Psychology of Exceptional Learning

The Thinking Space

John Munro

Many students have difficulty learning because

- they don't know how to go about learning in the most appropriate ways
- they have difficulty managing and directing their learning, seeing themselves making progress as learners.

We look at the background to these issues in this unit. Topics covered are :

- The metaphor of the thinking space
- Differences in the ways learners think about ideas : the codes learners use.
- Relating the ideas represented
- Teaching procedures that impose a heavy load on thinking space

Whenever we learn, we use part of our existing knowledge. Learners make sense of teaching information using what they have already learnt. A useful way of thinking about this is to think that part of what we know is 'under the learning spotlight'. This existing knowledge operates as a system of information processing units, that detect, organize and manipulate ideas. They differ in how they do this.

At the same time as we are 'bouncing around ideas in our thinking space', we can retain our interpretation of what we had just been thinking about earlier. We can also retain information that we have detected or 'received but haven't yet used. In other words, we are talking about what we are conscious of at any time, our awareness of a set of ideas at any time.

A metaphor that we use for this phenomenon is the 'thinking space' or 'short term working memory. This metaphor proposes that we have at least one 'space' somewhere in our thinking system where we 'do the learning work', where we change our existing knowledge. We retain in this space ideas that we are thinking about at any time, as well as information that we have received but not yet added 'into the picture'.

If we take this model of information processing as a way of looking at how individuals learn, it prompts us to ask various questions about how learners operate as processors:

- where does the processing (that is, the ideas-re organizing) take place ?
- how much information can a learner process at once ?
- what types of information can individuals process ? What determines this ?
- how do learners show they have engaged in information processing ?
- what initiates the processing at any time ?

The metaphor of the thinking space : Assumptions

The metaphor of learning that we are proposing incorporates the following assumptions :

Where we learn Learners have one or more sites for learning; our thinking spaces. These are where the activity to do with reorganizing what we know takes place. The information or ideas to which we are attending stimulate part of our existing knowledge. Something about the information or the ideas attracts our attention and causes us to decide to examine them further. The stimulated

part of our existing knowledge is prepared for modification. This becomes a 'site for learning' or a 'thinking space.

How much information we can handle while learning The thinking space can accommodate only a certain amount of knowledge at one time. The total amount of data that we can think about at any time is limited. This restriction can be interpreted in terms of thinking space and how learners use their attention. Learning is attention-demanding. We need to put more attention into some ideas than others. We can also change the amount of attention an idea needs.

We have all had the experience of 'drowning in information' or being in 'overload', when the amount of ideas we were trying to handle exceeded our capacity to do so. We have also all been in situations where emotion have been accommodated in our thinking space to the extent that we couldn't think.

Learners use their existing knowledge to learn new ideas New ideas are learnt using learners' existing knowledge; learners interpret information in idiosyncratic ways using what they know. We can encode environmental information in several ways; we can link it with specific past episodes and talk about it to ourselves.

During learning ideas are coded in the learning 'sites' in different ways The ideas we think about during learning can be coded or represented in these 'sites' in different ways; we can look at ideas in different ways. Each code links the new ideas with what is known in particular ways. Different learners retrieve different types of existing knowledge for making sense of the same information. Each code is linked with particular ways of thinking about the ideas and delivers a different perspective on the same ideas.

Ideas can be 'moved' between codes Ideas can be 'moved'[1] between codes by a recoding process that brings the new code to bear on the coded ideas.

Learners act on the ideas during learning in different ways Learners differ in how they act on the ideas during learning: some operate analytically while others may operate more synthetically.

Learners differ in how they manage, control and direct their learning In any learning act, we manage and direct (at least in some ways) our learning. We frame up goals for learning, plan how we will think about ideas, keep track of how well we are learning, know when we have reached an obstacle, decide to change our direction and decide when we have finished learning an idea. We can also recount how we believed we went about learning. We can ask ourselves questions about what we are learning. What we know about ourselves as learners provides information about how we learn. We tell ourselves early in learning how we will feel about learning the idea. Our attitude to learning is a judgment we make on the basis of our past success.

Students display what they have learnt different ways. The opportunity to display what we have learnt is necessary for many reasons. Learners prefer to do this in different ways. We may need to ensure that the change in knowledge is retained; we act on an idea in various ways to retain it.

The metaphor is frequently drawn as shown below. The limited capacity is indicated by the fixed space. The thinking space is shown linked with our existing knowledge base. The control mechanism is shown. This metaphor of learning is shown schematically in Figure 1.

[1]The notion of 'moving' ideas is a metaphor for the process by which an idea can be examined from a number of perspectives. It is not intended to propose a mechanism by which ideas are actually moved between codes.

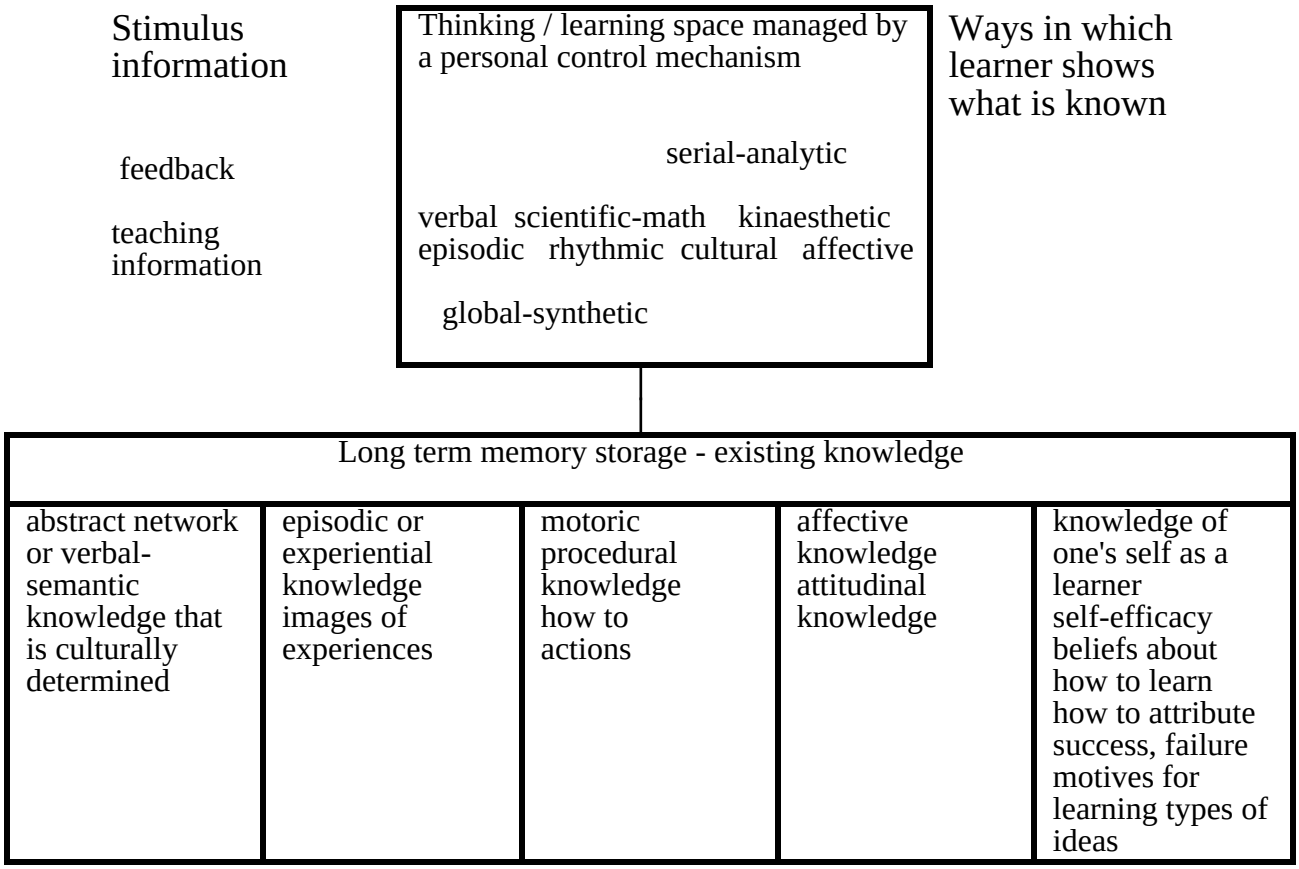


Figure 1: Diagrammatic representation of the metaphor of learning

Sites for learning : Thinking spaces

Our metaphor assumes that learners have one or more sites for learning. These are where the reorganizing activity occurs. Our metaphor[2] suggests that at an early stage in learning something about the information or the ideas to which we are attending cause us to decide to look at them further. It suggests that we think of all our existing knowledge being arranged around a dark room, spread around the floor, walls and ceiling of the room. Whenever we are thinking about a set of ideas, the part of our knowledge that is linked to these ideas becomes 'stimulate' or 'lights up'. The part that is stimulated at any instant (and therefore becomes the part that may change at that time) lights up as if a torch is being shone on it. This is where the 'thinking space' is at that instant.

[2] There are several metaphors for describing how existing knowledge is changed during learning. One model of memory, the 'stages' model, proposes short and long-term memory stages. Existing knowledge in long term memory is modified by somehow 'breaking it off' and depositing it in the thinking space or short term working memory (Baddeley, 1990).

The metaphor preferred in the present paper is the notion of a flexible or 'floating thinking space'. This metaphor suggests we can think of all our existing knowledge spread around a dark room and we can do something like 'shining a torch' on part of it. The part on which the torch is shone at any instant becomes the part that may undergo change actions at that time ; that is where the 'thinking space' is at that instant.

The first metaphor suggests a fixed space that at any time may or may not contain information. If we do accept this metaphor, we need to be able to explain how part of our long term memory knowledge is 'transported' to the thinking spaces. Most models of short term memory and long term memory assume this type of metaphor. Diagnosticians often talk about 'limited short term memory space'. Studies of brain impairment that suggest that cortical damage can affect short term memory but not long term memory are often seen as evidence supporting this metaphor.

When we are thinking about a different set of ideas a few minutes later, another part of our knowledge becomes lit up and perhaps undergoes change. What the metaphor suggests is that our thinking spaces are mobile, changing as if a torch is being shone around the 'room of our knowledge'. This metaphor is of a flexible or 'floating thinking space'.

Our metaphor suggests that a learner's thinking space at any time has a boundary; this is to show the learner can cope with a restricted amount of information at once. This restriction can be interpreted as a fixed amount of attention. An important issue in effective learning is how learners use their attention. Learners who can use their attention more efficiently are more successful learners. Ideas that make comparatively low demands on attention can be manipulated relatively automatically.

Learners can process a limited number of ideas at once. The processing includes the actual manipulation of the ideas and the retention of others. At any instant, some ideas are being manipulated and others are in a 'holding bay' waiting to be manipulated. They have been activated by the incoming information but have not yet been integrated within the new impression being built. When listening to a message, for example, learners may hold some ideas in an auditory form until they get time to integrate their meanings with the message being put together. Similarly, when we are reading aloud, we may say some words before we integrate their meanings within the impression that we are assembling.

Differences in the ways learners think about ideas : the codes learners use.

The ideas manipulated during learning need to be coded or represented in the learning 'sites' in ways that allow learners to think about them. Whenever we think about an idea we need to link, relate or organize it is some way with other ideas. We link it both with ideas that we already know and with other novel ideas in the information. This is how we make sense of it. Our existing knowledge provides us with 'thinking codes', that are ways in which we relate or link ideas. A code is a way of organizing and linking ideas. Ideas can be coded in different ways. One dimension of individual differences in learning ideas is how learners 'represent' or 'code' ideas.

Here is an example of these different ways of thinking about ideas. Following is a learning activity in which people learn about new idea, a 'bof'. They read through the information and decide what they think a bof is. They also describe what they do to make their decision.

> *Peter knew enough about bofs to know that he was in danger. Bofs, he knew, were short-sighted, but had a very good sense of smell and also very sensitive hearing.*
>
> *In the distance he could hear the roar of the river. Would that cover the noises that he was sure to make as he tried to escape ? The bof couldn't see Peter, but knew that he was escaping; its sense of smell told it this. It padded along on its huge paws, claws sharp and extended. It moved its head from side to side, its nose pointing up and swinging like a radar scanner searching for its target.*
>
> *Peter made his way to the waterfall. He stopped on the bank of the river, keeping as still as he could. Then he saw the bof again. It was standing on a rise that ran along the bank. It was hungry. It was also angry because it had been deprived of its dinner. It padded up and down on the green grass carpet making a soft grunting noise as it moved. Suddenly its nose pointed in Peter's direction.*

- Some people learn that a bof "is a sort of carnivorous animal that is not used to using its vision to track its prey but rather relies on its sense of smell" or "is a creature that has four limbs, is ferocious, is upright with claws and paws". These people often report selecting the key ideas and trying to link them together in logical ways. They select what they see to be the essential information and ignore much of the contextual detail.

- Some people associate a bof with animals with which they are familiar, for example, " A bof is like a bear / a huge oran utan / a dinosaur/ a robot, a spaceman, abominable

snowman". These people often report making a mental picture of the context and can 'see' the bof pursuing Peter near the river.

In other words, two main ways of thinking about the information usually emerge; thinking about the ideas in a logical, abstract way and thinking about them by making images of them in real-life contexts. Contemporary models of cognitive processing propose that learners use two main coding systems;

- verbal-propositional knowledge (word meanings and their interrelationships, knowledge of grammar, pragmatics) and
- nonverbal imagery (images for concrete and abstract concepts, actions, emotions and perceptual information, etc), stored usually in terms of particular episodes (Halford, 1993).

When students relate ideas using the nonverbal-imagery code they link ideas in real-world contexts, and connect ideas on the basis of when they occur in time and space. Ideas that occur in the same time and in the same place are in the one experience. When they relate the same ideas using the verbal-propositional code they make abstract connections between the ideas, for example, they may generalize, reason in terms of 'if ... then ...' relationships, etc.

It is useful to think of the codes as being 'idea-organizing'; they organise the ideas in different ways. They can organize ideas in a visual-spatial way, linking all of the ideas into a complete episode, analysing an idea in terms of its spatial features or look at each idea in terms of other ideas in the context. Alternatively they can link ideas in a decontextualized, more abstract way. Once each idea has been organized either by linking it with a name or decontxtualized symbol or with a visual image or icon, it can be linked with other ideas in different ways.

Although learners use both types of code, they differ in the ease with which they spontaneously and selectively do this. Some learners use imagery spontaneously across a range of situations, while others need to invest attention in doing so and use their verbal knowledge more easily.

These two types of codes can be discriminated or split further into other codes:

types of codes

abstract codes that represent ideas in ways independent of the learner		context-using codes that represent ideas in personal ways that depend on the learner		
verbal-linguistic	symbolic -mathematical	episodic	action	rhythmic -spatial

How do students use the codes to impose order in these different ways ? Linked with each code is a set of ways of thinking or thinking strategies. These operate as self-instruction strategies, by instructing learners to act on the ideas in particular ways. They direct the learner's attention to various aspects of the input information.

Teachers can facilitate coding

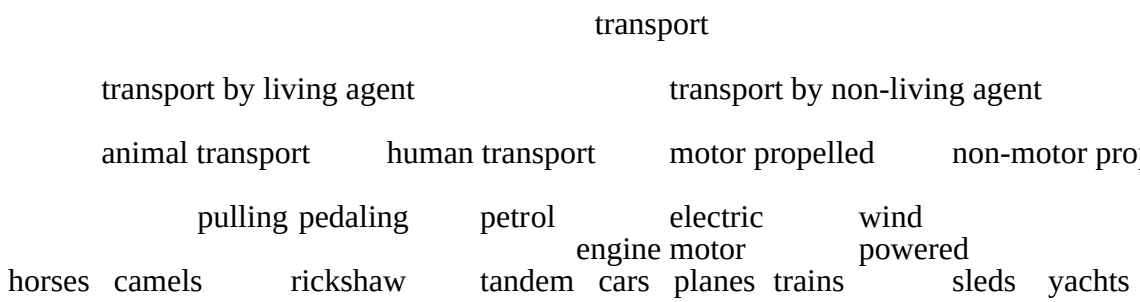
- by making organization in the information stand out,
- helping students to recognize when to use appropriate coding strategies, for example, to scan over the information, see if there are obvious patterns.

The present model proposes that, to build, students have access to several alternative codes, as follows. The thinking strategies frequently associated with each code are described with the description of the code.

Verbal/linguistic code : knowing by using one's understanding of the meanings of words and properties of language; thinking by organizing ideas into words, sentences and verbal propositions.

A verbal proposition is a unit of meaning that can be tested for its truth and is not tied to a particular context for its truth. There are several ways in which learners use verbal-linguistic codes to relate ideas. These include

(1) linking ideas by using their meanings. Word meanings are linked in inclusive networks or hierarchies so that particular concepts are linked both with more general and with more specific concepts. The concept of transport can be thought of in terms of the following network



When students use a verbal linguistic code, they can tap into these networks of ideas, A learner who explained that a camel and a tram were similar by saying that both were used for transport would reasonably be expected to be linking ideas by using their meanings.

When they are learning about a new idea they may try to put the idea into a more general category and also look at more specific aspects of it. They may also link it with ideas that are similar to or opposite in meaning. In learning about plovers they may use the knowledge that a plover is a member of the category of bird and their knowledge of the features of other birds to attribute properties to plovers (that they don't heave teeth, that their bones are hollow, etc).

(2) linking meanings into larger units such as sentences. Learners may make sense of ideas by looking for actions or changes, the agents of the actions and the objects of the actions. They may also look for when the action occurs and build ideas into 'if ... then' type relationships, for example, if an idea has particular attributes, it does ... . They may reason using verbal analogies, for example, "The old man walked and the little boy ...."

(3) linking sentence-level meanings into larger units such as stories (that is, narrative type structures), arguments, topic sentences, dramatic plays, etc. Imposing a story- or narrative type genre on ideas that they are learning assists some students.

When learners use this code they readily learn and think about ideas by

- telling themselves about the ideas, talking to themselves as they learn
- discussing the ideas with others, arguing and debating.
- paraphrasing or summarizing ideas as they learn them
- asking questions that focus on verbal relationships.

When learners do talk about ideas that they are learning, they are more able to bring their verbal reasoning to bear on the idea.

Students using this code will learn most effectively

- when ideas are presented in familiar language formats (for example, spoken explanations, 'process' approaches to learning , for example, in mathematics teaching) is more likely to facilitate learning than exposure to information in nonverbal forms.

- when students are encouraged to talk to themselves about information either in pictorial or symbolic formats. They need to convert the ideas to verbal forms to reason about them.

They remember most effectively ideas that they have converted to a verbal form and when they talk to themselves about the context of the ideas to be retrieved.

A student who had solved $6 + \square = 7$ was asked to say $6 + \square = 7$ in words. When he did this, he could see immediately that he was incorrect and could correct his error. Talking about ideas facilitates the use of verbal logic.

- when ideas are presented in a narrative form.

This code involves learners thinking in words rather than in mental imagery. They may have difficulty using ideas that they have built in this code to solve real-life problems and may need to talk to themselves about the problem context first. Also, they may need time to translate their ideas into actions, using self-talk to tell themselves what to do.

Thinking strategies used to build ideas in the verbal linguistic code include the following;

- talking to one's self about the ideas, paraphrasing the ideas, saying them in other ways; this brings verbal reasoning to bear on the ideas.
- putting the ideas into a story form and seeing how they fit.
- summarizing, looking for the main idea or topic, organizing ideas around a topic concept, using the topic to predict particular ideas.
- categorizing ideas in terms of verbal concepts, look at opposites.
- reasoning by semantic analogy, for example, reason that if an old man walks, a boy might run.
- looking at the verbal assumptions underpinning the ideas, for example, the connections between ideas in a sentence.
- predicting using the meanings of words, grammar, narrative structure, using the genre of a set of ideas.
- sequencing ideas using their meanings.
- generalizing ideas.
- analysing ideas using a verbal criterion.
- use metaphors and similes.

Learners learn the verbal linguistic code by interacting with others in social contexts. Through these activities they identify the social conventions for relating ideas in language. These observed regularities become templates for structuring knowledge in terms of verbal propositions. Learners in linguistically different cultures learn different linguistic ordering codes and conventions.

[3]***Symbolic mathematical code***; understanding by using abstract concepts and mathematical or scientific symbols, mathematical or scientific logic' to link ideas. The symbols and symbolic statements are decontextualized in the sense that they are useful across a range of contexts that differ in other ways. Students learn ideas by reasoning inductively and deductively. Representing sets of ideas by using formulae is an aspect of this code, for example, understanding $A = \pi r^2$.

A key aspect of this code is that ideas can look different but still share common features. In this way, the symbolic mathematical code is similar to the verbal linguistic code; the symbols, as with words, have decontextualized meanings. The formula above describes the area of small circles, large circles, green circles and circles within squares.

When learners use this code they readily learn and think about ideas by

- looking for and to impose order and consistency,
- analysing ideas for qualitative and mathematical properties,
- making objective observations and interpretations

[3] The term **symbolic mathematical code** is preferred to the more commonly used term 'logico-mathematical' code. The latter term implies that other codes may not have the quality of being 'logical'.

- reasoning inductively and deductively.
- drawing conclusions and
- formulating hypotheses as well as applying general rules to particular situations.

Thinking strategies used to build ideas in the mathematical-scientific code include the following; they

- reason that changes in one dimension balance changes in another "You double one but halve the other
- reason that although things may look different, the critical variables haven't changed, for example, a shark is a member of the same genus whether it is young or old,
- look at logical underpinnings of ideas
- use symbols for sets of ideas, think easily in symbolic systems
- manipulate ideas without reference to the real world meanings; students using this code may have difficulty using their knowledge in real life situations to solve real-world problems. Their solutions and ideas may seem to be unrealistic, 'away with the birds', etc. They need to learn how to contextualize their knowledge.

Students using this code when they are reading a novel such as "Cry the Beloved Country" may try to interpret slavery in an objective, value-free way and try to understand it in terms of formulae. Their creative writing may lack feeling and seem sterile, 'cut-and dried'.

Symbolic-mathematical codes are learnt through social interaction processes. The symbols and the meanings linked to them and the conventions or syntax for relating them, are defined by the culture. These codes are , to some extent, culturally specific, although the conventional mathematics symbolic notation system is more general than particular linguistic ordering codes.

episodic code (sometimes referred to as a visual/spatial code) ; understanding by making idiosyncratic nonverbal images of ideas. These images are linked in contexts with other ideas that occur at the same time or in the same place. Together the set of images make up an episode that can stretch over a period of time. The episode built is a set of images.

We can produce new episodes from existing episodic knowledge. We can also induce students to form episodes in order to facilitate their learning. When asked to explain how a tram and a camel are similar, a learner using this code may visualize them both in a particular context, for example, a camel and a tram travelling down a street. This may lead them to see that people and objects are carried or moved by both of them. From this episode they may develop a more general image of things being moved, whether it is on a tram, a camel or by other means. The general image can become an icon for transport. Learners can use it to recognize other instances of transport.

Information is stored using spatial and / or temporal relationships. These images may have a visual quality; students may use images that they have formed as a result of having seen events earlier. Learners note what things look like, what things occur at the same time and the order in which things happen, rather than the linguistic or matho-scientific features of the information. Ideas are linked in events.

The image is not necessarily purely visual; sound patterns, feeling and other sensations that occurred in the context can be coded with visual information. Most of us are familiar with the experience of hearing a piece of music and recalling the sentences that accompany it. Without the music we would be much less likely to recall the words.

This way of knowing allows learners to think in wholes; specific pieces of information are 'slotted' into a mental picture. The episode can accommodate a lot of information at once. Often students can manipulate the items by moving them around, imagining how they change over time. When a person visualizes a boat, the person thinks of the boat in a context (the sea, on a lake or river, sailing across an ocean) and may see people doing things on the boat.

Students build new episodes using images formed from earlier experiences. At an early age children learn to make out or 'see real things' in the sea of visual information that they detect.

They learn to identify balls, dogs and tables. They gradually build more complex images of everyday items and events.

From these specific images they construct icons or templates that operate as prototypes for ideas they are learning. They may develop a general icon for a cat or a car.

Learners' episodic knowledge allows them to recognize meaningful units in the information and to see how they can use these units to produce a similar pattern. Learners may be asked to assemble the pattern shown below, using the types of tiles shown or to arrange the pieces in a jigsaw type task. Use of the episodic code helps learners to see relatively automatically how the tiles or pieces fit together. They don't need to tell themselves about each tile in a verbal way in order to slot it into place and they don't need to actually move into place each tile and see how it fits; they can do these transformations mentally.

The icons or templates help learners to visualize ideas that they encounter when they read or process symbolic information. A reader can construct a series of images of a novel. Images of characters and locations in the novel are constructed by modifying the set of icons the reader has already stored. In mathematics learning a learner may have an icon based on a pizza for representing fractions, or use the icon of a bag of bolts to represent pronumerals in algebra. A 2-digit number such as 23 can be visualized as two bundles of ten and three loose sticks. When learners use this code to represent one idea they link it with other ideas that in their previous experiences have occurred with it at the same time or in the same place.

Episodes are comparatively easy to use and to modify for later use. When learners find themselves in an unfamiliar situation, they can relatively quickly match the new situation with known episodes, select the ones that match best and were most successfully used in the past and fit these over the new situation. They do this by linking the new idea with similar ideas in particular contexts at the same time in their past. An image of an episode provides a set of 'visual hooks' onto which particular ideas can be hung; this code allows students to think in terms of wholes. They may modify their episodic knowledge in order represent the new situation. The next time they see these ideas, they will probably recall them with the contextually related ideas.

This operating procedure is effective while the desired outcome is similar to earlier outcomes. If there is a need to interpret the new situation in a different way, simply linking it with earlier learnt episodes may not be as useful.

'Intuitive thinking' or knowing how to do something intuitively is an aspect of this. Learners can make a quick judgment about what something means, what they should do, what something might be like, because they match the current situation with earlier episodes. They often cannot explain why something works or how they decided what it means. It is like a person starting to watch a movie after it has been screening for several minutes and recognizing that it was a movie they had seen several years earlier. They can recall what happened by seeing the events in their minds. They may not recall specific verbal information. Similarly, people can often remember the words of a song when they hear a record of it being played but not when the song is not played; the incoming auditory information stimulates an episode that they had learnt. Some people very rapidly feel more comfortable with some people but not others. Again, this is based on evaluation using one's stored episodic knowledge.

When learners use this code, they readily learn ideas by

- making images of ideas; they visualize or imagine the new idea in the context of other ideas. They ask themselves "What pictures can I make of this". The pictures made consist of nonverbal images of the ideas to be learnt, for example, visualizing 23 as two bundles of ten sticks and three loose sticks or the images of ideas mentioned in a sentence of text.

- drawing pictures of what they are learning while they are learning

- being given the opportunity to take episodes apart, to note the images shared by two or more episodes that have the same idea and then building more general icons. These icons or templates still have a visual quality but are more generalized than a specific image.

- acting on the mental picture in logical ways, for example, rotating parts to match them, imagining three and one half pizzas being re-arranged so that each whole is cut into halves, imagining how a situation might change in two hours time.

- visualizing the end-point of a learning activity and then work backwards from this.

- using visualization as a mediator to make meaningful links or connections between new and already learnt ideas, for example, learning French words, for example

wind	picture of vent with air coming out	le vent
run	picture of a courier on a bike	courier

When ideas are encoded in visual imagery, learners need to put their ideas into words, organize their ideas along the lines of the verbal questions they may be asked.

Thinking strategies used to build ideas in the episodic code include the following; they

- visualizing; cueing learners to visualise helps them to match a visual image of the text against the stored visual episodic knowledge.

- contextualizing; to visualize ideas in particular contexts.

- comparing episodes that have the same elements, for example, before and after a change.

- how does an episode change ?

- analysing an episode using a spatial framework.

- predicting possible outcomes by changing a visual image in particular ways.

- sequencing ideas in terms of visual, spatial or temporal properties.

- relating ideas by using analogy with other episodes

Creative developments in the history of science and technology abounds with examples of this type of thinking lading to new possibilities. Kekule's discovery of the structure of benzene through his imagery of a snake forming a ring by biting its tail, Einstein's discovery of the theory of relativity through his imagery of a train accelerating to the speed of light and people moving on the train are examples. One might conjecture that Archimedes discovered his theory of buoyancy by bringing together in his mental imagery the king's crown and his bath. One would expect that he had bathed on many earlier occasions but had not formulated the connection between the volume of water rising when he climbed into his bath and the volume of his body.

Episodic learning is used frequently to teach individuals new preferences and ways of making decisions in advertising. Most advertisements in media present episodes that link both particular products and outcomes that are seen as desirable. These outcomes are frequently not explicitly stated; if they were, and if listeners or viewers submitted the information to verbal/linguistic or symbolic/mathematical reasoning, they may be less likely to make the decisions they make when experiencing the episodic presentation. Knowing more about the use of this code is likely to increase both the effectiveness of advertising and the ability of consumers to make more 'informed' decisions.

In summary then, information is stored using spatial relationships, patterns and properties and students relate ideas using their spatial or temporal proximity with each other rather than for logical or linguistic reasons. Ideas in the same event or episode are often related.

body/kinaesthetic code; understanding by using characteristic actions to represent ideas. Learners using this code are searching their ideas for actions or procedures. Many learners show a preference for understanding ideas as actions. They have difficulty learning in language-oriented classrooms because they can't obtain a sense of 'what the idea does' or 'how it changes'. These learners are often described as having 'mechanical intelligence'; they can learn an idea when there is the opportunity to learn it first as an action. These students often have difficulty talking about their understanding of an idea. They are more able to show you what they mean by acting it out.

For many learners, physical actions are learnt first and gradually become internalised as mental actions and operations. Doing actions first can lead to learning mental operations; mental actions and operations can be learnt by gradually internalising physical actions. The focus is not on what the action is applied to, but on the action itself. The idea that eighty seven is equal to seventy and seventeen can be understood by changing one of the tens to ten ones. The focus is not on whether the action is applied to a quantity of sticks or to a number but rather on the re-arranging action itself.

Many students who use this code often seem to learn 'with their bodies', for example, when learning about graphs they might move their finger to map out a straight line, parabola or circle. They can remember ideas well when they use characteristic actions or gestures that stand for the ideas, for example, in tests. Pupils who use this format often learn well with their hands and find it hard to remember the names of things. When they need to show what they know in words or symbols they will probably need time to translate their action knowledge into these forms. They may find it hard to recall the names of items and may need time to translate their action knowledge into words or alternative forms.

When learners use this code, they readily learn ideas by

- having the opportunity to act out ideas that they are learning, to link actions with words and more abstract concepts.
- use their bodies to represent ideas.
- discussing the functional, action-values of ideas.

Thinking strategies used to build ideas in the motoric code include the following; they

- imagine doing the idea, the idea being done, the idea working, etc. what will change ?
- link the action with similar actions that they have learnt
- reflect on inverse or 'undoing' actions : *if I undo what I did, will I get back to the starting point*. ?
- think in reverse, think backwards.
- ask *"How does the idea move / work / change ?*"
- ask *"How does change in one idea affect change in another* ?" *Would changing from a dictatorship to a democracy change how business would operate. What new types of actions would business have to take up ?*
- combining actions, combining them in different ways to lead to different outcomes.
- changing the order of actions in a sequence; how does this affect the outcome ?

rhythmic code; knowing by using rhythm, repetitive patterns and rhyme. While the rhythmic Learning ideas by rote or by chanting, for example, SOHCAHTOA, "two minuses make a plus" the six times table 'by heart', learning poetry, exemplify this using this code. What is learnt is a

whole sound image or a complete episode. The component parts can only be retrieved by taking apart the complete episode and looking for logical patterns (where these exist) between the items.

Many learners prefer to use a rhythmic code to learn new ideas. The set of ideas is learnt by embedding it in a song, poem or jingle. They recall the idea by recalling or replaying the rhythm pattern.

Just as students need to learn to use icons, verbal-linguistic units and action units, they also need to enhance their knowledge of pitch, tone, timbre and rhythm features.

When learners use this code, they readily learn ideas by

- detecting various features of musical patterns, comparing the elements of patterns.
- building ideas that they are learning into a song, a rhythmic pattern, sound associations, producing a beat pattern for a set of ideas. They may, for example, make up a song about Hamlet or a poem for remembering the first twenty chemical elements.
- building auditory mnemonics into teaching when they are learning new ideas, introduce new ideas in a song, jingle or poem format.

Thinking strategies used to build ideas in the rhythmic code include the following; they

- imagine the new ideas being played on a musical instrument, sung, recited in a poem.
- build the set of ideas into a beat or rhythm.

***affective / mood code*;** knowing in terms of affect, emotional feeling, or mood. Students recognize mathematical ideas as interesting, challenging, boring, frustrating, etc. They link this with their understanding of the idea. Ideas in a novel can be represented in terms of the feelings or mood they elicit. Patterns in the attribution of success and failure and level of persistence on tasks can also influence learning. Learning effective self-talk is useful here.

This way of knowing involves students recognizing mathematical ideas as interesting, challenging, boring, frustrating, etc. Learning a new idea requires motivation and persistence by learners and a level of self-confidence. Students who have a history of learning disabilities are likely to differ from their peers in their level of self-motivation for learning an idea, how they can be motivated, their interest in a particular idea, their valuing of it, how they attribute success and failure in mathematics and their level of persistence on tasks. Linking a high level of negative affect with particular ideas may be expected to impact deleteriously on subsequent learning.

interpersonal code; knowing in terms of historical, social, cultural or religious knowledge. Students from different cultures can interpret the same teaching differently. One culture may see no gender difference in access to learning a content area such as science or mathematics and will not define mathematics knowledge in terms of gender while another may believe that males have a greater right to learn science or mathematics.

Learning from each cultural perspective may lead to different outcomes. The basic structure of an argumentative essay written by a student from a Middle Eastern culture may be more likely to circular to the key idea, while an essay written by a student from an Anglo culture may have a 'straight line' analytic structure. The genres that learners bring to reading and writing may be influenced by the learners' culture. Learners who expect ideas to be presented in a circular way may find it difficult to integrate a linear presentation and vice versa. An comparative analysis of the cultural schemata used by age and ability matched readers from the United States and Palau (a Pacific island nation) showed marked cultural differences and read texts that were culturally familiar with a higher level of comprehension than unfamiliar texts.

Further, not all cultures foster a logico-mathematical code that uses an abstract symbolic system consisting of an infinite number of discrete units. It is debatable whether a learner would see what a set of nine apples and a street of nine houses have in common if the learner didn't have a word or symbol that corresponded to 'nineness'.

Religious adherence predisposes alternative ways of thinking about a set of ideas. Beliefs about scientific concepts such as evolution are influences by religious beliefs. Some fundamental Christian sects propose interpretations of evolution that differ from contemporary scientific explanations.

The need for an interpersonal code for linking ideas ? Many educators dispute the need for a separate code that allows learners to link ideas in terms of social, religious or cultural relationships. The extent to which it is necessary to propose a separate cultural code or whether these influences can be explained in terms of a verbal-linguistic code is not clear. As noted earlier, a learner's cultural and social group memberships determine or at least influences the meanings associated with individual words and concepts in the verbal linguistic code. This would suggest that an 'interpersonal code' is unnecessary. It is possible, for example, that a learner has access to a set of linguistic codes, one for each of the major cultures in which the individual interacts. The same words may have different definitions in the different cultural variants of the verbal linguistic code. As well, the verbal concepts may be linked differently, using different templates.

The cultural and social groups in which a person interacts does impact on the communication of the ideas learnt. Learners may evaluate their understanding at any time in terms of the extent to which it may be in turn be acceptable to and valued by the social group in which they find themselves. Students identified as gifted frequently decide not to communicate their ideas in peer group interactions because they believe, based on earlier experiences, that the group will not value them. This judgment of ideas built in terms of their social acceptability suggests a 'cultural evaluation' of ideas as a second step in the learning context. This evaluation process could operate as an 'overlay'.

In any culture it seems reasonable to suggest that some of the codes and ways of manipulating ideas will be more practically available and culturally useful than others. In Western cultures, the linguistic and mathematical-scientific codes and analytic-sequential thinking would seem to be valued more than the others in the sense that they are explicitly taught in formal education. The logic on which the mathematico-scientific and verbal linguistic codes are based are comparatively unambiguous and are ubiquitous. The episodic and kinaesthetic codes are used to communicate in a more restricted range of public situations. Cartoons are often seen as humorous because the ideas are combined in unusual or unexpected ways. In these cultures, body language and visual imagery are frequently seen as being less reliable than verbal and mathematico-scientific ways of communicating. In cultures in which ideas are communicated through imagery and body language more, these codes would be expected to be less ambiguous for their intended cultural purposes.

Learners differences in the use of these codes Learners differ in the ways and ease with which they spontaneously and selectively use these codes. Although students can use both verbal and nonverbal codes, they differ in their capacity to do so. Some students use imagery spontaneously across a range of situations. Others find this code harder to use and need to invest attention in doing so (Clark & Paivio, 1991). These learners are more able to use their verbal knowledge. This leads to an important area of individual difference.

Moving ideas between codes Ideas can be 'moved' between codes via a recoding process that brings the new code to bear on the coded ideas. The meanings that they had in earlier codes can be retained. The understanding at any time is the outcome of coding in one or more codes. Learning that involves more complex cognitive processing, for example, in mathematics, probably requires the use of multiple codes . Seeing correspondence between codes is an important cognitive function.

A question related to code switching or changing is whether an individual can access two or more codes for representing the one idea simultaneously. Can a representational form that has the

properties of two (or more) of the forms discussed be generated, so that, for example, both visual and verbal properties could be coded ?

These codes come from our existing knowledge. We have already noted that new ideas are learnt by linking them with matching ideas in the learners' existing knowledge; learners interpret information during learning using what they already know. The data organizational codes reflect an individual's generalized knowledge of how ideas are manipulated in various areas of knowledge. The structure of a learner's verbal-propositional code, for example, reflects the person's verbal-semantic knowledge; the linguistic relationships that are imposed are those that exist in the individual's general linguistic knowledge. The codes come from the individual learner's existing knowledge.

Incoming information or ideas that are the subject of thinking at any time activate existing knowledge that is perceived to be related and this is used to make sense of the information or ideas. Knowledge banks that may be activated include verbal-linguistic knowledge, episodic knowledge and procedural knowledge. The activated knowledge consists of sets of ideas linked in various ways. It is these ideas that provide the code. The incoming ideas activate particular related ideas and in doing so also activate the ways of relating them. These ways cue the learner to look for particular patterns between the ideas or within the information.

Ideas within each broad area of existing knowledge, are organized in various ways :

(1) ideas are organized into broad topic areas or 'schemata'. Each schema is a category of semantically related ideas. The meanings linked with items in the schema restrict the meaning of the particular schema.

(2) some ideas may be in abstract, decontextualized ways, for example, word meanings are linked

in a network or hierarchy of concepts,
in propositions, for example, 'if-then' relationships, both for

- defining a concept (that is, a 'declarative assertion'), for example, 'if the shape has three joined sides and is flat it is a triangle' and

- procedures for example, 'if you are asked to find the area of a triangle, you multiple its height by its base length and halve the outcome'.

(3) some ideas are other ideas that occurred at the same time and in the same place; ideas are stored in terms of complete episodes in a contextual way. This experiential knowledge is not organized as it is for declarative knowledge shown above.

An episode is in some ways a personal picture of 'snapshot' of a situation or experience that we have had. It is, however, more than this. It isn't an actual picture, because different people represent the same situation differently; they remember different aspects of it. As well as things that we have seen it in the situation, we represent things that we have heard, smelt and felt. However, it is a mental picture in the sense that what is represented is what we believed we experienced at the time. We think of them as what we see because we usually process visual information simultaneously, whereas when we process auditory we do so sequentially, rather than in terms of a whole context. However, an auditory, visual or smell sensation can excite or stimulate an episode or a set of them.

You can obviously have a range of episodes of a situation, for example, an episode of adding on one day, a different one relating to adding on the next day, etc. We can simply keep adding to the episodes.

Episodes are relatively easy to learn. Because they don't involve us re-organizing or manipulating the information in them in any major way, they don't demand a large investment of attention. They certainly demand less attention than forming the corresponding semantic network.

Each episode contains a great deal of information. However, the information is not organized semantically; ideas are not related conceptually but rather in terms of space and time. Episodes, then, as they are, are of limited use for dealing with semantic or conceptual tasks.

We do, however, use our episodic knowledge a great deal in everyday life. When we are confronted with a new situation, we attempt to retrieve from our store of episodes one or more that we can fit over the new situation. In other words, a new situation in which we find ourselves seems to 'activate' almost automatically in our long term memory similar earlier situations and we impose or match these over the new situation. By using our episodes of experiences we seem to know implicitly or 'intuitively' what to do; the original episodes 'tell us' this. Often, we are initially unable to explain why we did what we did. We just knew that it would work because it has worked for us in similar situations in the past.

We can also act on our episodic knowledge in various ways to build declarative and procedural knowledge. To do this we need to analyse the episodes, take them apart and note what two or more have in common. We can then attempt to fit the component ideas into existing networks and categories. We can also have students imagine how an episode may change in a short time or develop 'summary episodes'.

In summary then, existing knowledge can be described in various ways; on the basis of topic areas and on the basis of how the knowledge is structured, the logic by which the ideas are connected.

Relating the ideas represented

A second dimension in how people differ when they are learning is how they act on or manipulate the ideas in each code. This is the data-processing dimension of 'cognitive style' analyses. More than thirty aspects of this dimension have been identified (Riding & Cheema 1991), including

- field dependence versus independence,
- impulsivity versus reflectivity,
- convergent versus divergent thinking,
- wholistic versus serial thinking,
- random versus sequential processing.

Riding and Cheema recommend categorizing these data-processing strategies in terms of whether they are more analytic-sequential in quality or synthetic-wholistic. They propose that ideas can be manipulated in two ways ;

(1) analysed into parts and manipulated step by step in a sequential way

(2) integrated with other ideas, with each idea being treated as a whole rather than being analysed into parts.

The first type of strategy is described as or analytic while the second is synthetic or wholistic. While most learners use these strategies selectively and in an integrated way, some learners use one either inappropriately or excessively and this affects how well they can learn. The strategy used predominantly at any time influences

- how the learner manipulates information; wholistic strategies may ignore or miss specific details while analytic strategies have difficulty 'getting above' detail to 'see the big idea'.

- the extent to which the learner looks for and seeks external or imposed structure in the information. Analytic strategies seek external structure and when they are used, learners tend to prefer less flexibility, more highly structured learning situations and convergent learning tasks. Wholistic strategies seek internal structure and when they are used, learners are more flexible in their thinking, prefer situations in which there is less imposed structure and in which they can manage their own learning and can decide the learning outcomes. Wholistic strategies can tolerate ambiguity and unanswered questions better.

- the extent to which learners display impulsivity in learning. Analytic sequential strategies, with their focus on stepwise bit by bit processing mean that a learner will tend to reflect about an idea often for a long time and delay making an 'educated guess' about what an idea means. Wholistic strategies, on the other hand, involve students making 'rapid guesses' to see how well their impression matches the idea being learnt; they are more likely to 'guesstimate'. They give the impression of being impulsive.

Much of our formal teaching assumes that students learn best analytically. Those who have a preference for global-wholistic learning strategies are often alienated from effective learning.

Characteristics of each type of strategy. Comparison of learning behaviours of extremes of the two types are shown in the following:

Serial - analytic strategies	Synthetic-global strategies
• Look for parts or segments of an idea, take ideas apart and work on parts at a time	Look for overall patterns, scan. Think in wholes; don't take things apart
• Focus on detail and specific facts, have difficulty 'getting above' the detail.	Focus on the overall idea and often miss or ignore detail
• Learn step by step and delay giving an answer.	Leap in and answer quickly, make decisions quickly , make impulsive, intuitive guesses
• Think by moving in one direction (the direction provided by the teacher)	Think by moving in several directions at once give the impression of being flexible in thinking
• Follow other people's directions well	Prefer to direct and manage their own learning
• Find it easy to learn other people's explanations, procedures	Prefer to work out their own explanations : "Is this what you mean ?
• Good at analysing and sequencing ideas in conventional, predictable learnt ways	Arrange and sequence ideas in less predictable, creative ways.
• Display thinking that is predicable to others	Display thinking that is less predicable, harder to keep track of
• Prefer less flexibility in learning situations and convergent learning tasks	Prefer less flexibility in learning and open-ended learning contexts
• Prefer to be structured in learning contexts	Prefer to manage and to structure themselves
• Good at sizing up situations, modifying their behavior to fit the situation	Often not good at analysing social situations; may have difficulty conforming or 'fitting in'.

The use of the term 'analytic -sequential' in the present discussion needs to be clarified. When learners identify components or parts in information that others also identify, or when they look for these components, we can see that they are being analytic. In this sense the strategies used analyse ideas into parts prescribed by the social group or culture. It is possible to be analytic in a personal way, identifying parts not recognised by other members of the culture. In this situation, however, the learning may simply seem to be different. It is possible, of course, for global wholistic to analyse ideas in idiosyncratic ways. It is not appropriate to conclude that global-wholistic strategies don't analyse ideas; they may, but not show evidence of it.

Self-instruction strategies linked with each way of manipulating ideas. Just as each of the codes is linked with a set of thinking strategies, so the two types of manipulation or processing strategies are managed by self-instruction sequences. Students use

(1) analytic-sequential strategies when they tell themselves to

(1) take ideas apart, look for bits of an event or task,
(2) look for step-wise rules.

(2) wholistic-global strategies when they tell themselves to

(1) look at the overall idea, the broad, general idea
(2) bring ideas together in their own way.

Each type of strategy in the classroom and implications for teaching

Sequential-analytic strategies; characteristics in the classroom and implications for teaching:

- if the ground rules are clearly laid out, learners using these are more likely to play by them. If they don't have a course of action laid out for them they may not do anything, may have difficulty getting started. They may have difficulty with more open-ended tasks in which they need to put ideas together in new ways or when they are asked for their opinions. They need to learn how to deal with these types of tasks. They can

  - learn how to imagine possible outcomes, perhaps by visualizing, and then see how they can develop pathways to each.

  - practise 'reading between the lines' in English and other subjects and develop ways of looking at an idea from different perspectives. When you are writing creative essays you can refer to unresolved issues.

- learners using these are not fussed at all about learning new things as long as there is someone to teach them step by step.

- students using these strategies may have difficulty spontaneously looking at ideas from different perspectives. They may need to practise being flexible in their thinking and reminding themselves to do this. They can learn how to ask different types of questions about ideas that they are required to learn.

- learners may need to learn to see the 'big picture', they may have difficulty 'getting above' the detail level. They need to practise moving from working on a bit at a time to fitting the bits together to make the bigger picture. Teachers can do this by asking questions that direct attention to building ideas into more general ideas. They can work on

  (1) suggesting topic sentences for sets of sentences or a paragraph,

  (2) being given the first one or two sentences of a paragraph and then suggest what it could be about- the students suggest two or three possible options. They see another sentence and then another and keep trying to work on the most likely theme, reducing alternatives. They try to work on drawing in information from different sources at once and keep it going as long as appropriate. Encouraging risk-taking is important here.

  (3) suggesting a possible category name for two or three verbal concepts, for example, feeling angry, feeling hostile - What category am I thinking of ?

  Students can learn to ask themselves questions that direct their attention to do this

- while they may enjoy doing things in groups with their friends, learners using these strategies are often less likely to initiate the interaction; they seek to be structured. They may need to learn to be more assertive and to be more demanding. They may see themselves as 'victims' or with other people 'pulling their strings', rather than with themselves in control; they need to be given the opportunity to see that they can make situations 'work for them'. This can be difficult in families in which a child with a more extreme serial-analytic preference is close in age to a child with a more extreme wholistic preference.

Global-wholistic strategies; characteristics in the classroom and implications for teaching:
Students using these strategies

- may often put ideas together in unusual creative ways and reach solutions quickly.

- frequently want to learn things their way and have the freedom to manage their own learning in some situations.

- may attempt to dominate situations and have difficulty engaging in small group learning ; They often want to structure others, want to do things their way. They may have greater difficulty detecting how a group is operating and taking on its ground rules. They need to learn to recognize their current limitations at any time in a supportive, secure way, to accept these (remember how you learnt that? You'll be able to do this in .....)

  They need to learn how to work with others, they need to see that this helps them to achieve their goals, how to work in small groups co-operatively.

- are often worried about learning new ideas, taking risks in front of their peers, want to know 'how to do it' but because they lack the skill to learn bit by bit and don't believe that they will have the opportunity to learn in ways that they prefer. They may not see spontaneously how a new situation is like things that they have already learnt.

- need, when learning a new idea, to get a broad overall impression first may make learning difficult in subjects that are often taught sequentially, such as mathematics and the sciences. When they read to learn, for example, they need to learn to try to discover the general theme. When they are learning an explanation, look for the overall idea first.

- need to learn to direct their attention to noting or remembering specific details and analysing ideas. When needing to complete a large task that requires them to identify components, such as a research project, science report with a conventional structure, they may have difficulty beginning. They need to practise planning their way through these types of tasks and asking questions that direct their attention to the details of your subjects.

- may have difficulty keeping track of the thinking strategies help them. They think quickly but have trouble keeping track of what they did and why they did it. They have difficulty allocating attention to putting into words what they did; often this is not a priority for them. Set aside time each week to monitor these and keep a list of them, so that you can use them more effectively in the future.

- may also find it hard to organize their ideas in acceptable ways or give acceptable explanations. They may need to learn the conventional ways of displaying what you know.

- often don't know how to extricate themselves from negative situations; because they don't analytic strategies, they may just retreat altogether or else act in ways that are totally inappropriate to the context. They need to review situations, decide what options they had and wheat they could have done. They can imagine themselves doing it in the future.

- are frequently present as minor behavioural or discipline children in class-rooms. They have difficulty learning the rules of classroom management and frequently call out. Teachers can find this irritating when they are wanting the class to develop an idea and to give the slower

analytic-sequential students time to put the ideas together. In these situations the teacher can respond to the global-wholistic learner who calls out the answer by noting that she / he is sometimes correct and sometimes incorrect with the quick guesses and suggest that the child check her / his response. These learners often want to begin to work independently of the rest of the class while the teacher expects them to be part of the learning group and to listen to the ideas being presented.

In summary then, these students often give the impression of thinking and learning academic ideas in particular areas faster than their peers, display less predictable learning outcomes but as well have greater difficulty learning the classroom management rules. As a result, they are frequently identified as nuisances in classroom-centred activities.

Implications for academic learning There are clear implications for learning in the content areas and in displaying what one knows. In writing an essay, for example, learners using analytic-sequential strategies are more likely to sequence the ideas in predictable, conventional ways that they have learnt. Those using global-wholistic strategies are more likely to sequence the ideas in less predictable ways. An English teacher whose preference is for the analytic-sequential structure is more likely to display a valuing for the organization used by the analytic learner; the teacher is more likely to find this organization easier to read. A teacher on the other hand whose preference is for the sequencing of ideas in ways that have not previously been taught is more likely to value the organization displayed by the student using global-wholistic strategies. Generally teachers and students operate from their perspectives unconsciously.

Intuitively you would expect that these two types of learning strategies can be applied to each of the codes or garden beds. Ideas represented verbally can be analysed in terms of components of meaning or other language properties. As well, ideas can be combined to form a sequence of ideas. Similarly, ideas represented visually can be analysed in terms of their components, for example, in nonverbal tasks involving the analysis of pictures typified by the Raven's Progressive Matrices tasks. Visually represented ideas can also be arranged in terms of a whole.

Are the global-wholistic learners simply fast analytic-sequential learners ? The nature of the learning difference between the two types of learners is sometimes questioned. Are the global-wholistic learners simply fast analytic-sequential learners whose thinking moves in bigger jumps than their analytic colleagues along a single path or is their approach to learning quite different ? Global wholistic learners operate as if they are able to draw on several sources of information at once, rather than on one. They seem to draw on these several sources of knowledge selectively. Rather than waiting to be provided with a pathway for learning, they frequently attempt to provide their own ("Is this what you mean ?" etc). It seems that for them the teaching information to which they are exposed excites many more sources of knowledge at once than it does for their more analytic learning peers. They seem much more prepared to make hunches and to take risks. These students are often the gifted students.

Associated with this distinction is the students' preference for open-ended versus closed learning tasks Some pupils feel less secure in open-ended learning situations in which they are not sure where they will end up; they prefer more rule-learning oriented contexts. Other pupils are not as concerned about having unanswered questions at any point and are prefer more open-ended situations.

The use of the different strategies affect how easily students can get started on learning tasks. Students using analytic-sequential tasks usually find it easier to plan their way through learning tasks that are similar to ones that they have learnt to do previously. They find it harder to plan their way through learning tasks that are less familiar. Often in these situations they need to be assisted to ask themselves "How is this task like things that I have learnt earlier ? What does it remind me of ?" They need to spend time initially trying to recognise parts of the task initially and then build up an overall impression. Students using global-wholistic strategies, on the other hand, are often more likely to make broad guesses about the nature of the task and work on these guesses. Sometimes these guesses may not entirely match the actual task. They can spend time working in an inappropriate direction. What they need to do is to check their impression of the task against what the task actually says and to ensure that their initial guesses match or accommodate the

parameters of the task. They need to check that they are going in the direction in which the task requires them to go. see where you are going and get started easily. Others have more difficulty getting started. While their tendency towards being more impulsive and making decisions quickly will be an advantage for some tasks, for others they may need to be more reflective and analytic, checking the directions of their learning.

A management / control mechanism

A third dimension of the model of learning is the means by which learners manage or control their learning. In any particular learning act, learners manage, control and direct their learning; they can, for example, monitor progress being made during the learning, ask themselves questions about what they are learning etc. They have access to a management or control mechanism by which they can they monitor and direct learning; plan how they will learn, (the use of alternative codes and data-processing strategies during learning), monitor how successfully their learning is progressing (for example, to switch between alternative codes when learning an idea is difficult) and to review their change in knowledge about themselves as learners. When they have difficulty building it in one bed, (for example, reading a mathematics problem by verbalizing it) they can change to a different code (the visualizing or logico-mathematical codes).

Over a period of five minutes of learning, for example, students may construct an idea initially in a motoric code, re-code this understanding verbally and then in the logico-mathematical code in order to display it in mathematics symbolism. They may also switch from using analytic-sequential to wholistic-synthetic strategies, as the idea builds. When they find an idea too hard to build using one code, they may switch to an alternative code. They may find it difficult, for example, to read a mathematics problem by verbalizing the ideas and change to a visualizing code and employ more finely-tuned analytic strategies.

A key thing that distinguishes learning preferences is how the person transfers ideas learnt. Students who prefer a verbal code when learning an action sequence may need to talk to themselves in order to learn it and may have difficulty generalizing action sequences from one context to another. When processing visual-spatial information, they may talk to themselves about it, using verbal labeling. This ability to direct and regulate one's learning, to evaluate its effectiveness in terms of some goal or purpose and take further strategic action if necessary develops in parallel with an awareness of how the person's feelings about these ideas and learning preferences.

This mechanism is believed to operate via a verbal self-instruction mechanism that in older children and adults usually operates sub-vocally. Distinction needs to be made between the use of verbal knowledge here and the use of the verbal-linguistic code.

Teaching procedures that impose a heavy load on thinking space

Learning situations differ in the demand that they make on learners' thinking space. Teaching procedures that impose a heavy load include

- ***the split-attention effect;*** requiring students to synthesize bits of information that are physically separated. Learners need to invest attention in integrating them across physical boundaries.

- ***the redundancy effect;*** arises when redundant information that is not necessary is presented and again makes demand on attentional resources.

When these effects are removed from instruction, learning proceeds more efficiently . The cognitive load in these situations is referred to as 'extraneous' since it is external to the ideas to be learnt.

- ***requiring several linked ideas to be learnt at once.*** The ideas, as well, can vary in their cognitive load. Where a set of ideas is linked so that several need to be learnt at once, that is, they can't be learnt in isolation, the ideas will be heavy cognitively. An example is learning individual words in a foreign language and learning the grammar of the language. Learning individual words

can be done serially, one learnt at a time, so that the load at any time is low. Learning the grammar involves manipulating more data at once and is cognitively heavier. The cognitive load in these situations is referred to as 'intrinsic' in the sense that it is an aspect of the ideas to be learnt.

Extraneous and intrinsic cognitive loads interact in the learning situation. Teaching strategies are needed to target both. In situations where several ideas need to be learnt at once, learning will be more successful when the extraneous load is minimised.

There are several implications of this for teaching:

- teachers can help pupils to learn how attention affects their learning and to learn ways of using their attention most effectively

- teachers can give students time to allow them to attend to particular ideas

(3) teachers can include automatizing activities into their regular teaching, for example,

regular revision of key ideas
speed up the processing of information, tasks
rapid exposure to and processing of ideas

These activities help students develop their existing knowledge so that they can deal with comparatively large amounts of information at once. When students automatize core ideas they are learning, they are more able to build more complex ideas.

(4) pupils revise regularly core ideas and work on automatising them. They can build an increasingly large body of automatized knowledge, including skills (procedures that have become automatized) and declarative knowledge.

Students can allocate a portion of their regular on-going study programme to the automating of key ideas. They can work on linking ideas so that one idea easily activates related ideas.

(5) when pupils feel themselves 'drowning' in the ideas that they are learning, they can take steps to break the ideas into smaller parts, work on each part at a time and to automatize these before moving on to the larger idea.

(6) pupils can become aware of the effect of filling the thinking space with less useful, unnecessary information and attempt to avoid doing this

the effect of " I know I won't be able to do it. Everyone will think I'm a fool..."
worrying about tomorrow's maths test

Model of learning : An overview

As a first approximation, this model provides a 'snapshot' of what is involved in learning at any time. It provides a first approximation to how we go about making sense of aspects of world. How we 'make meaning' at any time will depend on the aspects of our existing knowledge that we activate, the ways in which we initiate the change, the actions we use to change our knowledge, our beliefs about the change, the social context in which we make the change and ourselves as 'meaning makers' at that time.

Our learning system is dynamic. Our sense-making or learning system has the capacity for continual change and to be dynamic. Our codes for interpreting ideas and organizing ideas derive from our existing knowledge. Just as this can be constantly changing, so can the ways in which we detect and organize information. Indeed, we need to do this.

The world in which we interact and make sense is changing. For us to go on making sense of it, so must the ways in which we go about making sense. We see this is in the ways in which new concepts and ideas are developed and new ways of describing them introduced. Our existing ways

of making sense will never entirely adequate or sufficient for making sense of contexts in which phenomena are changing.

The focus has been on the issue that learners have available to them a number of options. Some of these options may be used more frequently by one individual than others. This may be expected to be a self-feeding cycle in that those used most frequently, seen to solve problems, would become more automatized and are used in preference to others. This, over a period of time, gives rise to the phenomenon of cognitive styles, an inclination for thinking about ideas in particular ways. Can these options be changed through learning ? We believe they can.