'beyond reality'. This differs from operating in contexts that involve real life units that operate on real life rules and constraints.

As well, making decisions in virtual realities often involves rapid thinking in terms of two or more competing criteria at once in an 'on-balance' way. The context is usually in immediate time; reality constraints at a deeper level are not relevant. The consequences of risk taking are often transitory and require little deep consequential or inferential thinking.

To engage these students in what is seen as acceptable learning, educators need validated tools that assist them to understand what these students know and how they learn and think.

The conditions under which learning is likely to be initiated A framework for learning, I believe, needs to examine the conditions under which learning is more likely to be initiated. From a knowledge perspective, this is when individuals are aware that their knowledge of a topic is insufficient, in terms of various criteria. They may (1) need to solve problem; (2) seek to increase their understanding of a topic; (3) seek an outcome that requires thee knowledge.

This is the 'challenge; or 'purpose for learning' and can be conceptualised on a dimension ranging from an interest in knowing more about a topic and reducing uncertainty to achieving outcomes unrelated to the topic such as being accepted by others or course entry criteria. The mechanism for catalysing or stimulating learning in Western theories is the state of 'cognitive conflict' (Lowenstein, 1994; Piaget, 1986) or "sociocognitive conflict" (Tudge, 1990).

This state draws on both affective and cognitive aspects of knowledge. It is influenced by learners' earlier learning success in the domain, their attitudes and dispositions, interest, curiosity and valuing of the domain

as well as their conceptual knowledge and their knowledge of their learning context. It has been recognised as a factor in learning in recent years and subsumed under 'learners' agency and interest in learning' (Boekaerts & Boscolo, 2002). The present position examines it as a separate influence.

The challenge can arise both from the learner and from external sources. Its locus on an internal-external continuum influences the motivation to learn, the learning actions used to learn and qualities of the outcome. Obviously it has the capacity to both stimulate learning and to resist learning.

This continuum is linked with the 'autonomous learner' model of learning (Ablard & Lipschultz, 1998; Boekarets, 1997; Pintrich, 1995). This paper takes the position that self directed learning activity needs to be seen to be in balance with externally directed learning in any context and has a domain specific aspect, such that individuals learn to be 'self directing' and 'autonomous' in each domain.

The nature of the balance, it is proposed, varies culturally. Cultures differ in how they construct autonomous, self directed learning and in how they interpret it to describe thinking and learning, how they model and encourage autonomy, the areas of knowledge they value and teach and the opportunities students have to learn to be autonomous thinkers and learners. They also differ in how they encourage students to frame up purposes for learning and the extent to which they encourage a personal curiosity about areas of knowledge.

The learning or knowledge change process : The gradual changes in knowledge
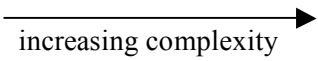
A sixth main element in building a model of learning is how it explains learning, that is, the actions or processes by which aspects of existing knowledge are transformed or changed, in terms of both individual and social-cultural processes. These aspects of knowledge are learn in different ways;

- experiential knowledge is learnt by linking the new ideas in specific contexts;
- abstract conceptual knowledge by linking new ideas in across specific contexts;
- strategic procedural knowledge as the selective use of action sequences;
- dispositional and attitudinal knowledge by linking values and feelings with the new ideas through affective attributional processes, feedback and modelling;
- knowledge of the contexts in which they learnt the ideas, for example, the roles of 'teacher' and 'learner';
- knowledge of how to learn by learning how to talk about and reflect on their learning, identifying what learning actions and motivation styles worked for them, monitoring their success as learners.

As well, the quality or form of each aspect can vary as learners change how and what they know about a topic:

1.   A newly learnt topic may be understood in an attention-demanding, non-fluent way. Learners may

     - understand its parts, but not integrate them.
     - understand it in specific contexts rather than as a generalized proposition
     - understand a proposition superficially and not see its implications or inconsistencies.

2.   With further learning of the topic, learners transform the knowledge to a more abstract, integrated form and may use established symbolic conventions. They can apply its more broadly and see analogies with other topics.

3.   Further transformations of the knowledge, so that it is more like that of the expert knowledge, are described in the next section Review and Consolidation.

These gradual changes in the aspects of knowledge of a topic and how it is known are shown in the following diagram:
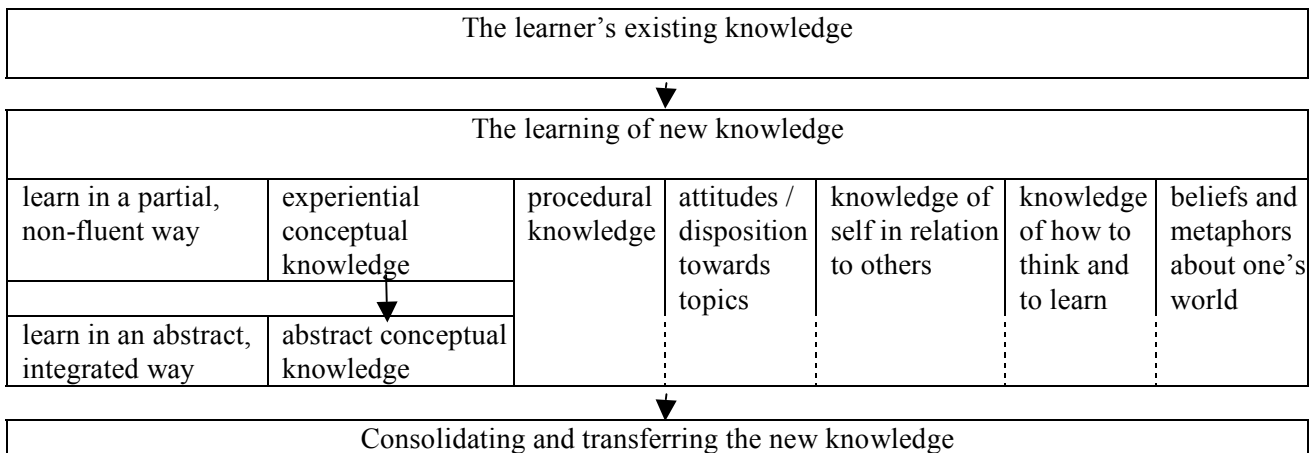
Aspect of knowledge	Form of the new knowledge increasing complexity →		
	Known in a partial, non-fluent way	Known in abstract, integrated way	Known in an 'expert way'
experiential conceptual		■■■■■	
abstract conceptual	■■■■■		
strategic procedural			
dispositional and attitudinal			
contexts for learning the ideas			
how to learn both cognitively and metacognitively			

Each unshaded cell is potentially an up-dated aspect of knowledge. As a learner's knowledge a topic gets closer to the 'expert' form, the aspects of knowledge become more integrated and the relevance of separate cells decreases.

A key element of a model of learning is describing and explaining these transformations.

Given the limitations of space, this paper focuses on conceptual learning. This section examines learning new ideas initially in partial, experiential ways and gradually moving to abstract, integrated forms.

As learners make this transition in their conceptual knowledge, they as well continue to transform the other aspects of their knowledge in parallel, integrated ways. They have the potential to learn more complex procedures, attitudes, ways of learning and thinking, etc. They can, for example, increase the complexity of the attitudes and disposition they link with the topic. These aspects of learning are on the diagram showing the phases of learning. The dotted lines dividing the aspects of learning is intended to show their increasing synthesis.

The learner's existing knowledge

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The learning of new knowledge						
learn in a partial, non-fluent way	experiential conceptual knowledge	procedural knowledge	attitudes / disposition towards topics	knowledge of self in relation to others	knowledge of how to think and to learn	beliefs and metaphors about one's world
learn in an abstract, integrated way	abstract conceptual knowledge					

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Consolidating and transferring the new knowledge

Learning conceptual knowledge in experiential ways. A key element of a learning framework is how it explains how existing knowledge is changed or a new topic is learnt. It is examined here for learning conceptual knowledge in experiences.

How new links are formed. Learning involves forming new links between aspects of knowledge. The new links may add to, differentiate and elaborate or replace existing links.

Learners generate the new knowledge by linking ideas in various ways, for example, they may

•   link two or more items or actions that occurred in experiences.

- sequence or order ideas in various ways.

- link ideas using shared features into categories and then concepts and later learn to link concepts into hierarchies.

- link symbols with items and then with sets of items that share a feature and later think in symbols.

- analyze ideas in terms of various criteria, identify the typical properties of sets of items and form prototypes, prioritize ideas.

- link ideas 'logically', first in concrete contexts and then in more abstract ways, for example in cause-effect and consequential, probabilistic, or inclusive/exclusive relationships.

- transfer links by using analogy, transfer a set of links to other contexts.

- synthesize two or more ideas into composite ideas.

These ways of forming new links are the thinking, learning or cognitive strategies and skills that learners gradually acquire and use to 'make meaning' of their world. The new links represent new meaningful relationships. They may provide improved understanding of a topic, ability to explain particular phenomena, additional beliefs and speculations about possibilities, new action sequences or problem solving procedures.

How do learners know which ideas to link ? As noted earlier, learners construct new knowledge under various conditions. Two extremes are:

- when instructed to link existing knowledge in particular ways. This type of learning frequently requires learners to process information in an analytic-sequential way.

- during self-initiated learning; learners speculate about a possible new link, try it out to see how it fits, modify it if necessary and perhaps rationalize it. Learners frequently make analogies using their experiential knowledge to form new links. Thinking strategies such as visualizing assist here.

  Learning by analogy is a key means by which learners create new ideas (Goswami, 1998). While Inhelder and Piaget (1958) claimed that it was used by learners how had achieved higher order thinking, Goswami and Brown (1990) showed that much younger children learnt by forming analogies between real life experiences and perceptually similar contexts. The use of analogistic thinking as an essential cognitive strategy is frequently neglected in formal education.

  Although this type of learning is frequently described as 'incidental' or 'spontaneous', anecdotal data suggest learners form a strategic knowledge focus; they are curious about the topic, generate questions and pursue an enquiry.

The balance between self directed versus externally directed learning has a matching distinction in constructivist theories of learning; that between radical constructivism (Von Glasersfeld, 1995) and ; empirical constructivism (Jonassen, 1991).

The new knowledge is usually tentative initially. Learners need to try it out to see how it 'fits' or 'works'. They do this in various ways, for example, they may reflect to test its 'sense' privately or display it more publicly to receive corrective feedback. It may also be experiential or intuitive initially. Learners may

- 'believe' a relationship exists, but cannot, at that time, justify it logically.
- have experienced it in particular contexts, but not be able to apply it in other situations.

Learners may show inconsistencies in the new knowledge, for example,
- show conceptual understanding in some contexts only.
- not co-ordinate their conceptual understanding with the correct application of it.
- not connect the conceptual understanding with the correct use of the related procedures.

In other words, they have learnt specific aspects of the topic but have not yet integrated and co-ordinated these aspects. Experiential knowledge is represented in imagery in particular contexts. Learners may 'feel an idea is reasonable' because it matches other experiences. They may not, at this time, have linked the imagery with more general logical language. Means for doing this are discussed in a later paragraph.

The new ideas become less tentative, experiential and intuitive as learners 'untangle' the topic from specific contexts (that is, 'decontextualize' it) and gradually automatize it. As they continue to practice and use the new ideas, they need to invest less thinking space or 'learning attention' in them. They now have more attention to allocate to making links with related ideas. They can recognize common features across experiences, question them, identify more general links them and test these. This activity can provide the necessary justification or logic and is described in a later section.

Corrective feedback is critical to learning Being a hunch tester' requires feedback about how the hunch 'works' or 'fits'. Learners use the feedback, both to evaluate and possibly modify areas of their knowledge, such as their understanding of the topic and their self efficacy (Bandura,1994). Hattie (2003) in a meta-review of a range of influences on learning, identifies feedback as the most important.

The corrective feedback is a type of formative assessment. To obtain it, learners need to know or learn 'how to read assessment situations', to display and align what they know, how to make opportunities for this and how to use the feedback they receive to evaluate their impressions. The feedback is itself knowledge that may include a comment on knowledge.
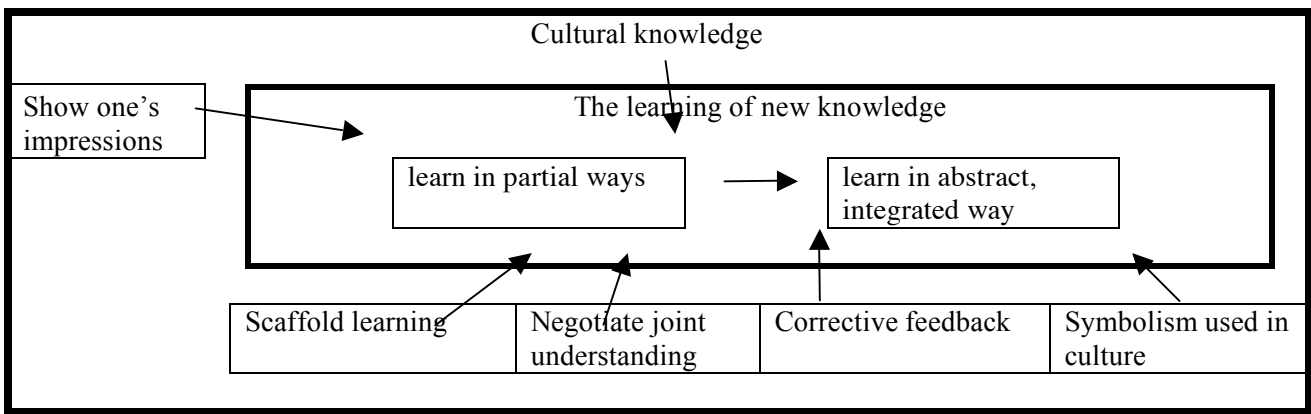
The feedback interaction provides a critical link with relevant cultural knowledge. Means for doing this are discussed in the next section. Cultures differ in how they construct the opportunities learners have for the feedback process, for example,. the conventions that govern acceptable display.

Learning is socially referenced Much learning occurs collaboratively, in interaction with significant others, for example, peers or teachers and mentors. Through participation in interactive dialogue and other activities, learners manipulate and trial their understanding, align it with that of others and use the feedback to reflect on and evaluate it. This permits learners to acquire a shared understanding or 'intersubjectivity' of the conceptual knowledge (Smolka, De Goes et al., 1995), to develop an awareness of 'cultural' or group knowledge (Valsiner & van der Veer 2000) and how this knowledge gradually emerges. They can also build their awareness of both the culturally referenced and personal aspects of what they know, how to use each in an integrated way and to value each aspect.

In other words, learners both learn the 'meaning making' or cognitive strategies mentioned earlier and how to use them, in collaborative learning contexts as well as individually. Peer imitation, modeling and using vicarious feedback are learning mechanisms. They learn to negotiate an understanding that has a shared component and to link their idiosyncratic knowledge of a topic with this. This is the 'sociocultural' / social constructivism (Scribner 1992; Valsiner 1994; Wertsch 1998). Cultures differ in their composite position on these interpretations of knowledge construction and on the learning activities they encourage for each.

An additional aspect of the collaboration is the opportunity for the scaffolding of learning. Social support from peers or adults can facilitate learning progress. The partners work together to co-construct the solution to a problem and decide the necessary activities.

Some of the cultural influences on an individual's learning are shown in the following diagram.

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┌─────────────────────────────────────────────────────────────────────────────┐
│                           Cultural knowledge                                  │
│  ┌──────────────┐    ┌──────────────────────────────────────────────────┐    │
│  │ Show one's   │    │          The learning of new knowledge           │    │
│  │ impressions  │──→ │   ┌──────────────────┐      ┌──────────────────┐  │    │
│  └──────────────┘    │   │ learn in partial │ ──→  │ learn in abstract,│ │    │
│                      │   │ ways             │      │ integrated way    │ │    │
│                      │   └──────────────────┘      └──────────────────┘  │    │
│                      └──────────────────────────────────────────────────┘    │
│         ┌──────────────┬──────────────┬──────────────┬──────────────┐         │
│         │ Scaffold     │ Negotiate    │ Corrective   │ Symbolism    │         │
│         │ learning     │ joint        │ feedback     │ used in      │         │
│         │              │ understanding│              │ culture      │         │
│         └──────────────┴──────────────┴──────────────┴──────────────┘         │
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Learners manage their learning activity.   Not only do learners engage in making new meaning during learning; they also manage or direct this activity. This is in greater demand during self initiated learning than when the learning is directed externally. However, in the majority of learning situations, learners exert some control over aspects of the learning. A key element of a learning framework is to explain the self management phenomenon, its nature and the mechanisms by which it operates.

This type of knowledge is referred to as 'metacognition'. It includes what learners know about useful learning strategies and how to use them selectively (Pitritch, 2002). Self talk or 'inner language' is a key vehicle for facilitating the use of metacognitive processes. Learners gradually build this knowledge from the time when they first become aware of the distinction between 'the knower' and 'what is known' (this is often towards the end of the preschool years (Kuhn & Dean, 2004).

As with other aspects of knowledge, this aspect has a social-cultural origin.   It reflects what individuals learn about how their culture uses linguistic knowledge to manage and direct behaviour and the culture's perspectives on reflection about knowledge and thinking.

Learners use this knowledge in various ways. When learning by solving a problem, for example, they plan how they will work through it, monitor the effectiveness of their activity, modify it if necessary and review what they have learnt.   They may decide how they will manage the cognitive demand of new learning and how they will allocate their learning and thinking activity. They make these decisions strategically and consciously initially and then automatically

One aspect of how children, and learners more generally, manage their learning is through their conceptions, beliefs and metaphors about learning.   One set of beliefs relates to how 'intelligence' works (Dweck, 1989). Some children believe that their intelligence is fixed. They avoid challenges that may show them as less competent. Other children believe that intelligence can be improved by effort and activity, seek challenges and show high persistence. Most children lie between the two extremes and show domain specificity in these beliefs. These beliefs affect the goals students set, their persistence and how they go about learning. They are mediated through students' self talk.

Learners can enhance their metacognitive knowledge and use in a range of ways:

(1)   by reflecting on and evaluating how they learn in specific situations;

(2)   developing an awareness of what they know and how it in enhanced;

(3)   learning to use both cognitive tools and the language for monitoring and analyzing their learning;

(4)   using question sequences such as "How did I know this ?" or "Why did I do this ?" to interrogate what they know and how they learn (Kuhn & Dean, 2004; Pitritch, 2002).

They also develop an awareness of their knowledge and later that of others and then expectations about knowledge generally.   They may learn, for example, that

- ideas are not 'set in concrete' (or absolute) by are 'our best guess' or interpretation at the time, are 'approximate' and can usually be changed.

- asking questions helps to think about what you know at any time and may cause you to change it

- it is acceptable not to 'be certain' about a particular idea.

Metacognitive activity can assist learners to make explicit and overt their tacit knowledge.

Learners use 'knowledge recoding' strategies during learning. One area in which learners direct and manage their learning is how they move between and integrate various aspects of their knowledge during learning. A learning framework might also be expected to examine how learners do this.

Learners use a range of 'knowledge recoding or transforming' strategies to 'look' at a set of ideas from alternative perspectives. Consider five learners testing a conceptual proposition. One learner visualizes it in particular contexts, a second acts it out, a third makes an analogy with a more familiar topic, a fourth says aloud the proposition and paraphrases it while a fifth searches for questions it answers.

These knowledge recoding strategies help learners to

- draw together multiple representations of a topic,
- reduce the 'learning attentional load' of a set of ideas,
- use what they know to generate new links and
- retain new knowledge for both short and long periods, possibly because they permit multiple codings of the same set of ideas.

Many learners acquire these strategies incidentally, in a developmental sequence. Others benefit from explicit teaching. The research on the effectiveness of strategy training (Swanson & Hoskyn, 1999) suggests that learners' environments and cultures influence their acquisition. In Western cultures at least, learners initiate and direct their use through self talk. Repeated use of the strategies enhances their automaticity.

Learning a disposition or attitude to a topic. When individuals learn about a topic, part of what they learn is a disposition or attitude to it, whether it is of interest, use or value to them and the ease with which they learnt it (Perkins, Jay et al., 1993).

This aspect influences subsequent learning. When one's knowledge of the topic is stimulated on future occasions, so is the linked 'emotional knowledge'. This influences one's motivation to learn more about the topic and how to do this. Interest has been largely overlooked in formal educational provision (Boekaerts and Boscolo, 2002), even though it accounts for about 10% of the variance in student achievement scores (Schiefele, 1996).

A key element for models of learning is to explain how attitudes and dispositions are learnt and how phenomena such as the motivation to learn under various conditions (for example, learning or mastery versus performance motivation), 'being interested' in a topic and self efficacy as a learner of the topic influence learning. These phenomena are domain specific, although they can generalize across domains. Three types of interest, for example, illustrate the generalization; a temporary emotional response to particular features in an activity, interest in a particular topic and the comparatively stable orientation to an type of activity (Hidi, & McLaren,1990; Schraw & Lehman, 2001).

The current model of learning proposes that several co-occurring processes explain how learners link emotional knowledge with the other aspects. These include

- the emotion they invest in the learning (Schiefele, 1996).

- the extent to which deep processing is encouraged (Schraw,1998).

- their perceived level of learning success.

- the extent to which the learners perceive they manage the learning activity, value themselves as learners and see that their activity led to learning, (McPhail, Pierson, Freeman, Goodman and Ayappa, 2000).

As noted earlier, the notion of learners' personal agency is linked with interest (Somerville, 2002).

These aspects are embedded in individual learning experiences. Over time, they become integrated into the learner's episodic or experiential knowledge of the topic. When the topic is stimulated on subsequent occasions, learners remember the feelings experienced on the earlier occasions.

Attitudes and dispositions to a topic are learnt or modified in a similar way. Initially, it is proposed, individuals learn a disposition, either positive or negative, in particular experiences or episodes as an implicit feeling. Gradually, the attitude, with its associated affective features, is defined across specific episodes or experiences and becomes linked with the decontextualised concept. This generalisation is possible when the learner has access to the appropriate 'language for thinking'. With further learning the attitude and conceptual network become fused such that they operate as an integrated meaning-processing unit.

This transition in understanding how individuals learn attitudes is consistent with the taxonomy for affective domain learning proposed by Krathwohl et al., (1964). This taxonomy proposes that individuals initially show a preparedness to receive or to tolerate an idea, then a willingness to respond actively to it, a valuing of it, an increased valuing such that the set of ideas has a preferred or prioritized influence on their thinking and finally organizing the values, beliefs, attitudes associated with the set of ideas into an internally consistent framework through which they evaluate the world.

The increasingly more complex disposition to a topic proposed by Krathwohl et al.'s taxonomy would seem to involve a re-organisation or transformation in the learner's topic knowledge, with the links between the aspects becoming increasingly automatized. As well, one might expect the implication of self talk and the analysis of the ideas from multiple perspectives. These aspects of learning are discussed in later sections.

Learning the context. In addition to learning new conceptual and procedural knowledge, ways of learning and thinking and dispositions, learners store knowledge about the situation or context in which they learnt. This includes their perceptions of the social climate of the learning context, the instructional climate and the quality of the interactions with significant others (Hofman, et al., 2001).

These aspects of knowledge are probably integrated within the learner's experiential or episodic knowledge of the learning context. They influence both the goals students frame up for learning in the future (Chaiklin & Lave, 1993) and how they engage in it.

Abstract conceptual knowledge : 'Deepening' and 'broadening' the understanding. Learning continues after the initial construction of the new knowledge. Learners transform their knowledge, leading to enhanced understanding (Diakidoy and Kendeou 2001; Vosniadou, Ioannides et al. 2002). They synthesize aspects of the new ideas, recognise common properties and features and link them in more complex ways. They make new links as they

- analyse the topic from different perspectives,
- analyse its application in various contexts,
- use the knowledge to solve problems,
- predict and anticipate, and
- trial the topic in unfamiliar contexts.

A key element of a model of learning is how it describes and explains these transformations.

The theory of learning developed in this paper explains this transformation in terms of the re-linking of ideas as learners are able to deal with the topic more broadly. They learn to

- link the conceptual-abstract, episodic and procedural aspects of the topic, move more seamlessly between the aspects and use them more consistently.

- think about more of the aspects; through their freed-up thinking spaces and attentional resources they can elaborate and extend the ideas through questioning and link them more broadly with what they know.

- recognise the key elements of the new knowledge across contexts; they learn to abstract or decontextualise their understanding .

- transfer the ideas, identify their boundaries and use analogies.

- generalize and summarize the key ideas of the topic; they identify what is common or shared across a range of specific instances or contexts.

- re-organize and re-prioritize aspects of their knowledge so that they can think in terms of main and subordinate ideas at once.

- use symbolism to represent the knowledge more efficiently in generalised propositions.

Rather than simply reinforcing or extending what they already know, these ways of thinking permit learners to transform their understanding, re-forging links to represent more complex relationships that they had not perceived earlier. This 'deepens' the knowledge, organising it into 'multiple layers'. Links between the layers are learnt through strategic questioning, analysis and synthesising. Many school curricula neglect to support this type of learning (Bransford, Brown, and Cocking. 2004); the Third International Mathematics and Science Survey describes them as "a mile wide and an inch deep".

Beginning to use symbolism to represent the ideas allows learners to access the conventional symbolic ways of communicating about the topic and can extend their knowledge further. They can also learn these more complex transformations of their knowledge through

- interactions with more knowledgeable partners;
- learning to use the symbolic conceptual tools in the domain and
- peer-engaged processes that test out and develop these processes.

They trial and test more complex possibilities and anticipations. The feedback allows them to confirm, modify or reject their expectations.

This transformed understanding of the topic allows them to deal efficiently with increasing amounts of information about the topic. Symbolic representations of knowledge allow a greater quantity of specific topic knowledge to be organised, categorised, 'compressed' and accessed more efficiently. Learners who transform their knowledge in these ways are, one would expect, more able to deal effectively in information rich contexts.

This transformational sequence for conceptual knowledge in some ways matches those proposed by Vygotsky and Piaget. However, in line with neo-Piagetian scholars who reject the notion of qualitative stage-like characteristics, the present approach sees the broadening and deepening of conceptual knowledge as being domain specific, once the learner has the relevant conceptual thinking tools and resources (for example, thinking space resources) and appropriate language relationships.

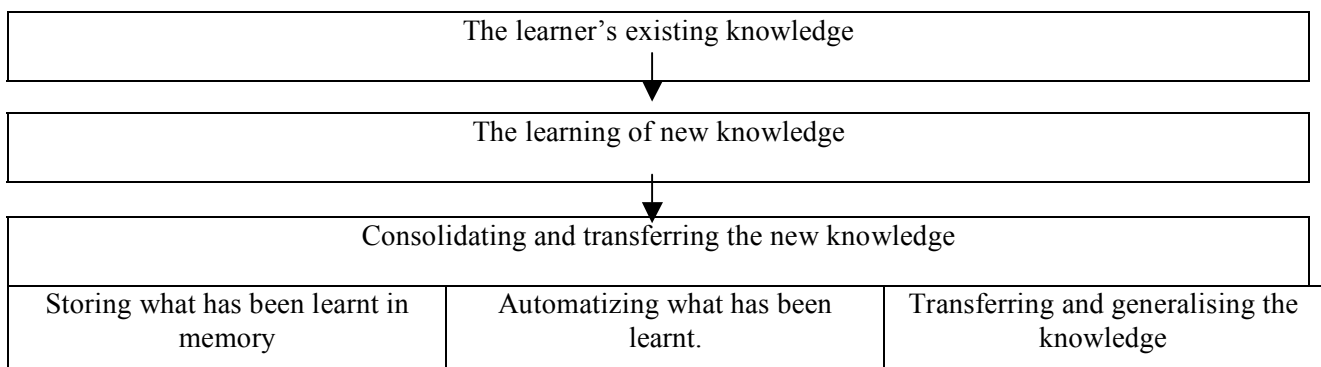**Consolidating and reviewing what has been learnt**

The new knowledge continues to be transformed as individuals learn more about it. So far this paper has examined learning or extending a topic first as tentative ideas referenced in specific contexts with scaffolding and the transition to a more integrated, consistent and decontextualised or abstract understanding.

The newly learnt knowledge can be transformed further: it is organised in ways that allow it to be

- retained long term;

- automatized and

- used in open-ended ways for knowledge creation and transfer

This version of the new knowledge has been described as 'expert knowledge'. The sequence of transformations from the initial learning outcomes to this form is described as the 'novice to expert'. A main element of a model of learning is to examine this transformation.

These aspects of learning can be indicated on the diagram showing the phases of learning as follows:

The learner's existing knowledge

The learning of new knowledge

Consolidating and transferring the new knowledge		
Storing what has been learnt in memory	Automatizing what has been learnt.	Transferring and generalising the knowledge

Storing what has been learnt in memory and recalling it It is possible for learners to retain a new idea it only briefly. Successful learning is usually associated with long term retention. A main element of "models of learning" is how the retention of knowledge long term is explained. Storing what has been learnt in memory and recalling it is a critical aspect of knowledge enhancement (Baddeley, 1990).

As already noted, the knowledge learnt can be retained in various forms or 'memories'; as (1) abstract conceptual networks in semantic long term memory; (2) generalised experiences in episodic memory; (3) automatized procedures (Tulving, 2002). Retention of conceptual or procedural is usually the preferred option, even though it is the linked episodic knowledge that will facilitate the application and transfer of the knowledge and its use in creativity.

When learners' retention is monitored over several learning sessions, their memory representations change from being primarily episodic to more conceptual, generalised semantic knowledge (Conway et al, 1997). This is attributed to the knowledge becoming gradually 'schematised'. As noted earlier, this involves qualitative changes. as learners interrelate ideas and re- organise it conceptually (Conway, Cohen & Stanhope, 1991, 1992; Semb & Ellis, 1994).

In other words, even though this transformation in located at the consolidating phase, it doesn't necessarily occur in time after conceptual abstract learning. Learners begin to store their new episodic knowledge in long term memory and gradually add to it as they acquire the more decontextualised forms.

Learning strategies to achieve the schematization and to encode knowledge in long term storage include:

- expressing in 'linking statements' or propositions the key concepts to remember;

- compressing it' into its key ideas;

- linking aspects of the new knowledge with what is known, for example, saying where the 'key ideas' fit it, how it elaborates existing knowledge;

- 'building memory "icons" and

- practising recalling it.

Cultural influences on memory have several sources. They differ, for example, in the dominant forms of memory they value. Some value storing in imagery forms while others value more abstract forms (Chan, 1999). They also differ in how the processes of memorisation and understanding of new ideas are integrated (Kember, 1996; Marton, Watkins and Tang, 1997).

Automatizing what has been learnt. In parallel with long term storage, the new knowledge can continue to be re-organised so that learners use it more automatically and, often without being aware of it, use the network of ideas as a lens on their world. Constituent ideas are re-prioritised and meaning networks increasingly elaborated and differentiated. Learners re-organize topics and domains in the following ways: They

- organize their knowledge in schemas around core concepts or "big ideas" that guide their thinking about the topic and that allow them to recognize features and patterns that others would not see.

- build more extensive differentiated and elaborated conceptual clusters around the core concepts that represent more complex meaningful relationships (Glaser & Chi,1988).

- use the clusters rapidly and efficiently to think about and to interpret information at a higher conceptual level; they use the clusters to chunk information in relatively "effortless, automatic and fluent ways.

- organize their knowledge in ways that allows them to search it and to retrieve selectively what is relevant to any particular problem (Ericsson and Staszewski, 1989); they build into it "conditional tags' (Glaser, 1992) that allow them to retrieve specific aspects when they are needed.

- manage and use their knowledge with high level competence, for example, they monitor how they use it during problem solving and readily change direction or re-question what they know.

Knowledge in this form makes less demand on the thinking space during learning than corresponding less cognitively complex knowledge. Individuals whose knowledge of a topic is organized in this form can learn and think much more effectively about the topic because they can use their thinking spaces (that is, their working memories or their attentional resources) much more efficiently.

Transfer and generalise the knowledge The knowledge can be organised so that it can be used to construct 'creative' or 'innovative' ideas. In this form the links between 'what it means', 'how it is used' and learners' positive feelings about it are sufficiently strong that they can see its possible use in unusual situations; they can make 'far transfer' of the ideas and 'think divergently' about it.

They can use it to interpret, describe and solve problems and to resolve issues. They can also see that it is, in some ways, incomplete. They can move between multiple forms of it very easily (for example, between symbolism, logic and imagery), direct how they use it, possibly construct multiple interpretations and be prepared to make subjective judgments about these. Models of creativity (for example, Urban, 2004), agree that these types of knowledge are more likely to lead to creative outcomes.

The present learning model proposes that learners are more likely to form this type of knowledge when they :

- explore, analyse, reflect on aspects of the new ideas from multiple perspectives and synthesise new understanding, for example, by applying the 'higher order' thinking strategies conventionally identified by thinking tools such as Bloom's levels of questioning.

- explore the transferability and generalisability of the ideas in both near and far transfer analogic thinking, reflect on the analogy process as a means of generating creative knowledge.

- learn to engage in 'possibilistic enquiry' and thinking, ask "What if…" type questions and think in options ways in open-ended creative problem solving.

- create new episodes for the ideas using creative imagery thinking.

Cultures differ in how they foster these 'open ended' ways of thinking about the ideas (Chan, 1999).

The conceptual framework that synthesizes the various elements

The foregoing description of a knowledge-based analysis of learning may be interpreted as suggesting a linear transformation sequence that begins with the learner's existing knowledge of a topic and maps this first into new episodic knowledge of the topic, then to conceptual-abstract knowledge and finally to automatized knowledge. One might therefore conclude that new conceptual-abstract knowledge of the topic cannot begin to be formed until after the new episodic-conceptual knowledge has been learnt.

A one-directional linear sequence is not intended. Instead, what is proposed here is the type of 'parallel distributed model of learning activity described by McClelland and Rogers (2003). While the three phase knowledge model largely describes how the transformations occur, it is proposed that learners can move between the phases in less restricted ways. Learners can, for example, retain their episodic conceptual knowledge in long term memory; they don't need to wait until they have transformed it to an abstract conceptual form and to retain that.

Within each phase, two or more of the relevant types of learning activities can occur at once. What does change during each phase and across the various phases is how learners allocate their learning attention or thinking space. At one time a learner may invest most of their working memory in learning about two or three specific episodes, then use it to identify what they share and then return to individual episode thinking by analysing another episode to check their hunch. In other words, while the knowledge transformation is expected largely to follow the sequence described earlier, it is possible that learners may think about more than one aspect at a time and can also return to 'earlier aspects' to check and validate their current thinking.

A major limitation on the learning capacity at any time is the automaticity with which a learner can manipulate ideas; the greater the number of related or linked ideas a learner can handle automatically at once, the more thinking space the learner can allocate to learning and thinking about the ideas (Kirschner, Sweller & Clark, 2006). In other words, as the complexity of the knowledge learners have stored in long term memory increases, the more knowledge they can accommodate in their thinking space and the greater the capacity they have for learning and thinking about them.

Summary

The purpose of this paper is to identify the main elements that I believe need to be highlighted in a framework when building "models of learning". I have done this from the perspective of knowledge change by a learner or a group and the learning actions used from a broad autonomous learner models. The paper assumes that learning is not an end in itself but is instead a process that leads to enhanced knowledge. It also assumes that the learning - teaching interaction can be understood, at least in part, from a knowledge enhancement perspective.

This perspective sees the intermediate display of knowledge during learning and formative corrective feedback as important processes. It describes the 'process' dimensions and the 'knowledge elements' that are transformed during learning. The learning actions are not sequential but used in a 'balanced parallel-

processing way'. At any time during learning the successful learner will prioritize the use of one or more actions.

The evidence basis provided for the elements is their sourcing in earlier research.

Given the context specificity of learning, are more general models of learning possible ? The issue of domain specificity is frequently raised in relation to models of learning. To what extent does this knowledge enhancement model have applicability across contexts, for example, different domains of knowledge, different cultures, age levels, multiple learning styles, different reasons for learning ? The notion that so much in learning is 'context specific' may lead one to question whether more general learning frameworks are possible.

Within particular constraints, it is assumed that the three main phases of knowledge transformation describe learning across these variations. Two of these constraints are the additional assumptions that (1) the culture/s in which the learner is learning facilitate/s the linking and (2) the learner has the 'learning capacity' (both cognitive and affective) to make the necessary links. Throughout this paper reference has been made both to cultural influences on specific aspects of how the knowledge might be changed and the nature of the change. As well, ways in which knowledge is re-organised or transformed for each phase are described. These assist in identifying the learning capacity constraints.

The model developed in this paper proposes that while a network of ideas, a way of thinking about ideas, a procedure for applying ideas or an attitude may be learnt initially in context specific ways, it has the potential to be extended to other contexts, through processes such as analogy and procedural application. As well, the model proposes that when individuals learn new links between ideas, they also learn the contexts in which they experience the new links, how they went about learning them and their attitudes to them. The knowledge remains even though it may be up-dated through subsequent learning.

Within particular constraints, this paper proposes that the three main phases of knowledge transformation describe learning across these variations. Two of these constraints are the additional assumptions that (1) the culture/s in which the learner is learning facilitate/s the linking and (2) the learner has the 'learning capacity' (both cognitive and affective) to make the necessary links. Throughout this paper reference has been made both to cultural influences on specific aspects of how the knowledge might be changed and the nature of the change. As well, ways in which knowledge is re-organised or transformed for each phase are described. These assist in identifying the learning capacity constraints.

In summary then, issues related to the context specificity of learning are not seen as necessarily problematic for the knowledge enhancement model presented here. Learning is likely to remain context specific only if the opportunity to re-organise and generalise the new knowledge across contexts is not provided.

How does the knowledge enhancement model take account of developmental trends in learning capacity ?

The focus of this paper has been on individuals learning a topic. The complexity of knowledge an individual can construct is determined individually. Infants are not expected to construct abstract verbal propositions. The phases of knowledge transformation discussed in this paper are obviously constrained by developmental factors. Given the limitations of this paper, these constraints are acknowledged briefly.

One aspect of cognitive development is the set of cognitive strategies to which the learner has access. These are acquired developmentally. More cognitive strategies, that is , those used to transform knowledge in more complex ways are assembled from simpler strategies. The linking actions for forming experiential conceptual knowledge, for example, are used to construct the actions for forming decontextualised conceptual knowledge.

A second aspect relates to the automatization of knowledge. As particular units of meaning are automatized, more complex knowledge can be constructed. Young infants first automatize the representation of motor or action aspects of knowledge and then perceptual aspects. From these they recognise similarities and common features and then begin to use symbols such as words to represent these common features.

A third aspect relates to the use of language to transform knowledge. This capacity is learnt as children begin to 'internalize' their egocentric speech; the dialogue they use to describe their interactions with the world. This internalization assists individuals to form a range of links not previously possible, for example, to recognise what is common between past and present events and to reason cause and effect or consequence.

Developmental factors have a key role to play in the knowledge enhancement process. The learning capacities of an individual are determined in part by their developmental pathway.

How can this model facilitate teaching ? This approach, describing how knowledge changes during learning, can facilitate teaching in a number of ways, for example:

- It focuses the role of teaching on knowledge enhancement and encourages students and teachers to think of teaching from a student 'knowledge enhancement' perspective. In other words, it uses knowledge to link learning with teaching.

- As well, it locates student knowledge enhancement as a key foundation in dialogue about learning and as a key criterion to consider in decision making. Discussions about school architecture, the relevance and use of new technologies, practices in formal education such as the length of teaching sessions and the school day, the best assessment practices, can all be referenced, in part, on knowledge enhancement.

- It provides a means for describing the 'learning pathway' through a topic in a systematic way and facilitates the implementation of personalised learning. Identifying the characteristics of knowledge at each phase of the transformation assists this.

- It provides a tool for understanding and /making sense of' student knowledge at any time and contributes practically to 'assessment for learning'.

- It helps the implementation of teaching that will explicitly guide learning, for example, by asking "What is the next step in enhancing students' knowledge /understanding ? What knowledge links need to be formed ? What conditions are most likely to achieve this?" It assists teachers to use assessment for learning procedures to guide the next embodiment of a topic. The teaching can identify, for example, useful dialogue, questioning, feedback, collaboration to take student knowledge to the next level of complexity. In formal school contexts, a class may be developing two or more topics at the same time, one at the early phase of learning and one at a later phase. It assists in handling this.

- It provides a tool for looking at learning that can be used across knowledge domains. Teachers from several subjects can use a similar conceptual tool for analysing and talking about learning in their areas, identify similarities and aspects unique to their domains.

- It respects multiple ways of learning and cultural influences on learning and provides a conceptual tool both for recognising and teaching to multiple ways of learning. It assists, for example, a comparison of learning in new technology contexts with learning in more traditional contexts.

In summary, the model provides a set of conceptual tools that educators and students can use to understand and monitor learning and to implement pedagogic practice that supports knowledge enhancement.

The framework has been used to identify teaching or pedagogic information most likely to catalyse or scaffold learning at any time. The set of learning actions has been mapped into explicit sequences of 'teaching procedures' that are most likely to guide knowledge enhancement for individuals or groups. It has been used in Australia to

1. design and implement teaching for students who have literacy or mathematics learning difficulties;

2. understand and synthesize the research on gifted learning;

3.   teach students who have information processing learning difficulties such as AD/HD students.

4.   examine cultural differences in learning , develop the notion of 'learning internationally', focus on the cultural specificity of conceptual differentiation, help teachers recognize the cultural influences on knowledge and learning and to take account of these in teaching.

5.   develop an explicit approach to the facilitation of professional learning by teachers and schools, for example, to facilitate improved pedagogy and whole school improvement.

Effective teaching as a scientific activity.   This approach defines effective teaching in terms of the extent to which it enhances knowledge. This includes minimizing the influence of potential barriers and obstacles to learning.   The developmental approach described here leads to the implication that all aspects of knowledge enhancement can be identified and monitored.

In particular it proposes that each phase in knowledge transformation for a topic can be described in terms of knowledge criteria. It also proposes that particular teaching activities, used strategically based on the learner's knowledge at the time, can catalyse the change. It suggests that specific changes in knowledge can be predicted and observed.

Effective teaching is more likely to be scientific activity when teachers have the conceptual tools necessary for observing the knowledge transformations in individuals and groups and use in strategic informed ways the teaching strategies necessary to catalyze the knowledge to change in the required directions. In other words, the teachers are equipped to guide students' learning most effectively.

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