Psychology of Exceptional Learning

We know in different ways: how our knowledge is organised

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Learning involves changing what we know. If we, as teachers, are going to be successful in helping our students to do this most effectively, a key issue for us is

What are the different ways in which we can know ? How is what we know organized ? How can we tap into this knowledge base most effectively ?

Different ways in which we can *know about banking* is shown in the box below. Once we have identified these, we can look at how these change. In this section we look at the different ways in which we can 'know'. This provides a basis for looking at how these different areas develop.

domain specific language; I know how to talk about banks and to bank staff; the jargon used:	*ways of learning* I know how to learn banking ideas and solve problems
Knowing about banking	*attitudinal knowledge;* I know the values of banking
declarative knowledge- I know what banking is and what it isn't.	*procedural knowledge*- I know how to bank; how to deposit, manage savings, borrow

In this unit we look at the different ways in which students are required to know ideas.

Many students have difficulty learning because

- their knowledge is not organized in the appropriate way
- they have difficulty using what they already know about the ideas they are required to learn.

We look at

- The different ways in which we can know.
- Types of conceptual knowledge.
- Episodic or experiential knowledge.
- Conceptual network knowledge
- Procedural knowledge : How to do it
- Ideas organised in networks around related topics.
- Implications for teaching
- Recommended teaching procedures

The different ways in which we can know.

Does your teaching hit its mark ? Learning involves changing what we know. Whenever we teach a topic, we assume that our teaching stimulates what students already know about it. Our teaching, can however, miss its mark. Students can know about ideas in any topic or content area in different ways. If their ways of knowing the ideas don't match our teaching, then learning is less likely.

You will have noticed on occasions that some of your students may have difficulty

- making links between what you are teaching and what they already know; they find it hard to make sense of the ideas you are teaching.

- showing what they know in particular ways; you know that they have learnt the ideas but they can't show them in the test situation.

- using their personal experiences in the classroom; you know that they have had relevant experiences but don't use them in formal teaching.

- applying what they know in new situations, making use of their knowledge, transferring it to unfamiliar contexts.

- putting their understanding into words; they can draw pictures or act out what they know if they are given the opportunity to show what they know in these ways.

- using an idea although they can explain it , for example, they know why a camera works but can't use one.

- knowing when to use an idea or explaining it although they can explain why it works.

- learning ideas in abstract, formal ways but can learn them in real-life situations .

All of these arise because of the different ways in which students know or understand ideas.

What students know, discipline and classroom management. These issues also have relevance for students' self-esteem, discipline and classroom management. Students who have difficulty using what they know to make sense of what they are being taught may become disillusioned with learning and begin to display unacceptable classroom behaviours. Teachers who do not know how to use students' existing knowledge effectively are more likely to have discipline and management problems in their classes.

Skilful teaching involves tapping into what students know about an idea and gradually leading them to modify this knowledge. To do this most successfully requires an understanding of how students know ideas . It also requires an understanding of the demands that our teaching tasks make on learning. Teaching that doesn't do this will leave students bored, dis-interested in learning and feeling that the ideas have no relevance for the.

Students who believe that they know ideas but have difficulty displaying them in the classroom and therefore don't receive positive feedback for what they know may, in the long term, dis-engage themselves from functional learning. Teachers who don't give students the opportunity to show what they know in appropriate ways and then, if necessary, to learn the conventional ways of showing what they know, increase the likelihood of dis-engagement and alienation from learning

Intuitive personal theories of learning

Some key questions:

- what is knowledge ? How does it differ from information ? When does information become knowledge ? Difference between information and knowledge. Interface in human processing where information is interpreted. A key issue for teaching; not all information necessarily becomes knowledge.

- how is our knowledge organised ? Describe how you think our knowledge is organised. Different types of knowledge;
  - concepts,
  - procedures, skills, strategies,
  - beliefs,
  - attitudes.
- how / why/ why do we change our knowledge ?

Theories of knowledge representation How is knowledge represented ***?***

Theories of knowledge representation operate at two levels:

- microscopic level; these theories look at knowledge in terms of its smallest parts.
- macroscopic level; these theories look at ‘bodies’ of knowledge or integrated sets of meanings.

At the microscopic level

At the microscopic level, we look at the ‘smallests bits’ of knowledge. Many of the information processing approaches explain how we make sense of information by using these types of theories. Key assumptions of microscopic theories of knowledge:

- our conceptual knowledge consist of ‘tiny units of meaning’. These allow us to detect bits of meaning in information to which we are exposed.
- particular sets of units become 'fired up', 'excited' or 'activated' by the information they detect. Other detectors won't become fired up at all.
- our detectors are linked into networks. The set of detectors that experience excitation at any time constitutes a topic or theme that person knows. A topic has diffuse boundaries
- the set of meanings that are fired up at any time become a 'space' or 'window' for thinking
- the meaning detectors differ from sensory detectors.
- meaning detectors can detect meaningful abstract symbols, icons, images and actions.
- the network at any time links ideas that we believe have something in common.
- the units of meaning can be linked in different ways
    - on the basis of co-occurring in the same place at the same time.
    - on the basis of 'semantic’ or logical relationships with other ideas.
- the 'links' are also detectors that specify relationships between concepts and are concepts, for example, 'belongs to', 'includes', 'occurs in the same situation /at the same time as' .
- part of a network processes several sources of information in parallel.
- when both types of networks are activated for the same idea, the understanding of the idea is richer and more differentiated.
- when some detectors are fired up, so are some of the others that are linked with them; the 'firing' spreads through a network. This is how we predict or anticipate.
- when 3 or 4 linked ideas are often activated simultaneously, their mutual activation becomes so rapid that we say the idea has been 'chunked' or that the links have been 'automatised.
- the links allow us to 'organise ideas' into new ideas.
- our detectors have an emotional link, for example, 'causes stress', 'happy'.
- the set of detectors is linked with ways of showing what we know

- in any problem-solving situation, we try to represent the problem using part of our meaning network - we try to simulate the situation in our network.

This microscopic level allows us to understand a range of aspects of how knowledge is used.

Macroscopic level models of knowledge

We can also look at clusters or groups of meanings at once. These are the macroscopic models of learning. They describe the different ways in which we can know.

Suppose you receive from your bank a brochure intending to teach you about **the banking revolution and what it means for you.** You can link the information in the brochure with what you know in different ways: you can

- imagine yourself in your local bank or at an ATM; ***experiential or episodic* / imagery / figural / spatial knowledge.** Ideas linked with other ideas that co- occur in an experience. This knowledge is intuitive; implicit and 'subjective'.

- recall that 'banking refers to ways of managing your money' and think about concepts to do with personal banking, investing and borrowing money. This is a more abstract knowledge not linked to particular experiences - '***semantic' or abstract-verbal knowledge*** . Combining concepts into networks with more general concepts, more specific concepts and mutually exclusive concepts. The higher levels of semantic networks are defined by a culture, through its language.

  These two types of knowledge tell you what ideas mean and how they are related to other ideas.They are types of conceptual (or 'declarative') knowledge. Each idea is a concept - a set of items that share a property. The two types of conceptual knowledge differ in:
  - decontextualized versus contextualized ideas..
  - differences in how the can be used

- do actions when you bank; ***procedural knowledge*** , knowing 'how to'.
  This knowledge can either be
  - embedded within a context and linked directly with other contextual elements.
  - decontextualized.

- have an emotional reaction to banking, for example, you may believe that banking is one of the most (or least) valuable institutions that can exist in a society; ***attitudinal knowledge***, how disposed positively or negatively you are to the topic. This includes the specific attitudes or how students feel about ideas in the subject area, how much they value them, how disposed positively or negatively they feel about them, their beliefs and attitudes about the ideas, how they feel about themselves as learners of the ideas. It can also be called ***affective knowledge about ideas.***

- recall how to learn / think in a 'banking' way; two types of thinking strategies:
  - *cognitive strategies:* refer to how learners think about ideas.
  - *metacognitive strategies:* how learners direct and manage the cognitive strategies. They include
    - planning; deciding when and why to use each cognitive strategy,
    - monitoring the ideas they are learning and fine-tuning them,
    - evaluating how effectively the learning is progressing, choosing,
    - taking further strategic action if necessary to change direction and
    - reflecting on what they learnt and what worked for them.

  Metacognitive knowledge is our awareness of how we learn and think. It includes knowing that a particular action is a useful learning strategy, how, when and why to use it.

- ***knowledge of when to learn;*** motivational knowlege, self-efficacy (Bandura)

Knowledge in these areas work together to influence how we think and learn. Your attitude to banking, interest in it and how successfully you believe you can learn about it, determine whether and how you think. How well you make sense of the information and link it with what you know determines what you learn. How successfully we believe we learn affects our attitudes towards the ideas, how prepared we are to try out ideas, to take risks when learning and to manage our learning. These in turn affect the learning outcome.

Existing knowledge

Teaching information

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- provides existing content knowledge to change
- what the outcome of learning might be like
- how to get there
- how useful are the ideas once they have been thought through, learnt
- how worthwhile it is embarking on the learning
- how the thinking - learning will be managed; what will they be expected to do to learn, what will they expect their teachers to do
- what do they know about actions to use to think; learning / thinking strategies ?

A comparison of microscopic and macroscopic level models of knowledge.

microscopic level	macroscopic level
our conceptual knowledge consists of units of meaning in the information	our knowledge base or long term memory
particular sets of units become 'fired up', by the information they detect	the parts of what we know that we are thinking about at any time
the set of meanings that are fired up at any time become a 'space' or 'window' for thinking	our short term working memory or thinking space at that time
meaning detectors differ from sensory detectors	distinction between short term sensory storage and short term working memory.
units of meaning linked in different ways • based on being in same place at same time; • basis on 'semantic links'	representing an experience / episode / image, visualisation, contextualising abstract representation, verbal / symbolic thinking cognitive styles, multiple ways of knowing
the 'links' are concepts; they detect relationships between meaning concepts	propositional thinking; language, reading tap into meaning-relational-meaning links
part of a network processes several sources of information in parallel	this is how we tell if information from different sources 'fits together' or makes sense
when both types of networks for the same idea are activated, understanding is richer and more differentiated	dual coding theory; access to multiple codes short term working memory codes; phonological loop, visual scratch pad
when some detectors are fired, so are others linked with them	this is how we predict or anticipate.
when 3 or 4 linked ideas are often activated simultaneously, their mutual activation becomes so rapid	we say the idea has been 'chunked' or the links have been 'automatised

the links in the information allow us to 'organise ideas' into new ideas	The grammar of a sentence can, for example, tell us how to link some ideas for the first time.
our detectors have an emotional link	motivation to engage knowledge
some meaning detectors are linked and others aren't linked	rational thinking is when two concepts linked logically intuitive thinking is when two ideas not linked occur in the thinking space impulsive thinking when we link two meaning units without considering the relational concept (if there is one)
set of detectors is linked with ways of showing what we know	proceduralising our knowledge of a topic, converting what we understand to actions
in any problem-solving situation, we simulate the problem using part of our meaning network	

In the following sections we examine various types of macroscopic knowledge.

Conceptual knowledge

Conceptual knowledge refers to what particular ideas mean and how they are related to other ideas. Put simply, a concept is the awareness that a set of items are believed to share a property, for example, the set of earthworms, the set of instances of honesty and the set of novels. It can also be the rule that specifies the attributes necessary for belonging to a particular group or concept.

This knowledge is called ***'declarative knowledge'***; it allows you to answer 'what', 'when to' and 'why' questions about the idea. You can use your knowledge of the concept of earthworms to decide whether an animal is an earthworm and why it is an earthworm. You can also explain when to use the term 'earthworm'. Conceptual knowledge is shown in the following situations

- students learn the features of a novel and decide whether a text is a novel or a biography.
- biology students produce their own theories of how earthworms breathe by synthesising what they know about how humans breathe with the living conditions of earthworms.

We use conceptual knowledge in various ways during learning; to

- categorise and classify, to recognise instances of an idea,
- recognise when to use an idea, when ideas are appropriate,
- explain links between ideas, to understand ideas and their relationships with other ideas.
- transfer and generalize our knowledge.

A piece of information is not necessarily by itself a concept. It is only a concept when the learner uses it in this way. If people believe that the word *'dog'* applies only to a specific animal and are not aware that other animals share its features, they understand *'dog'* as a label, not as a concept. If they understand that *'dog'* can apply to other animals and that these animals have common features, they understand 'dog' as a concept.

Concepts can be combined to form more general (and more abstract) concepts. The concepts 'dog' and 'cat' can be combined to form 'domestic animals' or 'pets' and these into the more general concept of 'animals (non-human) that live with humans'. They can also be split into more specific concepts. The concept 'dog' can be split into different breeds, for example, 'Alsatians', 'Terriers' or into the functions dogs perform, for example, 'watch dogs', 'sheep dogs'. For each concept, there is

also an 'opposite' concept- the things that are not in the group. For the concept 'cat', the 'opposite' concept is 'not a cat' and would include everything that is not a cat. This can be shown in the following network map

animals (non-human) that live with humans

domestic animals or pets' wild animals

dogs cats

Alsatians 'Terriers watch dogs sheep dogs

Our teaching frequently requires students to develop this 'conceptual awareness', to understand how to put thoughts into categories and to transfer knowledge to new situations. It also requires them to change the boundaries of a concept. The concept 'cat', for example, can be broadened to refer to other animals that show the quality of being self-directed, working quietly, moving sleekly and changing in unpredictable ways.

Types of conceptual knowledge. Concepts can be linked in different ways. One way of seeing how students make these links is to monitor how they answer questions that tap their conceptual knowledge. Consider the replies of two nine year old students to the following questions:

	Jan	Peter
Explain what is meant by the word 'winter'.	*Winter is a season. It's a time of the year when it is cold. It lasts for a few months. the middle of the year". It's opposite to summer*	*It's cold outside in winter. I play outside in winter I have It's in to put warm clothes. It rained lots of days last winter and I got a cold. We went to the snow last winter.*
What is a telephone ?	A *telephone is a way of sendingmessages. They help us sentmessages. There are ordinary phones and mobile phones*	*I talk on our telephones to my friends. We've got three. Dad has a car phone that was stolen.*
Name two Australian states.	*Victoria and Queensland*	*Don't know* When asked where he'd been on holidays he said *Tasmania and Queensland*

The answers of the two children suggest they have linked concepts differently, as follows

Conceptual networks versus episodes. Jan's answers suggested links with other ideas that were either more general or more specific than the questions asked. She linked winter with the more general concept of season and with its opposite, summer. This linking is sometimes described as 'hierarchical'. The concepts are thought of as being organized in hierarchical networks:

seasons

long time types of seasons

winter summer

lasts for few months cold weather

Peter's answers, on the other hand, suggested links with ideas that occur in the same place at the same time, for example, raining or snow, or the need to wear warm clothes. His ideas about winter were anchored in particular contexts or situations that were personal experiences for him:

It's cold outside in winter.	If you play outside in winter you have to put on warm clothes.	It rained lots of days last winter and I got a cold.	We went to the snow last winter.

Jan tapped into a network of ideas that contained telephone. She moved up and down through it, linking ideas at various levels. Peter recalled a set of episodes or experiences that contained the word "winter". The ideas linked with winter in each episode occurred at the same time or in the same place; the ideas were contextualized. Both students displayed knowledge about winter. They had linked the ideas, however, in different ways.

Episodic knowledge is 'implicit conceptual knowledge'; learners use it to recognize instances of a concept and can decide when to use the concept but may have difficulty discussing how they operated conceptually or explaining why they made their decisions. They can't 'tell you why'; they 'just know'. Network knowledge on the other hand is explicit conceptual knowledge; learners with network knowledge can explain why they made their decisions.

Other examples of the two types of declarative knowledge are the following:

Conceptual question	Response suggesting network organisation of ideas	Response suggesting episodic organisation of ideas
How do photographic cameras operate ?	Cameras are used to record images on film. They need the correct light and exposure for an image to be formed.	When we go on holidays we use our camera to record in pictures what we did. You can't take photos if it is too dark without a flash.
What is a tree ?	A tree is a living thing. It changes carbon dioxide to oxygen. This is called photosynthesis. There are several types of trees.	We planted some trees in our back yard. We made sure they got enough water and sunlight so they wouldn't die. You can breathe when you live near trees because they make oxygen.
Describe a star	Stars are made of burning hydrogen at very high temperatures. They give out light and heat.	Stars shine at night because they make light. They are on fire and this makes their light.
How would you explain what 'art' is ?	Art is a way of representing our world. It is a way of communicating. There are different types of art; painting, sculpture, drawing.	Art is when we draw and paint. Last week in art I drew some fish. I really like art.
Describe the special features of a letter ?	A letter is a type of writing. It is addressed to particular people and carries a message. It usually has the name and address of the person it is written to and is signed by the writer.	Last week I wrote a letter to my aunt. I told her what I got for my birthday.
What is a minim ?	A minim is a musical note. It is played for a certain time. It is longer than a quaver and shorter than a semibreve.	You see minims on written music. I play minims on the French horn. You play them slow.

Episodic or experiential knowledge.

The examples of episodic knowledge show how learners relate ideas using their experiences in specific contexts. Their knowledge of the concepts are stored in a contextual way, with each idea linked to other ideas that co- occurred with it. Their knowledge could be used to identify instances of the concept, although they may not necessarily be able to explain or justify their decision. Peter's understanding of winter, for example, can be described as

- ***intuitive***, in that he 'has a feel' for the idea; he can recognise instances of it.
- ***implicit*** in that he can't explain why he made his decision. It may have seemed obvious or self-evident to him and did not need to be justified in propositions such as "*Winter is when it is likely to be cold for a long time"*.
- ***'subjective'*** rather than 'objective'; it is based on Peter's experiences and others may not make the same decision in the same situation.

Because of these characteristics (and others), episodic knowledge is generally not as valued in formal education as much as the corresponding conceptual-network knowledge. It is, however,

- the knowledge that students often bring to school about a set of ideas
- the knowledge that is frequently used in real-life transactions.
- one way in which we categorise information and decide when to use what we know.

It is important, then, that students learn to use it and that our teaching build on it and show students how to use it.

What is an episode ? An episode is in some ways a personal picture or 'snapshot' of an experience. 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. It contains a great deal of information. As well as things seen in the situation, we can record what we heard, smelt and felt. It is what we believed we experienced at the time. Images of experiences are integrated, with the elements linked in space and time in much the same way as they were in the original situation .

The images are content specific rather than abstractions of the experience. We think of them as what we see because we usually process visual information simultaneously, whereas we process auditory information sequentially, in bits, 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.

As well as representing experiences in imagery, we can also construct imagery for things that we have read or heard without having directly experienced them. Learners can create episodes in which previously unrelated images are combined in spatial and temporal ways. They can convert verbal-linguistic and symbolic information into imagery forms. You may build a set of images or a 'mental videotape' for a novel you are reading or a story you heard. These imagery episodes can have the same status for future learning as direct experiences. The generated images don't have to look like the items they represent; they simply need to code particular features of the idea. This leads to the distinction between perceptual knowledge and imagery knowledge.

We use episodic knowledge by matching When we encounter a new situation, we retrieve from our store of episodes one or more that we use to make sense of it. Our stored episodes allow us to link information in the new situation with what we already know. We do this by a matching process. Features in the new experience stimulate almost automatically corresponding elements in the stored episodes. These can then be used in the current situation.

When items in the current situation are matched with items in the stored episodes, we can retrieve other linked items that are in the stored episodes but may not be in the current situation. We can impose or add these to the new situation, thus going beyond the information that was given.

We see this all the time in everyday life. A 2-year old has an Alsatian dog at home and calls it "doggie". When the child sees a miniature pony she calls it "doggie". The child learns through bath play that some objects float and others sink. When given a new toy, the child can decide with reasonable accuracy whether it will float or sink. In neither case can the child explain her decision.

In this way we seem to know implicitly or 'intuitively' what to do; the original episodes 'tell us' this. The 2-year old expects a new toy to float because it feels light. She has an 'intuitive feel' for the idea of floating without being able to explain why. She knows that it would float because things that have been light have floated in similar situations in the past. Her knowledge is 'implicit'; she possesses it without being able to explain her understanding. Explicit knowledge about an idea, on the other hand, is shown when the person can link the idea with other ideas.

Episodic knowledge allows learners to

- recognise that a new situation is like earlier experiences and that what else we know about the earlier experience may be relevant here and

- decide how to act, by transferring procedures in earlier experiences to the new situation.

It is easier to match a new situation with stored episodes if they both have obvious shared features and or if the shared features stand out. Transfer is more difficult in situations in which the shared features are not so obvious or where students can't see how to make links as easily.

Episodes are relatively easy to learn. They don't involve information being re-organised in any major way and don't need a large investment of attention. You can obviously have a range of episodes of a situation, for example, an episode of winter on one day, a different one relating on the next day, etc. We can simply keep adding to the episodes.

The information in each image is stored in such a way that it can be scanned and transformed later in the same way as the real situation can be scanned. Learners can take episodes apart, analyse them to obtain specific information, change or rotate aspects in the episode, imagine how they will change over time. Students will often need to manipulate the items in an episode in these ways to use the knowledge for dealing with the more abstract semantic or conceptual tasks typical in much of formal education; as they are, episodes are of limited use here.

Episodic knowledge is what students often bring to school. Often, however, it is not valued in formal education as much as the corresponding network knowledge. Possible reasons for this:

- because it is intuitive and 'subjective' rather than 'objective', it is not seen as being as useful.

- formal education values the capacity to explain logically and to justify.

- teachers and schools don't know how to use it to build corresponding network knowledge, how to assess it, how to use it to help students apply what they have learnt.

We need to develop teaching strategies that allow students to use their episodic knowledge to build network knowledge about a topic. Students often learn to devalue or mistrust their implicit or intuitive knowledge in formal education; they believe that it is not relevant or useful. They need to see it as a first step learning of the idea. Teachers need to let their students see that their episodic knowledge is valued and can be used for further learning.

Generalised nonverbal images Learners can generalise from specific episodes to form summary or 'prototype' images of key features in the episodes. A summary image puts together what we see as the salient or common features in several specific episodes. A person's summary image of a bear has the features seen as most typical of bears. From these summary images learners may develop icons or templates for ideas in new situations.

Learners may, for example, have an icon based on pizzas to represent fractions, or the icon of a bag of bolts to represent pronumerals in algebra. These icons provide students with 'visual hooks'

onto which particular ideas can be hung. Students can act on the image in logical ways, for example, rotate parts to match them, imagining three and one half pizzas being re-arranged so that each whole is cut into halves.

One type of knowledge includes images that are structural analogues of the world, perceptual correlates from particular points of view. They bear a correspondence to the environment they represent and are used by learners to represent the world, to solve problems and to acquire new knowledge. A prototype image of a cat may have a particular colour or size, have specific features and move in particular ways. The image has the 'typical' features of a cat.

These images are analogue representations, whereas the propositions in conceptual networks are analytic and less tied to a context. A proposition representing a cat is not restricted to particular colours or sizes but can assume a number of different values. The prototype image may have specific values such as a certain colour, body posture, etc.

Some people have argued that images don't exist separately and that the subjective experience of imagery could actually be coded in propositional form. However, at more global levels of analysis these appear as different kinds of representations.

There are essential differences between imaginal and analytic representations. For the proposition 'man is bigger than cat' the image of the relationships is *intrinsic* in that the fact is represented by drawing the man bigger; the relation 'bigger' is intrinsic in the image. In the propositional representation there is nothing intrinsic in the expression 'bigger than' that allows it to represent size; the validity is based on linguistic convention and is extrinsic to the representations itself.

Limitations of episodic knowledge While implicit knowledge works in practice, it may not be necessarily logically consistent. Many of the preconceptions children (and adults !) have about scientific concepts fall into this category. A 3- year old may know that light things float. He might reasonably expect a needle to float, because it is light. It sinks. Children (and adults) know that to move a car or a wheelbarrow at a regular speed along a flat surface in the real world you need to push it. As soon as you stop pushing, it stops. These experiences develop the notion that to keep something moving at a regular speed, it needs to be constantly pushed.

People skilled in science, however, believe this not to be the case. You don't need to keep pushing an object to make it move at a certain speed. In fact, they learn that the opposite is true; when you push an object, you change its speed. The fact that in the real world we need to keep pushing to make something go at 5 km an hour is explained by friction. If the object were moving along a perfectly smooth, frictionless surface at 5 km per hour, we wouldn't need to keep pushing it. These types of misconceptions are common in learning in science and in most areas. Whilst they are inadequate, they provide a base for developing knowledge further. When students make this implicit knowledge explicit, they can modify it and to relate it to what they already knew.

Episodic knowledge is not useful for explaining, evaluating, summarising, synthesising or analysing. These are the ways usually provided in formal education for showing what you know. To display it in these ways, it needs to be re-organised into the network format by making aspects of it explicit.

Using episodic knowledge to build network knowledge. When you first learn a set of ideas, the natural urge is to get a feel for them before you link them with other ideas. We try to get episodic knowledge of the ideas in everyday situations before the network knowledge. You experience a situation and remember aspects of it without understanding why things happened and a few weeks later you may quite suddenly feel that 'things fall into place', that you can see why things happened the way they did in the situation.

Implicit knowledge is what we know about an idea before we analyse it logically. Because we often need time to do the analysis, in natural situations we can retain a new idea implicitly until we have time to analyse it and link it with other ideas. We may not have the level of reasoning or thinking necessary for making the links, the language-thinking abilities necessary for putting these ideas into words, the motivation or the interest in making the links earlier. This is a major influence in child

development. Children represent ideas in perceptual or iconic ways early and learn how to analyse them logically at a later developmental stage.

They frequently however, do not have the opportunity to do this in formal education; they may be required to learn a new idea in its explicit sense when they first encounter it. Many children find this difficult and need to 'get a feel' for the idea first. Once they have demonstrated an implicit understanding they can begin to explore the explicit links between the idea and related ideas.

Conceptual network knowledge

Combining concepts into networks with more general concepts and more specific concepts is a second metaphor for thinking about the links between concepts. Much of what we expect students to learn in formal education are concepts arranged into networks around topics or themes. When we ask them to explain, evaluate, compare, summarise, paraphrase, synthesise or analyse, we are assuming their knowledge is organised in these ways. We can have networks of concepts for topics such as food, physical education, pets, gardening or cars. Network knowledge helps you to

(1) give reasons why you think an item an event is/ isn't an instance of a concept, for example, why growing fruit is an instance of gardening,

(2) link an idea with more general and more specific ideas, for example, relate 'car' with 'a mode of transport' and with 'Mazda 323s' or explain how a car is like a horse.

Much of what learners learn in everyday life away from school on the other hand, and bring to school, is episodic knowledge. We need to help them to re-organise this into network knowledge. An example of concepts linked in a hierarchical network is the concept of transport, shown below;

			transport	
have combustion engines			have electric motors	are wind-driven
car			tram	yacht
Holden	Mazda			
626	323	929		
323s built in 1982	323s built in 1984		323s built in 1986	

Concepts in the network can be linked into propositions, explanations and principles, for example

(1) Means of transport can be powered in different ways.
(2) How are trams and Mazda 323s similar ?

The groups at each level of a hierarchy can be set up using different criteria; they may

- share the same perceptual features, that is, look the same, for example, they are all yellow,
- look different but share a semantic property, for example, contain the same number of items,
- look different and differ in some semantic properties but share the same functions, for example, all used to carry people,
- differ in semantic and functional properties but share the same generic properties, for example, Jan might extend her 'seasons' network into the more general form for the abstract idea 'time durations':

			time durations		
	long			short	
seasons	years	months	minutes	hour	day

winter summer

Concepts such as 'time durations', 'animal', 'responsibility' or 'freedom' are not as comprehensible as those that have direct concrete reference, such as 'two', 'yellow' or 'Mazda 323'. Many of the more abstract concepts are defined by a culture, through its language. The language shapes the conceptual networks that students learn. We are all aware the Eskimo culture has more words for describing the different types of snow than English.

As well, languages differ in how they categorize ideas. Some cultures would not see it useful to place dogs and fish in one category (vertebrates) and flies and ants in another. For them having or not having legs is a more sensible classification. Similarly, not all cultures place in the same category ("bird") a feathered animal that flies, a large two legged animal that has a beak, doesn't fly and puts its head in the sand and a piece of meat cooking over a fire. Our culture has decided these higher level concepts. Other cultures, through their language, arrange the categories differently.

Teachers need to be aware of the origin of concepts because we are expected to teach them. Many students find it harder to learn more abstract concepts such as 'time durations', 'animal', 'responsibility' or 'freedom' than concepts such as 'two', 'yellow' or 'Mazda 323' and are more likely to mix-interpret them. We will revisit this topic when we examine cultural influences on learning.

Differences between the two types of conceptual knowledge These include:

• *decontextualized versus contextualized ideas.* Jan's answers earlier were decontextualized; they didn't make reference to specific contexts. Peter's, on the other hand, were contextualized; they were anchored in particular situations and events.

• *differences in how they use the declarative knowledge* Both children had declarative knowledge of winter. However, organizing the concepts in these different ways affects how they can use the knowledge. Jan could link the concepts into propositions and explanations, for example, she could explain how winter and summer are similar. She may not have been as likely to link tobogganing with drinking cocoa in talking about winter as Peter would be. Peter may not be as able to explain propositions about winter or why he made his decisions but could recognise a broad range of experiences linked with winter.

Implications of the two types for teaching Formal teaching frequently ignores the episodic knowledge students have about a topic and tries to teach network knowledge directly. Many students

- don't believe that they know anything about what they are learning, when in reality they do. It is just that their knowledge is in episodic form and the teaching hasn't helped them to connect it with the network ideas being targeted.

- don't see how the network knowledge they are taught at school is relevant to their world. They can't see how to use it other than to pass examinations. They need the opportunity to map the network knowledge into real-life contexts by producing episodes, that is

  translate into
  network knowledge ----------> real-life episodes

- don't see how to transfer their network knowledge to new situations. They need to discuss the types of situations in which their knowledge is and isn't useful.

More generally, students need to see how their declarative knowledge can help them to

- recognise objects; when you know the concept of winter, you can recognize instances of it and so reduce the complexity of your environment and the amount of information you need to carry. The concept 'winter' has a linked set of properties. This is true for any concept we are teaching students. When you recall the concept, you can recall the linked properties.

- decide when to do things, when particular knowledge is appropriate. When you know the concept of winter, you can retrieve the linked procedures.

- reduce need for constant learning. Once you have decided that a season is winter, you can give it all the linked properties. You can recognise new objects without new learning and can go 'beyond the information given'

Students need to practise using conceptual knowledge in these ways.

Where do concepts come from ? Developmental trends in forming concepts

To teach conceptual knowledge, we need to understand how it develops. It has two sources; our experiences and our culture, through our language. Relatively simple conceptual networks come from experiencing objects that share perceptual properties (for example, items that are red) along with the signs that refer to the shared properties (for example, the word "red"). The more abstract levels of the conceptual networks depend on how the language delineates and organises ideas.

Action-based' grouping From a young age children show they classify objects by acting on them and noting the actions they do. They apply the same action to different objects, for example, they push a toy engine, a toy car and a piece of wood and use actions to symbolize events or items in symbolic play and gesturing.

Perceptually-based groupings As they learn the words or signs for how things look, sound or feel, they start to categorize objects and events into perceptual categories, for example, 'yellow'.

Meaning-based groupings Gradually they learn to classify items that look different but that share meaningful properties into the same category, for example, their concept of 'animal' includes dogs, cats, elephants and magpies; they understand practically the set of 'things that breathe'. They can also justify their decisions. They form concepts based on function or use, for example, "a boat, a train and a car are similar because they all carry people'. They use meaningful properties that aren't perceptually based. They need to sort or group real-life items to form mental categories.

Abstract groupings Students learn to think about concepts without needing to refer them back to real-life situations; they can deal with them in abstract ways and can weigh up and work on different levels of an abstract hierarchy. They learn to comprehend infinite sets and concepts.

When students need to learn concepts with which they are relatively unfamiliar, they may need to learn them in an action way first, then visualise them, explore their meanings first in real-life contexts and finally in an abstract way.

Formal teaching, on the other hand, sometimes doesn't give this opportunity and it presents the ideas in abstract, decontextualised ways. Many students will have difficulty learning them in this way; they need to move through the different ways of thinking about the concept, as follows:

manipulating the idea in an action-based way, forming action-based groups.
|
manipulating the idea in a perceptual-based way, forming perceptually based groups
|
manipulating the idea in a meaningful way in real-life contexts
|
manipulating the idea in an abstract way

The language to which children are exposed influences the concepts they learn. It is speculative whether concepts such as family or adolescence would exist without words for them. Mere labelling a phenomenon is insufficient. For it to be a concept, it needs to refer to a set of instances that is recognisable by those using the concept. For the concept of family, it would be possible for a culture to have different words for a 2-parent family, 1-parent family and extended family. It

would also be possible for a culture to break the span of child development from infancy to adulthood into several or few ranges, with a separate name for each.

Using episodic knowledge to build network knowledge.

Children in real-life naturalistic situations learn episodic knowledge before they learn the corresponding abstract network knowledge. They know how to do something and to recognise instances of it but not be able to explain it. They can show an implicit understanding of buoyancy by predicting that a heavy object will sink while a light object will float or by showing how they can change an object to make it more likely to float before they can explain how they made these decisions. Their explanation in terms of heaviness comes later.

The first step in learning many ideas is to get a feel for them. You learn their links with other ideas later. This is how we learn in a wide variety of everyday living situations. You experience a situation and remember aspects of it without understanding why things happened and a few weeks later you may quite suddenly feel that 'things fall into place', that you can see why things happened the way they did in the situation.

Implicit knowledge is what we know about an idea before we analyse it logically. Because we often need time to do the analysis, in natural situations we can retain a new idea implicitly until we have time to analyse it and link it with other ideas. We may not have the level of reasoning or thinking necessary for making the links, the language-thinking abilities necessary for putting these ideas into words, the motivation or the interest in making the links earlier. We represent ideas in perceptual ways early and learn how to analyse them logically at a later developmental stage.

They frequently however, do not have the opportunity to do this in formal education; they may be required to learn a new idea in its explicit sense when they first encounter it. Many children find this difficult and need to 'get a feel' for the idea first. Once they have demonstrated an implicit understanding they can begin to explore the explicit links between the idea and related ideas.

Procedural knowledge: How to do it

So far we have focussed on declarative knowledge, that is, how students link or relate ideas. Another type of knowledge in any subject area is 'how' to do things in that area; the procedures or characteristic actions. This knowledge helps us to act or to do things. Our procedural knowledge maps into motor actions, that is, leads to the person acting in some way. Students show this knowledge by doing. Some procedures map into mental actions. Knowing how to includes knowing how to do a mathematics task, gather information, repair a camera, pump up a bike tyre.

In episodes, procedures are embedded within a context and linked directly with other contextual elements; the procedure is contextualized. When learners are exposed to new situations, they can use the procedure by matching aspects of the learnt context with the unfamiliar context; they superimpose what is known with the new. A learner who has learnt to pump up a bike tyre can pump up the tyre of motor mower or pump up a lilo as long as connections can be made between elements in the contexts.

Procedures can also be decontextualized. Counting procedures and reading procedures are decontextualized action sequences for most adults. They can be applied to a range of contexts and the individuals applying them can describe how they apply the actions.

A comparison of the public domain theories refer broadly to procedural, episodic and semantic knowledge is shown in the following table.

theories	semantic knowledge	episodic knowledge	procedural knowledge
Wechsler	verbal intelligence	performance intelligence	
	verbal/linguistic logical/math thinking	visual/spatial thinking	body/kinaesthetic

Structure of Intellect	symbolic and semantic aspects of contents	visual, auditory aspects of contents	behavioral aspects
Piaget	abstract understanding used to reason logically, explain 'why' (operative knowledge)	copy of a person's reality represented in imagery (figurative knowledge).	
cognitive style	verbal-linguistic or abstract preference	imagery or concrete preference	
Dual coding theory	verbal code using words, grammar, pragmatics	nonverbal code using images, emotions, episodes	nonverbal code using actions

Knowledge of the language of the content area

Each content area has its own ways talking about ideas, its own jargon and often its symbolic language, such as the formal notational symbolism of mathematics. Scientific ideas are linked in different ways from ideas in music or poetry. This is knowledge of the language of the content area, that is, domain specific language.

Why do some ideas interest us ? Affective knowledge about ideas

Why do some ideas interest us more than others ? Linked with what you know about how well you can learn, you also learn to feel in particular ways about ideas that you learn. This is your **affective or emotional knowledge** of the ideas. It refers to how you feel about ideas in the subject area, how much you value them, how disposed positively or negatively you feel about them, your attitudes towards them. When we learn new ideas we not only link them with what we already know in a cognitive way but that we also link emotion and how we feel with them. Cognition and affect (or feeling) are inextricably linked.

Whenever we learn an idea, we link emotions with it, for example, whether the idea is enjoyable, interesting or useful. Part of the learning involves linking our feelings about the ideas, their level of interest and utility for us, how well we can learn them.

When we retrieve these ideas later to make sense of related ideas, we retrieve these feelings. At the same time as we think about how ideas are linked, we also decide whether we think the ideas might interest us or are useful to us. Our understanding has both cognitive and emotional components. We seem to become aware of these two aspects automatically. Models of how we represent our existing knowledge need to take this into account. So does our teaching.

Many students develop negative perceptions in some of these areas. They may rarely have felt interested, curious, happy or satisfied as a consequence of learning. Whenever required to learn in the future, they may feel threatened and anxious. These feelings influence the child's learning in a cyclical way so that without educational intervention, earlier perceptions are generally reinforced.

Learners link their emotional reactions to a learning task through self-talk, for example, "I always get fractions wrong. I just can't do them" or "I hate writing essays". Teachers need to be aware of how negative self-talk can restrict learning and the teaching strategies to use to counter it.

Putting together the various ways of knowing

The various areas of knowledge are linked with each other, so that when you begin to learn a new idea, you can frequently recall what you understand about related ideas, how they are used and how you felt when your were learning them. The question arises of how these different areas are linked.

Our knowledge is organised in themes. One thing that becomes clear is that some aspects of our knowledge at least are organised around themes or topics. Some topics are broader than others and contain them, for example, the topic of transport includes the topic of travelling by elephant. Some topics are not usually included within other topics, for example, it would be unlikely that most

people would include the topic of travelling by elephant within the topic of submarines, although you could, of course, do this. This inclusion / exclusion notion has led people to suggest that our knowledge is organized into broad networks of ideas, with ideas that we believe to be related linked in some ways. These networks are often referred to as **schemes** (or schemata).

Schema models of knowledge A schema is a body of knowledge that includes what a person knows about a related set of ideas. It includes both abstract (decontextualised) and contextualised conceptual knowledge and procedural knowledge. It also includes attitudinal knowledge, how you have felt about the ideas in the past and what you did to learn about them. Some ideas may be linked in a strict hierarchy. Some ideas may be linked more loosely. The links are determined by your prior learning and have different strengths;

- some ideas will be very strongly linked with another idea; whenever you think of one idea, you can't help but think of the other, for example, you may always link elephants with trunks and tusks, or you may always link the written word 'apple' with its spoken form.

- some ideas are linked more loosely; based on what you know, a particular idea may be equally likely to be linked with two or three other ideas, depending on the broader context, for example, trunk may be linked with a long distance telephone call, a large container for carrying personal possessions, a part of your body or an elephant's appendage.

- some ideas are rarely linked with others.

The schemata that learners have at any time determine how they will make sense of information. *As* an example of how schemata are proposed to operate, read and complete the following text .
Tom was a tired weight lifter. He had worked hard on the weights. Finally, his coach pointed to a set in the corner: "That's the last for you today". As Tom walked towards it he thought "This barbell looks light': but as he moved closer, he was that it was _____

The extract finishes ....dark. *"I'll need to paint this one too': he said* . Most readers predict *"heavy"* instead of *"dark";* they believe that Tom had been exercising with the weights, not painting them. Some readers express surprise at the reference to painting, while others re- read to see why they had formed their belief and whether they had missed an earlier reference to Tom being engaged in painting the weights.

The explanation for our thinking here is that ideas in the text, such as 'tired weight lifter', 'worked hard on the weights', 'coach', 'barbell' and 'light' trigger in our long-term memory a schema that contains matching elements. This matching can occur because the schema has 'slots' or 'place holders' into which the ideas from the text can be slotted. In the present case, it is our schema for 'weight lifter'. This schema is a network of ideas that includes knowledge about being a weight lifter (the work done by a weight-lifter's coach, the feelings associated with a weight-lifter lifting weights, wearing a tracksuit, perspiring, etc.), syntactic knowledge, knowledge of letters, words, visual patterns, how one reads, etc. Words such as 'heavy', 'overloaded' would be expected. This area of conceptual knowledge can be shown diagrammatically as follows:

work in gyms and have a coach	interested in the weights they can lift	strong muscles
lift sets of weights repetitively	weight lifters	interested in building up their bodies
get tired lifting weights	wear a track-suit	perspire

We can also 'go beyond the information given'. By tapping into the schema for weight lifter we can anticipate or predict ideas that are contained in our schema but are not mentioned in the text. We are less likely to predict the concept of "dark" because it is rarely associated with being a weight lifter. Had the word 'weight lifter' been replaced by 'painter', one might expect 'dark' .

Schemas have a number of properties

- ***they have sets of features that they match with different aspects of the information in a particular situation.*** These aspects include the context, the main and subordinate ideas and the procedures used. For any schema, some of the features are more important than others. For weight lifters these include the types of weights that are being lifted (barbells, dumb-bells, etc., rather than bricks or weight belts, the reasons for lifting them, where the lifting is most likely to take place, how much is lifted.

- ***they are like theories*** in that they allow learners to interpret and to link otherwise disparate information. The total schema at any time is the individual's understanding of an event. The fact that the weight lifting example surprises you suggests that you had a generalised or prototype knowledge of weight lifting to which you relate the current situation. This allows you to make sense of the event and to infer or anticipate what might happen.

- for any topic, ***schemas usually contain more information than is provided in the situation***. This allows us to 'go beyond the information given' and use what else is linked within our schema. In painting a house, if no mention is made of the undercoat, our schema tells us to consider this.

- they provide us with ***a way to organise the incoming information*** and to see how well it fits with what we know. A schema provides us with 'organising units', that is, ways of looking at the information as well as a framework for integrating it.

The metaphor of the conceptual network explains how we organise part of our knowledge. Learners use these networks by tapping into them at various points, using adjacent portions to organise the ideas that they are learning, moving up and down through the network to relate ideas. They can use the ideas in the network to predict and anticipate, to confirm or question the course of their learning. Learners operate as if they are imposing the networks that they have learnt over the ideas.

Multiple ways of knowing

Dfferences in how we go about 'representing' or 'coding' information.: ***Paivio's Dual Coding Theory.*** Individuals differ in how they code the ideas that they are learning. One model for this is the dual coding theory developed by Paivio and colleagues over the past twenty years and reviewed most recently by Clark and Paivio (1991).

The dual coding theory proposed two ways of representing ideas; either verbal/linguistically or nonverbally. This theory proposes that people can represent ideas in at least two ways; either by using their verbal knowledge or by using nonverbal imagery. Individuals have access to both a linguistic-verbal representational system and a nonverbal system.

Information coming in and detected sensorily

Imagery coding system	Verbal coding system
• makes images by coding shapes, sounds, actions. • a single image contains much information • several sources of information can be processed simultaneously	• uses word-like verbal codes • the verbal ideas are related by their linguistic properties • information is processed sequentially

The verbal system includes knowledge of individual words and their meanings, relationships between meanings, verbal propositions, knowledge of grammar, pragmatics and what words look and sound like. The nonverbal system includes non-linguistic images for concrete and abstract concepts, shapes, sounds, actions, emotions, and other perceptual information (colour, size, etc). This information may be stored in terms of particular episodes or representations of events. A

single nonverbal image may represent a context and contain much information about items in that context. When a person hears the word 'door' verbal knowledge activated by the person may include the place where you enter or leave a space, it is like a gate, it is able to move to allow or prevent entrance to a space, that the category of door can be divided into smaller categories (front doors, roller doors) and may be related to larger categories (barriers). Nonverbal knowledge activated by this word might include a mental image of a house in which the front door stands out, a car door being opened, etc.

Individuals have both verbal and verbal representational systems. When a particular piece of information is detected, for example, they hear or see the word 'door', both types of information are stimulated and integrated into an understanding of the word . Matching verbal and nonverbal information are linked, so that seeing or hearing the word 'house' may stimulate a visual image of where one lives and the word 'Beetles' may stimulate either an auditory or a visual image of the Beetles singing. These pieces of information and the links between them are learnt.

Individuals differ in their capacity to use either imagery or verbal information; while some will use imagery easily, others will do so with difficulty. A corresponding situation applies to the use of verbal information. According to Clark and Paivio, some individuals can use imagery spontaneously and automatically across a range of situations, while others find it much harder to use and need to invest considerable attention in doing so. These people are more able to use their verbal knowledge. This then, provides the basis for individual differences in learning. It would seem reasonable to expect that those who find mental imagery easier to use to represent knowledge will demonstrate a preference for using this representational form rather than the verbal representational form.

Use of either representational system can be cued by instruction. Reminding students to 'make a picture' as they read is more likely to lead to the construction of a visual representation of a text. Similarly, instructing readers to paraphrase or summarize as they read is more likely to stimulate attempts to use the verbal coding system.

Multiple intelligence model

Gardner's (1985) multiple intelligence model suggested that there are at least seven ways of learning or 'knowing' ideas;

types of intelligence	thinking and knowing in terms of
• verbal/linguistic	words and one's knowledge of language
•logical/mathematical	symbolism and scientific logic and order
• visual/spatial	visual imagery and using spatial information making mental pictures
• body/kinaesthetic	actions
• musical/rhythmic	nonverbal sounds such as music, rhythmic patterns and beats
• interpersonal	other people's perspectives, moods and feelings
• intrapersonal	what one knows about one's self as a learner
• environmental	what one knows about biology and the environment

The verbal/linguistic and logical/mathematical ways of knowing are aspects of the verbal coding system while the visual/spatial, body/kinaesthetic, musical/rhythmic, interpersonal and intrapersonal formats are aspects of the nonverbal or imagery coding system.

Gardner proposed that individuals display a preference for using some ways of learning over others.

Questions arising from Gardner's model.

To which stages of our learning model do the seven ways of knowing apply ? Do they apply only to the ways of thinking about ideas or do they include input preferences ? Gardner's description suggests he is referring to ways of thinking about ideas, while teaching activities intended to develop the ways of knowing focus on changing the input format of the information .

Interplay between the different ways of knowing. There are several aspects to this.

- When learning an idea does a person use one or two or more ways at once, perhaps with one way dominating, as suggested by the dual coding theory ?
- Can a person switch between alternative ways of representing the idea ?

How is the set or range of ways of knowing managed or directed ? When the learner is given a task, how is the decision made to use the visual/spatial way rather than the verbal/linguistic way ? Do we make this decision automatically or do we need to learn which way is likely to be most useful ? How do we decide when using a particular way isn't working and we need to change gear to switch ways ?

Why may a person show a preference for a particular cluster of ways of knowing ? A key concept in learning is the issue of attention. To learn anything we need to invest attention in it. The amount of attention that all of us have for learning is limited . We have all had the feeling of 'drowning' in learning situations in which the teacher has gone on presenting us with too much information for us to handle and all that we wanted was for the teacher to stop and to give us the opportunity to consolidate or to ask questions. In relation to the ways of learning, we believe that using any one of them can demand some of our attention. The more we use a particular way of learning, the more automatically we can use it and the less attention we need to invest in using it. When we can get away with investing less attention in using one of the ways of knowing, we have more attention to use for building the idea in question. We believe that as adults the ways of learning that we prefer to use are the ones that we can use more automatically.

Sternberg's triarchic theory of intelligence consists of three aspects:

• a componential or analytical aspect; the type of intelligence composed of knowledge used to process and analyze information and the means for gaining it; a person's • stored linguistic, nonverbal, logical-mathematical knowledge and abilities; • metacognitive processes; strategies, tactics used in intelligent behavior. Individuals use to generate behaviors or outcomes. They are what standard psychometric intelligence tests value.	Content area knowledge brought to institution, learnt through training, context general knowledge, more abstract knowledge, Ways of learning and managing this type of knowledge
• a creative aspect of intelligence involving insight, synthesis and ability to react to novel situations; the insightful dimension. A measure of intelligent behavior is how well individuals approach and respond to novel, unfamiliar tasks, situations and problems that are outside their experiences. This dimension looks at the connection between how well a person does in a given task/situation and the amount of experience the individual has had in that task/situation	This relates to _ how knowledge is used in creative ways to _ create new products _ create new processes, procedures recognising, making opportunity for creativity

. • a practical aspect of intelligence, which involves the ability to grasp, understand and solve real life problems in everyday contexts; how individuals relate, link and use their knowledge to their external world. It is the contextual or "street smarts" aspect of intelligence. It looks at how well knowledge / behaviors are used in sociocultural contexts and involves adapting to and shaping one's environment.	Using knowledge in a culturally 'street wise way; how well the person can align what they know with the institution, work within particular arenas such as _ political arenas _ economic arenas _ ideological arenas _ client areas _ contextual arenas

Intelligence involves the interaction of the three aspects

Domain general knowledge

So far we have focused on specific topic knowledge. We also have general knowledge that is not being restricted to a particular domain. It includes general ways of thinking and solving problems and what we know about using language across a range of subjects.

The distinction between domain specific and general knowledge is useful for examining the different types of learning outcomes. The proposal of an organising mechanism responsible for the apparently orderly changes in existing knowledge suggest access to 'domain general knowledge' that includes the knowledge learners have about themselves as learners and how they learn. This knowledge is not restricted to a particular area.

Much of domain general knowledge is process knowledge. It includes

- generalised ways of thinking and reasoning across subject areas, for example, reasoning cause and effect in a range of situations, reasoning by analogy and means - end analysis.

- procedures for solving unfamiliar problems, for example, using what one knows to represent a problem, to plan, implement and evaluate a solution procedure for solving it.

Knowledge that becomes general may begin in one or two particular content areas and gradually become transferred and generalised as the individual uses it in a broader range of situations.

Implications for teaching

Why do teachers need to consider the different ways of organising knowledge ? To help learners change what they know, it is useful for us to know how their knowledge is organised, how they have linked ideas. This lets us see how it can be modified most effectively.

• ***the outcomes of education usually require network knowledge*** Much of the subject or topic knowledge we expect students to learn is organised in conceptual networks. They are required to explain cause, to evaluate, compare, summarise, paraphrase, synthesise, analyse, transfer, generalise. All of these assume that ideas are linked in conceptual networks that permit causal, consequent, analogous and comparative linking.

Much of what they learn away from school and bring to school is episodic knowledge. This is frequently not valued in formal education. We need teaching strategies that can help students to use their episodic knowledge to build subject knowledge.

• ***student awareness of the different outcomes of learning and how they are organised means enhanced learning*** If learners are aware of the different types of outcomes they need to learn and how their knowledge is organised, they can improve how they go about learning them.

When they expect to learn particular outcomes, they can do so more easily; they know what to look for. They also need to do different things to learn the different types of ideas.

Teach all aspects of an idea. Avoid focusing on one aspect of knowledge and neglecting others. Students are often taught some ways of knowing a set of ideas without others. If we teach networks without having students build specific episodes, they may not be able to use or to transfer the ideas. If we teach procedures without allowing them to build episodes, they may know how to but not when to. They may learn

- declarative without procedural knowledge, for example, they know why a camera works but can't use one. They know concepts without knowing the procedures that go with them.
- procedural without matching declarative knowledge; they learn how to use a particular procedure in mathematics or English but not when to use it and can't explain why it works.
- procedural without episodic knowledge; they learn how to do something but not when to.
- episodic and conceptual networks but not procedural knowledge; they can explain a phenomenon, know when to use it but not how to use it.

Secondary students are often taught declarative or procedural knowledge without establishing whether they have the necessary episodes. Episodic knowledge provides a reference for conceptual and procedural learning. We need to ensure either that when we are teaching new declarative ideas, either students can recall relevant episodes or we need to teach them. Without these they may have difficulty integrating new procedures into their repertoire. It is insufficient to tell them that what they are doing are inappropriate or wrong and to tell them what they should do instead.

Students can learn a set of ideas from the three perspectives by learning to ask

- *In which contexts does it arise, what ideas occur with it, when is it used ?* an episodic perspective.
- *What more general / specific ideas is it linked with, how is it explained?* a network perspective.
- *What actions characterise the set of ideas* ? a procedural perspective.

Declarative knowledge can be used to learn procedures and vice versa. Knowing that an unfamiliar machine is a lemonade-driven car may mean that you look for the key to start it and means of steering it. Knowing how to ride a bike may lead you to decide that an unfamiliar object on which you lie sideways, pedal with your hands and steer with head movements is a novel kind of bike.

The concerns teachers express about the difficulties their students have using what they have been taught suggest a need to teach the different types of outcomes. They may note that their students

- don't know when to use ideas; they may know how to apply a procedure when told to do so but have difficulty deciding when to. They need to develop episodic knowledge of the ideas.
- can show how but not explain why
- may lack procedural knowledge; they can't use their conceptual knowledge in practice. They can explain 'why' in a limited way but not show how. They need to learn the actions and procedures that accompany the idea.
- may understand ideas in particular contexts but not transfer them; they know 'why' in a limited way. They need to decontextualize them, link them in a network.

Having taught ideas in a subject such as history or maths, teachers can check whether students can

- link it with other ideas in the subject or topic area, add it to a network map
- link it within specific contexts
- do the appropriate actions and procedures and
- demonstrate a positive attitude to it, value it.

Allow students to learn episodic knowledge before network knowledge. The first step in teaching many ideas is to help students get a ' feel for them' first and learn their links with other ideas later. They learn episodes by

- encoding experiences in visual imagery and show that they know it without being able to explain why; they just know that it works

- constructing experiences to match abstract, decontextualized , conceptual knowledge..

Imaging experiences. Students can build images of episodes. During or after an experience they close their eyes and visualise or replay the situation, noting the main components. They can compare stored experiences form different but related experiences, for example, different images and note how they differ, what has changed, etc. They can note the features that are shared by several episodes. They can imagine a situation changing in particular ways and describe how it has changed. They can discuss ways of analysing episodes.

Learning to contextualize abstract knowledge in sets of episodes Formal education often teaches abstract, decontextualized , conceptual knowledge. Students don't transfer this easily to new situations. To be useful, it needs to be contextualized by linking it with episodes. Students create possible episodes for the abstract ideas and explore how well these fit.

Consider apprentice electricians learning Ohm's Law. If they don't have matching episodes for the abstract ideas, they may have difficulty using this knowledge to wire up a house. Teachers can have them imagine how the ideas can apply in their work, discuss how the ideas apply to how many power points they might include in a circuit, how many appliances can be plugged into the circuit safely. They can practise 'transporting' their images to new situations.

These issues are also relevant to discipline and classroom management. We can tell students that they must not display particular behaviours, but unless they have episodes that match the desired behaviours, they will be less able to display the required behaviours. Teachers can help them to learn new episodes, particularly if the background experiences of students have not led to them to learn the appropriate episodes earlier.

Episodic knowledge provides a base for imaginative activities. Children can imagine how their episodes might change over time. They can remove the boundaries of their episodes and try to 'stretch them' or let them grow. They can imagine combining or overlapping two episodes.

Teaching explicit concepts requires three types of activities

- ***grouping and classifying***, students learn the shared property, discuss how they classify, the shared features they use, how they distinguish between instances and non-instances.

- ***learning the name or label*** that refers to the shared properties and the group . The language students use children influences the concepts they learn.

- ***discussing the conceptual structure***; they discuss the boundaries of the concept, how the concept is like concepts that had already learnt and how it differs .

When teaching concepts, teachers need to keep in mind that

(1) concepts differ in their level of abstraction and where a concept is not perceptually based, learners need to align their impressions of what it means with the culture's understanding.

(2) different cultures may organise a set of ideas in different ways conceptually, so that concepts in one language don't necessarily map directly into concepts in a second language.

Small group activities : How do different public domain theories talk about the different types of knowledge, where do they draw boundaries ? What do you know / have you learnt in your pre-reading about the various types of knowledge or memory; how is each organised ? Describe how each theory believes knowledge is represented. What types of knowledge does it focus on ?

- developmental theories (genetic epistemology; Piaget (conceptual knowledge, figural knowledge); socio-cultural developmental theory, Vygotsky, (internalised cultual knowledge; signs and ways of thinking, Bruner) and modifications
- information processing models that focus on how learners process and retain knowledge, theories of short and long term memory; ACT* (J. Anderson) , memory processes theory ; three types of long term memory structures: declarative, procedural and working memory.
- Hiererchical models of intelligence
  - Vernon: verbal -educational (verbal fluency, numerical) vs spatial mechanical (spatial, psychomotor, mechanical
  - Gustafsson- crystallized intelligence (verbal comprehension, verbal achievement, numerical achievement) vs general visualisation (visualisation, spatial orientation and flexibility of closure)
  - Guilford : contents dimesnion- figural, symbolic, semantic, behavioural
- radical behaviourist theories, learning theories, operant conditioning (eg Skinner) - knowledge is the set of behaviours or responses we have stored and what we know about feedback contingencies
- cognitive behavioural theories- knowledge is the set of mediating subvocal r--s links we have stored
- social behavioural theory : Knowledge of when to learn; (Bandura), motivational knowlege, attitudes, self-efficacy
- metacognitive theories of learning (Brown, Pressley, Levin : knowledge of how to learn; cognitive, metacognitve knowledge)
- constructivist models that grew out of the developmental models.
- multiple ways of knowing; knowledge stored in a set of separate modules (H. Gardner), Dual Coding Theory (A. Paivio) , triarchic theory (Sternberg), cognitive style
- situated learning (J. Lave)
- Paralled distributed knowledge, connectionist theories; McClelland - knowledge stored in networks of information detecting units
- Situated knowlege- Lave knowledge is stored in interactions between individuals in a group