Psychology of Exceptional Learning

Memory is a key link in learning

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Many students have difficulty learning because

- they don't retain ideas effectively during learning
- they have difficulty recalling ideas that they have learnt.

We look at the background to these issues in these notes.

- The role of memory in learning.
- Models of memory
- Short term working memory
- Long Term Memory

Memory is a key aspect of effective learning and teaching. Just as the shovel is a main tool of the gardener, so is memory a major tool for the effective learner. The processes of memory, however, are often not well understood in teaching process. As a result, we find ourselves teaching the same ideas on several occasions and bemoaning the fact that our students cannot recall what we have taught them. And yet, how often do we knowingly include memorising strategies in our teaching ?

The role of memory in learning.

Learners need to retain knowledge in different ways during learning

(1) ***long term retention;*** to use the knowledge at a later stage, to display the knowledge in different contexts and to build on it during later learning. They may need to remember what was said, to apply it and use it in various ways.

(2) ***short term retention while learning*** : to add to an idea that they are learning at any time. Students learn an idea at one time at then need to use it a short time later; they need time to integrate the ideas. They may need to hold the idea so that they can add it to new ideas to come later. Usually we give too much information at once to students . During learning or completing a task such as "46 + 78 - 2- halve it, x 3 ", there is frequently too much information for you to concentrate on at once; you need to hold some of it in a 'holding bay' so that you can return to it when you can give it some attention. Sometimes you need to switch between ideas- you need to retain one idea while thinking about the other. This is what we do while we read or to add to conversation that continues over 1 - 2 minutes.

(3) ***short term retention for task completion :*** to use it to perform a short term task, to carry out instructions in order or use the idea to achieve an outcome, for example, write down a dictated sentence, retain a phone number for 1 - 2 minutes and dial it.

Learners differ in the ease with which they perform these retaining functions. Some find it easy to retain ideas that they have learnt earlier but have trouble putting together the ideas in the first place. Others find it easy to assemble the new ideas over a span of a few minutes but find long term retention difficult. In extreme cases it has been noted that during periods of neurological change, for example, when the brain suffers a trauma such as a stroke or a more long term change such as Altzheimer's Disease, one of these functions but not other is damaged.

Investigators have suggested another type of memory function as well; this is when we see, hear or feel something but haven't carefully analysed it. If you are in a dark room watching slides and the slide projector goes off, you can retain the last sensation without having analysed it. In the same way, if you hear a loud noise or have someone poke you, the sensation of the noise and the feeling stays for a short time after the actual noise or sensation stops. This is a sort of 'sensory memory'.

These differences in function have led people to believe that there are different 'levels of memory.

- ***long term memory*** One level is learners' existing knowledge. The sum total of what people know about the world is their long term memory**.** We can remember ideas in the form of words, in visual images or pictures in our mind and as actions. This has led people to suggest we have several knowledge banks in long term memory':

  - a verbal semantic memory in which ideas are stored in 'networks of meanings'. These are often referred to as schematic or semantic) networks .
  - an episodic memory that stores our experiences, what we have seen, heard and done. Ideas may be stored here in nonverbal forms, such as is imagery. There is little evidence at present, although information coded in episodic memory form can be retrieved by semantic cueing.
  - a kinaesthetic memory that stores our memory of actions and action sequences
  - an affective memory that stores our memory of emotional feelings about ideas
  - a memory of our beliefs about how we learn.

- ***short term memory*** Holding an idea for a short time for any of the purposes above is seen as a short term memory function. There are obviously different types of short term memory. Retaining ideas while we think about them is referred to as short term working memory. This is like having sites for learning or thinking spaces. A second type of short term memory is holding ideas or information in a 'waiting bay' or 'buffer zone' until they can be handled.

- ***sensory memory.*** This refers to retaining a stimulus for a very short period before you have had time to process or analyse it. This is how we retain information before we have time to analyse it in our thinking space. There is a sensory memory for each way in which we can feel. There is one for seeing, for hearing and one for when we are touched. In each case the sensation is retained for a very brief period.

Differences between the three levels of memory

The three levels of memory differ in various ways:

- ***how much information they can retain while learning something new***. the total amount of information they can deal with at once. At any time the total amount of short term memory and sensory memory we have is limited. Learners can process a restricted amount of information at once. Long term memory, on the other hand, has a much larger capacity.
- ***what things affect how much you can retain while learning***, such as information in different formats.
- ***how the complexity of the ideas that you are learning affects how well you can remember it***. In short term working memory you can remember more information when you understand it well, when you have automatized it. This had important implications for teaching. of automatizing the information).
- ***how the information is coded***; see what interferes with what we need to remember. If you are trying to remember a phone number by saying it over to yourself and someone speaks to you, you are more likely to forget it than if someone shows you something.

Models of memory

Two types of metaphor have been developed to explain how these levels of memory operate:

- ***a structures metaphor***, that proposed that we have several separate structures for doing the memory functions and

- ***a processes metaphor***, that proposed that the different levels are because we process the information in different ways.

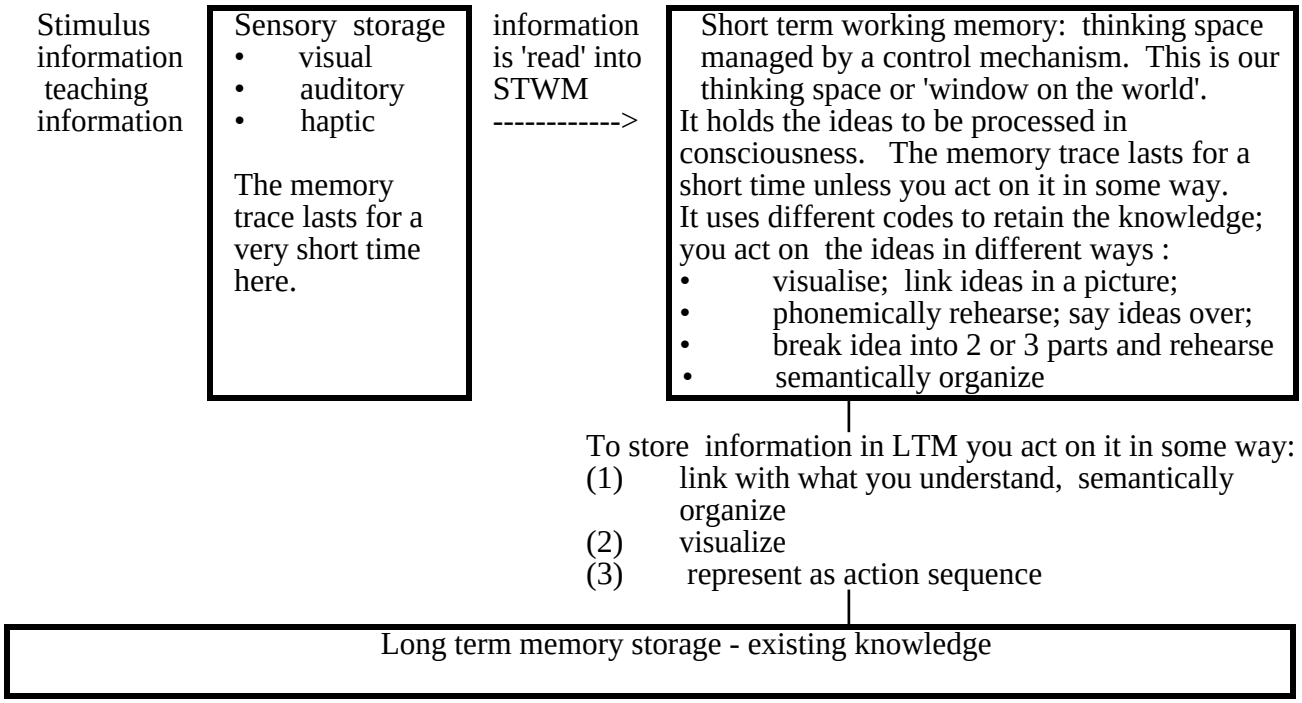
The structures models propose 3 types of memory store:

- a sensory level store in which incoming information is retained until it is processed (a short term sensory storage or STSS),
- a 'working memory' in which ideas are manipulated during processing (STWM) and
- a long term store (LTM) in which knowledge is retained long term in banks or networks.

The processes models propose that we act on the knowledge we want to retain in different ways:

- to retain the knowledge for a short time (that is, in the thinking space), you can act on the ideas by converting them to words and to nonverbal images in various ways: you can
    - visualise; link ideas in a picture;
    - phonemically rehearse; say the ideas over to yourself
    - break the idea into 2 or 3 parts and rehearse each part
    - look for meaningful patterns in the information and use that to link the ideas
- to retain the knowledge long term, you can act on the ideas by
    - semantically organize the knowledge; consciously link the new ideas with what you already know, note how it is similar to and different from what you already know (storing it in verbal semantic memory).
    - link visual imagery with images that you already know, link the new imagery with familiar ideas in space and time (store it in episodic memory) .
    - thinking about the ideas as sequences of actions (store it in kinaesthetic memory).
    - noting the feelings or emotions you link with the ideas (store it in affective memory).

It is possible, of course, to integrate the different structures with the different processes into a single model. The processes are how we retain knowledge at each level and how we 'transfer knowledge' between the various levels. These are usually the models that we use in teaching and learning. We generally think of the 3 types of memory store as shown in the following diagram:



abstract conceptual knowledge	episodic knowledge	procedural knowledge	affective knowledge	knowledge of one's self as a learner

Several versions of the structures approach have been proposed. These include

- Atkinson-Shiffrin's model that proposed three stages or levels of memory

	STSS ---->	STW memory ---->	LT memory
Information comes in	Information retained long enough to scanned for interest	Information 'encoded so that or it can be 'thought about in various ways	Information is stored in banks or networks
Duration	up to 1 second	up to 1 minute	lifetime

- Baddeley's model that proposed the thinking space with two attached memory buffers.

Information comes in	Short term working memory a thinking space and at least 2 holding bays or "buffer memories" Visual sketch pad / Articulatory code	-------> *phonemically rehearse* *semantically organize* *visualize in space and time* *action sequences*	Long term memory umbrella term-there are several 'types' of long term memory

In summary, the three types of memory are summarised in the following chart:

Attribute for comparison	Short term sensory storage	Short term working memory	Long term memory
How information is coded	Information retained long enough to be scanned for interest	Information 'encoded' so that it can be 'thought about'	Information stored in banks coded in meaningful ways
Types of memory	A memory for each type of sensory input	Storage codes and 2 buffer memories; visual and auditory	Several 'types' of long term memory
Duration of retention	up to 1 second	up to 1 minute	for a lifetime
How much information can be retained	Limited amount of information, depends on stimulus features	Limited amount of information limited capacity; 1 to 5-9 'bits'	Unlimited amount of information; unlimited capacity
Strategies used to retain information	Information 'read' into short term working memory	phonemically rehearse, semantically organize, visualise, convert to action	Practise recalling it Automatise meaningful links between ideas Summarise ideas

We will examine short term and long term memory in greater depth in the following.

Short term working memory

In this section we examine how short-term working memory operates, the demands that our teaching make on these processes, the problems students have with short-term working memory and the teaching procedures we can use to help students to enhance their use of this.

What demands does your teaching make on STWM? What problems do your students have with STWM ?

Problems students have with STM Problems that students have with short-term working memory include

- recalling information long enough to combine it with other ideas; they find it hard to combine parts of an idea. They forget parts of the ideas that they are learning.

- remembering what to do 1 minute later; the students haven't taken steps to retain instructions in their thinking spaces.

- remembering only part of the information; they remember what was said first and last and forget the middle or 'medial' information; they may, for example, recall the first and last letters of a word they are learning to spell.

- recalling information in a particular order.

- difficulty attending to information; they find it hard to keep attending to the information long enough to learn the ideas; their 'thinking space' seems to become overloaded very quickly or they have difficulty focusing their thinking activity.

How much information can be retained in short-term working memory ?

We have already noted that short-term working memory has a limited capacity; we can handle a restricted amount of knowledge at once. Below I have described some 'experiments' that you can try out to see what things affect how well you can retain information for a short term.

How much information can be retained at once ? The first question relates to how much information we can retain. Often in learning we feel ourselves drowning in the information and feel we are not able to keep track of all of it. Often we feel as if we would like to 'turn off' the information producer or at least slow down how fast it comes. Try the following activities either with peers or with students.

- to examine the capacity of short term auditory memory. Ask students to recall each of the following rows of digits in the order that they are said. Say each of the digits in each of the following rows. Say one digit per second. Note the longest span of digits that students can recall in the correct order.

3	6	8						
4	7	9	1					
3	2	7	1	6				
4	2	7	3	8	5			
1	8	4	9	2	5	0		
2	4	3	8	6	9	5	1	
8	0	2	4	3	5	6	2	9

You can investigate the memory span for remembering lists of names in a similar way. Students can investigate the things that affect the span of their thinking space. Adults can usually keep track of between 5 and 9 separate pieces of information.

Developmental trends in the amount of information they can handle. Students differ in the amount of information they can handle. Memory span is a measure of capacity of thinking space; the number of unrelated pieces of information you can recall after a brief interval. It increases from about 2 items at age 2 years to between 5 and 9 items at age 12.

The issue of how much information students can retain in their short term working memory is more complex than noting the number of items they can recall. What constitutes one item or unit of meaning depends on the specific information and what the learner knows about it. In relation to language, for example, one item can be a letter, a word, a sentence or a paragraph, depending on what learners know and how they organize it. This relates to the 'chunking of knowledge'. Working memory capacity can give the appearance of being increased when a student can 'chunk' more knowledge into each item.

What things determine how we go about holding information in short term working memory ? What things determine how we go about holding information in short term memory ? How can we help students to learn more about how short term auditory memory operates ?

The opportunity to act on the temporary knowledge. Ask students to recall each of the following rows of digits in the order that they are said under the various conditions;

(1) when they have time to rehearse the knowledge; after you have said the list of numbers, pause one minute before asking the students to recall the numbers.

(2) when they say something between hearing the numbers and recalling them; after you have said the numbers, ask students to recite the alphabet for 1 minute before recalling the items.

(3) when they engage in a different type of activity between hearing and recalling the numbers. for example, after you have said the list of numbers, ask the students copy visual designs or shapes for one minute before recalling them.

Say the digits one digit per second. Adjust the actual number that you say to the age of your group. Use the activity above as a guide of how many to say each time.

	Digits		
(1)	4, 7, 9, 1, 3, 2, 7, 5, 1, 8, 4, 9, 2,	pause one minute	recall
(2)	5, 8, 0, 2, 4, 3, 8, 6, 2, 9, 5, 1, 2,	recite alphabet	recall
(3)	3, 6, 8, 0, 2, 1, 6, 4, 2, 7, 3, 8, 8,	copy designs	recall

What factors interfere with recalling the items ? Certainly recalling the numbers when you recite the alphabet seems to interfere more than recalling them after copying the designs. What does this tell us about how short term memory operates ?

The extent to which the information is organized affects temporary retention. Ask students or peers to recall lists of words that they hear where

(1) the words are presented in a random order.

(2) students are told the categories from which the words come before providing them with the information. Telling the students the categories acts as an 'advance organizer' that the students can use to organize the knowledge they hear.

(3) the words are organized into categories and presented so that they hear words first from one category then from another.

(4) the words have a high imagery value; they can be easily visualized.

You can use the following lists for adults:

random list	advance organizer	organized	high imagery
	synchrony, vehicles	input	value
	disorder, goodness		
untidiness	co-incidence	sober	coral
simultaneously	disorderliness	grave	jump
tandem	sledge	lugubrious	train
dredger	motor cruiser	limbo	discharge
precious	contemporaneous	pandemonium	cricket
towboat	invaluable	hades	barge
disarray	trawler	zest	bird
great	wholesome	relish	archway
synchronisation	stunning	appetite	uniform
edifying	slovenliness	partiality	knife edge

Have students discuss how and why the organisation of the information helps retention. What are the implications of this for how we teach ?

How knowing the individual knowledge units affects how much can be stored in short term memory. Another possible influence is how easily learnt are the individual items. Compare the efficiency with which students can recall items in each of the following lists. You can show each column in turn, each for 1 minute.

gvbo	fust
ebgt	prag
moie	triv
kmde	cral
fvob	spom
dild	clat
plga	creb
bgma	somp

The second list is easier to encode in short term working memory because the units to be remembered match units that children have stored in their long-term memory; they are easier to name.

What things helped you to remember ? Ask students to review the influences on how we retain information short term:

- how we can impose order on or see patterns in the input that we need to remember. What patterns can students look for in the information you present in class ? How can you help them to learn to do this ?

- if they know there are likely to be particular types of themes or categories in the information, they can look for these and use them. If we tell students the major questions that up-coming information will answer, or if we tell them the theme of the information, this helps them to retain it. Are there particular patterns students can use in what you say to them ?

- they can learn to scan over the data and see if there are obvious patterns and see whether there are advance organizers they can use.

- they can learn to use visual imagery.

- having a chance to automatize it or at least become more familiar with bits of the information first before needing to remember it as a whole helps them to remember it.

How can they learn to do this ?

Auditory memory for prose

Conventional teaching frequently requires students to retain connected prose in short term working memory. Students need to listen to explanations, descriptions and other oral presentations that can last up to ten minutes, select the salient ideas and organize these in short term working memory. What processes are involved ? Have students listen to the following oral presentation and then write down what they remembered :

There was, in short, enough method and consistency to Fleiss' madness to convince many from a whole generation of scientists that he had made a series of profound scientific discoveries. Above all, to those contemporaries who shared Fleiss' biological assumptions, his ideas seemed to occupy the visionary forefront, not the lunatic fringe of hard science. Some even interpreted resistance to his ideas as a sign that he, like the long-unappreciated Mendel, was too far ahead of his time.

What short term working memory processes do they use ?

Auditory memory for sentences You can do a similar activity for a series of sentences that increase in the number or words. Students can note how many ideas in prose they can handle effectively at once and things they can do to increase this span.

Presenting information so it is more easily retained in short term working memory

One thing that we can do as teachers is to present information to students in ways that make it easier to retain in short term working memory. If we present information in ways that mean that students need to invest less attention in organising it, they will be able to retain more in short term working memory. It should be kept in mind, however, that students also need to learn how to organize the information themselves. In other words, the information can be pre-organized or 'gift-wrapped' prior to exposing students to it for example,

- ***present the ideas so that they are organized to match how students learn,*** for example, saying ideas in ways that can be easily visualised or imagined as actions, having the students say aloud the ideas to be remembered.

- ***provide time regularly in the course of teaching a set of ideas for students to rehearse and consolidate the ideas***. Teachers frequently have the tendency to 'go on' talking and to overload or 'flood' students in ideas. It is a good practice to present two or three ideas, pause briefly (for about 5 seconds) and then resume. Students can learn gradually how to consolidate in short term working memory.

- ***make the meaningfulness of the ideas stand out; break them into digestible parts and allow students to familiarise themselves with each before being expected to integrate them***. When they need to link ideas, encourage them to talk about the relationships between the ideas

- for visual information, use different colours, pictures+words, spatial position etc. to break up the ideas into digestible parts.

- for spoken information, use differences in stress, pauses, say key words first, teach using a rhyme or rhythm.

- ***use advance organizers***, for example,

  - say topic to which ideas belong eg, for students to recall a list of ten items, comprising examples of fruit, furniture and types of sport, tell students the names of the three categories in the data. For students learning the properties of the planets, discuss with them at the outset the properties that will be examined, for example, the comparative size of the planet, its order and distance from the Sun, its atmosphere.

  - pre-organize the information prior to exposure wherever possible into categories, for example, for the planets, present the same properties in the same order for all planets. Reduce the amount of re-organization students need to do in order to link ideas.

  - use concept maps to say main ideas, show how ideas will be organized, the main questions they will answer, for example,

Which planets are biggest / smallest ? Which planets are closest to the Sun ?

Properties of the planets

- ***help students make clear links with what they already know***. To remember a new way of factorizing in mathematics or a new way of spelling present the information in such a way that it

- reminds students of what they know, for example, *You know how to factorise ab-ac by taking out a common factor.*

- links the new idea with what they know, for example, *You can't use this procedure in all cases when you factorise. You need to use a different procedure for* a^2-b^2.

- ***present ideas in ways that match the organisation they will be required to use to link them.*** If students are to learn a new network of ideas or to add to an existing network, present ideas in a network format at one point in the teaching. If students are to learn the ideas in a particular sequence, teaching them at one time in the required sequence.

- ***help students to automatize the core ideas that they are learning***. These ideas will make less demand on thinking space capacity.

- ***provide students with retrieval cues that will help them to retrieve the knowledge***. This is not strictly an organisational teaching procedure at the time when you present the information to be recalled but rather the information provided when you ask them to recall. If you give students information about the categories to which the 'to be retrieved' knowledge belong, then this will assist recall .

The intent here is that students will learn gradually to organise information in these ways themselves, that they will, for example, generate spontaneously their own advance organizers by learning to ask questions of the ideas to be remembered. We don't know much about how children differ in their ability to generate organizers, or how this may depend on different types of things that they are learning. We need to examine, for example, what they child need to know / do to generate advance organizers for a particular set of ideas.

The types teaching procedures here are intended to assist students to 'chunk' the information to be learnt more effectively. By helping them to recognise chucks in the information, they can encode it more effectively in short term working memory.

Memory strategies to assist retrieval

Teaching students how to act on their knowledge to retain it more effectively. We noted above that learners use a range of strategies for prolonging what they know in short term memory. This gives them more time to think about the ideas, to link them with other ideas and to explore new ways of linking. As well, acting on the ideas in these ways can mean that they can be encoded in long term storage.

We can act on the knowledge in various ways, that is, use memory strategies, to assist us to retrieve the knowledge. Memory strategies include

- rehearsing the information; vocalising it,

- organizing the knowledge in some way, imposing their organization on it

- elaborating the information (often not spontaneously displayed until adolescence.

IN terms of their effectiveness, elaborating and organizing the knowledge achieve a higher level of recall than recall.

Developmental changes in what children do to the information to recall it more easily Children's spontaneous use of these types of strategies increases in range and efficiency with age in the order shown above. Children below 7 years are less likely to use (that is, produce) effective memory strategies spontaneously; this has been referred to as a 'production deficiency,. They can, however, frequently learn how to use them and can use them when reminded by others to do so although not with an immediate improvement in recall . This is where the teaching becomes important. Children with learning disabilities show memory production deficiencies; 'passive learners'.

It is interesting then to speculate where the strategies develop from. Many studies have shown that children below 7 years are less likely to use (that is, produce) effective memory strategies spontaneously. Teachers are unlikely to include the explicit teaching of retention strategies in their classroom routines. Similarly, while parents may encourage memory retrieval activities by asking their children to recall past events and that this correlates with memory performance , this is not directly linked with learning retention strategies.

Providing students with cohesive, integrated teaching in which they have the opportunity to explore and trial their own ways of retaining information has been shown to benefit the development of memory strategies. As children use the various memory strategies, their knowledge of how memory operates gradually improves. This knowledge is called 'metamemory', that is, what learners know about memory and how it operates. They learn to monitor what works for themselves in various contexts and how to use their memory resources.

Teaching learners to rehearse the knowledge, to recycle the knowledge, for example, by verbalizing the ideas, saying them over and over to ourselves, speaking silently about them; this is useful for some types of information that are to be retained for a short duration.

Teaching learners to organise the knowledge; students learn to impose their own organization on the information by 'acting on it' in particular ways. Teaching students to categorise sets of items they need to recall facilitates recall. To recall a list of ten items comprising fruit, furniture and types of sport, students may see that the list consists of the three types of things.

Students need to learn how to do this and to have time for it. They need to learn

- how to look for and to use patterns in the input
- how to chunk the information to be remembered into digestible bits.

They note that

- the items to be remembered are examples of ideas they already know.
- there is a recurrent pattern going through the ideas.

They need to talk about the patterns they see in the ideas and how these help them. Scanning over information to be remembered, learning what questions to ask one's self about it, is important.

Teaching learners to elaborate the knowledge by adding to the items to be remembered, for example, linking them in a sentence or image. Effective elaborations tie the 'to be remembered' new ideas with what is known for example, remembering the names of the colours of the rainbow in order by making the first letter of each colour name into the word *Roy G Biv.* There are two types of elaborations:

verbal elaborations, in which the knowledge is elaborated using words, for example

- *The colours of the rainbow are Roy G Biv*
- *All good boys deserve fruit*
- *My very excellent men, just show us nine planets.*
- saying the items to be remembered in a jingle; this encodes them in a rhythmic code

visual elaborations, in which the ideas are elaborated in visual imagery, for example,

- students who need to recall the sequence of events in a story they are reading can build the ideas into a set of images in a 'mental videotape' and then replay the sequence to themselves when they have to retell the story.
- students recalling the key ideas in the Greenhouse effect by drawing the diagram.

They may not recall the main elements when asked. When reminded of the 'silly picture' they drew, they remember the "*cow, no the ox and the car in the sky. These stood for oxygen and carbon dioxide.....*"

Developmental trends in using elaborations need to be kept in mind during teaching:

- young children (Prep, early primary) can use elaborations provided by their teacher but can't be expected to generate their own
- older primary children can create their own elaborations when they have used them earlier and see what they are like and how they can help them.
- secondary students can create their own elaboration strategies spontaneously.

Verbal-visual mnemonics work on the principle of elaborating the knowledge to be remembered. The mnemonic consists of a sequenced set of visual or auditory images, such as

one is a bun *two is a shoe* *three is a tree*

four is a door *five is a hive* *six are sticks*

seven is heaven *eight is a gate* *nine in a line*

To use the mnemonic the learner first identifies the ideas to be remembered and then links each idea with one of the images in the sequence. A third year Economics student who had severe learning difficulties reading and remembering used this to recall the major factors that influence a trans-national company establishing a branch in a new host country. First the student established each key idea and then linked it with the corresponding image. The ideas and the images made are as follows:

The judicial system in the host country needs to be considered.	For *one is a bun* the student imagined the bun on a judge's wig
The available workforce in the host country needs to be considered.	For *two is a shoe* the student imagined working men's boots and executive shoes.
Educational levels and levels of literacy in the host country needs to be considered.	For *three is a tree* the student imagined books and manuals dangling from the tree.
The level of unionisation in the host country needs to be considered	For *four is a door* the student imagined the clenched fist of the union movement coming around the door.
The level of transport in the host country needs to be considered.	For *five is a hive* the student imagined bees driving, riding bikes, flying planes.

This student found the visual mnemonic easy to use to recall the ideas and then to expand on each.

The ***'method of loci'*** is another type of mnemonic. It involves using a set of fixed, familiar images to remember a set of ideas. Fixed sets of images can include each room in your house, 10 key distinctive points you see when you visualise a trip home or the shelves in a cupboard. You use the mnemonic by linking an item to be remembered with each image, for example, you imagine the first piece of knowledge to be remembered in the first room you enter or at the first landmark on your way home, the second piece in the second room or at the second landmark, etc.

The ***key word method*** is a third type of mnemonic. To remember an unfamiliar word, you can link with it a similar familiar sounding word and then a visual image. This is useful for learning connections between words in foreign languages and English, for example, for "quartorze" in French meaning "fourteen";

auditory link imagery link
quartorze -------> cart horse ------>horse pulling cart with 14 on it

courier (to run) -------> a courier -------> a courier running

le vent (the wind)----> a vent ---------> a vent with attached ribbon blowing

Rhyme and song can also be used as mnemonics, for example,• *Thirty days have September, Aril June and November.....* or learning the tables by singing them.

Give students the opportunity to try out the various short-term memory strategies, see what works for them in various situations. These strategies include the following. Many of these allow you to remember information that would otherwise be recalled for a short time to be remembered long-term.

What teaching practices can interfere with short-term memory ?

(1) restricting the opportunity to rehearse, for example, the teacher continuing to talk while students are thinking about an idea. There are many occasions when teachers need to stop talking and allow students to manipulate ideas in short term memory.

(2) not helping students to see how ideas are related or linked, how they can be organized

(3) requiring students to display what they are retaining in short term memory in ways that themselves demand attention for execution, for example, a child who has difficulty putting into words what she / he knows needing to do this to display knowledge.

What behaviours in a classroom suggest poor short term memory strategies ? Many of the behaviours due to short term memory difficulties are often attributed to inattention or bad behaviour. Teachers need to be aware of these. Typical behaviours that can suggest short term memory difficulties include students

1. having difficulty recalling directions, particularly without contextual support.

2. frequently requesting instructions to be repeated.

3. frequently 're-looking' at the blackboard or information source; they have difficulty encoding information .

4. showing restlessness when required to retain information in short term memory.

5. showing phonemic confusions when required to retain information for short durations; they may, for example, substitutes original words for similar sounding words.

6. have difficulty answering longer, many-word questions.

7. displaying better what they know by drawing.

8. having a greater tendency to omit medial information during learning.

Helping students know more about how short term memory operates

The issue here is what teachers can do to help students to learn how to make maximum use of their short-term memory processes. Part of this involves

- giving pupils the opportunity to explore how they use their thinking space and how they can enhance this, especially when they are learning in different areas. Does this help them to understand how to use working memory strategies more effectively ?

- developing their awareness of different types of short term memory Have the children hold a picture and then a set of words in short term memory. Compare the effect of saying words and looking at related pictures on each memory trace.

- helping them to be aware of how they are using their STWM. They may be filling their thinking space with negative self-statements. These restrict how efficiently they can use their space for thinking about the ideas at hand.

- providing them with a model of short term working memory; does this improve their STM ability ? Teachers can present information in different ways, for example, chunked and unchunked and ask them to comment on why it is easier to remember under the chunked condition.

The effect of retrieval on what is remembered.

Students show what they know by retrieving their knowledge. In this section we are interested in knowledge that has been retained for a brief period Often, the act of retrieving this knowledge disrupts its memory, so that, while they are retrieving the knowledge, they forget what it is they are forgetting. As a consequence, students show they have remembered less that they would have if they had shown what they were retaining in another way.

You will often notice this when students begin to talk about something that they have just learnt. Soon after beginning to say what they were retaining, they forget what it was, although they are sure that they 'had it' a few seconds earlier.

This influence arises when students may not have automatised the mode or format by which they are required to show what they have retained. Because they need to give attention to showing what they have remembered, they take it away from what they were remembering and so forget part of it. This effect is not nearly as serious for long term memory because in that case the knowledge is permanently there, to be retrieved later.

Can we enhance short-term memory performance ?

A major implication of the above is that we can enhance short-term working memory performance. To examine this implication more carefully, it is necessary to consider the question *What is the nature of STM enhancement ?* This question leads to other questions

- What do we mean by STM enhancement ?
- Where enhancement has been displayed, how permanent is it ?
- How broadly based is it ? Can it be demonstrated across a range of tasks ?
- What have studies that report an enhancement actually done ? How has short-term working memory changed ? When short-term working memory is enhanced, what actually changes, for example, the individual's ability to code the information, the ease with which the information can be rehearsed, the extent to which it is protected from interference, (that is, forgetting), the ease with which it can be retrieved, the span of short-term working memory ?

Research has yet to answer these questions.

In summary a key aspect of short term memory processing is that to retain ideas for a short, temporary duration you use what you have stored in long term memory. The efficiency of short term memory is, in other words, determined by what you have stored in long term memory.

Long Term Memory

Storing information in long term memory How can you help pupils to store and recall information in your subject area ?

Storage and retrieval Remembering key ideas long-term involves two aspects;

(1) storing the information in memory by linking it to knowledge already there, and

(2) retrieving it by gradually reconstructing the information.

Key properties of long term memory are

- how much information can be retained in LTM ? Theories of memory suggest that an unlimited amount of information can be retained long term. Having storage capacity isn't a problem. What causes difficulty is recalling or retrieving it.

- how much information can be retrieved at once from LTM ? This depends on how the information is linked with other ideas and how automatised it is.

Types of long term memory

How do remember information long term ? What do you do to remember in each case ? Try out the following memory tasks and reflect on what you do to remember.

1. What did you do Good Friday this year ?

2. What is the name of Elvis Presley's first wife ?

3. When did the West Gate Bridge collapse ? How many people died ? Who was blamed for the collapse ?

4. Who did Bob Hawke follow as president of the ACTU ?

5. Who did you sit next to in Grade 4 ?

6. What does subterfuge mean ?

7. Suggest 3 synonyms for twitch ?

8. What was the date when Bjelke Peterson was voted out as leader of the National Party ? What was the name of his immediate successor ?

Different types of long term storage.

Several investigators have distinguished between different types of long term memory

(1) storing ideas in terms of their meaningful relationships to other ideas ; verbal semantic memory.

(2) storing ideas in nonverbal ways; storing ideas in terms of distinctive episodes in which the ideas were experienced (episodic memory), storing ideas in terms of action sequences, storing ideas in terms of emotions.

Verbal semantic memory Verbal semantic memory stores our knowledge of concepts, rules., principles and skills. It contains the generalisations we have drawn and acquired from experience. It represents states of the word that are not perceptually present. This enables humans to build 'mental models' of the world. It is the accuracy of these models that determines how well we understand that knowledge.

The knowledge in verbal semantic memory is thought ot be organised in network structures. Each concept is linked with more general concepts and with its features. There are two types of features; those that define a concept and those that are characteristic of it. Defining features are what the concept must have, while characteristic features are what a concept typically has. For the concept of 'bird' features is a defining concept; all birds must have feathers. A characteristic feature of this concept is being able to fly; most birds can fly but some can't, for example, emus and penguins. This doesn't make them not birds but they are less typical of birds. When people store knowledge in verbal semantic memory, they need to store both types.

Two aspects of memory teaching

Encoding or storing the information in long term memory teaching To teach students to encode or store the information in long term memory, teachers can encourage students to link information to be remembered in ways that help them to add to existing schematic networks, eg, relate ideas to what they already know, draw concept maps and draw in the new ideas, discuss links between known and new.

Storing ideas in long term verbal semantic memory. Teachers can

(1) ask students to describe the main ideas that they will recall as concisely as possible. At the end of a learning unit or a lesson, students can

- tell their partners what they will remember about the ideas learnt
- reflect individually on what they will remember
- elaborate on key words given by their teacher about the ideas to be remembered.

Students who have difficulty saying what they will remember will obviously have difficulty remembering the ideas.

(2) ask students to relate the new ideas to their existing knowledge base. They can ask

What do these ideas remind me of ? How are they like / different from things that I have already learnt ?" What topic do they fit in ?

(3) ask students to draw a picture of the main ideas or use a concrete model of them, showing how ideas are related.

(4) draw a semantic map of the ideas.

(5) describe when the ideas might be used in the future. The students imagine themselves remembering the ideas in the future.

(6) write about the ideas. Writing the ideas to be remembered, writing them as key words can facilitate later recall.

Storing ideas in long term episodic memory. Teachers can ask students to

(1) visualise the ideas in the context, build them into a 'mental videotape' that they replay, note how the ideas are related in the context of the imagery.

(2) practise replaying the mental image of the ideas frequently, 'see again' or 'relive' the series of actions.

(3) draw a picture of the main ideas, or use a concrete model of them, showing how ideas are related in the context.

(4) use an imagery context or 'scaffold' in which the ideas can be related.

(5) describe when the ideas might be used in the future.

As well as encoding the ideas, the students need to practise retrieving them later. Students can show they are retrieving ideas by

- ***recognising them***; some students will find it easier to recognise ideas that they have learnt earlier before they can actually recall the ideas by drawing them, talking about them, etc. Recognising the ideas involves deciding whether information matches what they have already stored in memory. For many children it will be a necessary first step in retrieving information.

- ***recalling them***; this involves retrieving in some way aspects of the ideas learnt earlier, rather than simply recognising them. Students can show this by

  - reproducing the ideas learnt earlier without much investment of attention and
  - reconstructing the ideas by re-building them bit by bit.

In most learning situations, students need to reconstruct the ideas first of all. Gradually external prompts are removed as students automatize their recall and this becomes reproduction.

Learners differ in how well they can retrieve information. Students who have learning difficulties frequently have difficulty retrieving verbal-semantic information. This is, in fact, a major reason why they have learning difficulties. They need to be allowed to recognise ideas initially and then gradually learn to recall them.

Storing information in long term memory : Teaching self-instruction strategies

Teachers can help students to learn to use various self-instruction strategies to facilitate recalling information from long term memory. An example of this is the following. Students learn to script themselves with the statements shown in italics:

(a) *"I need to remember a new idea / procedure/ type of problem"*. Students prepare themselves to remember, or 'cue themselves in' .

(b) *"I need to say what I am going to remember as briefly as I can"*. They describe as succinctly and concisely as possible what it is they are going to remember. If there are several related ideas to be remembered, they can be encouraged to pick out the main steps or parts and try to compress them into 3 or 4 major steps. They can

(1) write a summary card showing the main ideas and

(2) draw a concept map or flow chart showing how the ideas are related. These charts help students to 'get above' individual ideas, and to see how they fit together.

(3) draw illustrative pictures that contain the various elements to be remembered, often by symbolising the key concepts.

The students can put the main ideas into categories and give each category a distinctive name. Those who prefer to use visual or kinaesthetic imagery here can draw a diagram of the key ideas or represent them as an action sequence. They can use the categories to classify several instances or examples of the ideas. This helps the students to classify problems and to answer the question "What type of problem is it ?" Index cards are useful here for recording the categories.

(c) *"What does this idea remind me of ? What is it like that I have already learnt ? How is it different ?* The students link up the idea being learnt with other ideas that they have already learnt. Drawing a concept map or categories charts that links the idea with other ideas in their memories will help them to remember it. .

This linking helps students trying to see familiar ideas and processes in the new idea. They need to ask themselves "Where have I done things like this before ? " To answer this question, they may need to go back through their work books or use their summary cards, etc.

(d) *"What can I use to help me to remember this idea?"* It is often useful to use a distinctive drawing that the teacher include in the students' workbooks, physical gestures that they do to symbolise the ideas to be remembered (for example, an action signifying "undoing a bundle first"), a descriptive term (for example, "ready / not ready") to represent the idea. The memory prompt or jolter or 'mnemonic' that you use here should be well understood by the students and used by them. It is important that they can tell you what they will remember when they next experience or see the mnemonic.

(e) *"What is the use of the idea, what does it allow me to do?"* "When will I use it in the future ? What type of problems it will help me solve ?" etc.

(f) *"I imagine myself remembering the idea"* The students imagine themselves remembering the idea at a future time. They also describe aloud what is helping them to remember it.

To facilitate recall of ideas teachers can write prompting questions on the board

- How will you decide what to memorize ?
- What things might make it difficult for you to remember this ?
- What things can you do to help you to remember these ideas ?
- When was the last time you had to remember something like this ? How did you do it ?
- Work in pairs. Come up with a strategy for remembering it .

For remembering the 2 prophecies in Mac Beth the class can come up with sets of symbols

Mac Beth's future	Banquo's future
he will be Thane of Glamis (pronounced Glarms) could be represented as a set of arms	he will be 'lesser than Macbeth and greater.'could be shown as stick figures.
He will be 'Thane of Cawdor' could be represented by a door	he will be 'not so happy yet much happier' could be shown by a face changing from sad to happy

The symbols are drawn on the board as the lesson develops. When it is time to consolidate the learning outcomes the ideas that they represent can be discussed, rehearsed, the students asked to close their eyes and to visualize recalling what they meant. The symbols could be used to facilitate recall in the next session.

Retrieving information from memory by reconstructing it

When students recalls the idea on the next few occasions, do not demand total retrieval or recall of the idea, but instead allow gradual reconstruction. In this way they will gradually automatize recall. Teachers can use the following sequence;

(1) begin with a recognition task; this lets you know whether they can recognize the general context or theme of the work.

(2) check that they knew what to do to produce the information, for example, what the items in a mnemonic such as a picture or an action represented. Knowing what to do in order to produce the items, if you can't remember them automatically, is a very important intermediate stage in getting to the automatic recall.

(3) ask they to produce the as much as they can about the set of related ideas, shown in the mnemonic such as the picture without regard to the specific organization of the ideas relative to each other (for example, cause and effect) in the least mentally demanding situation.

(4) start to break up the complete set of information in the less demanding context, organising some of the ideas relative to each others, for example, the ones that go together, the ones that caused others, etc.

(5) start to break up the complete set, in the more demanding context.

(6) break up the complete set further first in the less demanding context and then in the more demanding context.

(7) recall individual facts, first in the less demanding context and then in the more demanding context.

How do we deal with forgetting ? Can we reduce the effect of forgetting ? Teachers can help students

- to automatize their ideas, have them practise recalling and using them repeatedly, build regular revision and revisiting of the ideas into the teaching.
- to become more aware of how their memory operates.
- by improving how we cue students to remember the ideas. If we can develop effective memory cueing in our teaching, students will feel more at ease recalling and may gradually imitate and take on board for themselves the cueing strategies, so that they use them to cue their knowledge.
- by helping students to encode the ideas initially so that they recall them better later. If I include visual imagery in my teaching, I can use it to assist recall later.

The aim of these teaching procedures is to change the information that the students have learnt and make it more accessible, by organizing it more efficiently, compressing it, linking a mnemonic with the ideas etc. These strategies don't increase the capacity of long term memory by they enhance retrieval by making interference for that information less likely .

The 'total memory system', the learner and the teacher. Teachers can draw on both verbal semantic and episodic memory by using appropriate questioning. Students can retrieve information from episodic memory, analyse it in short term memory in terms of its verbal semantic properties and then re-store it again in long term memory, this time in verbal semantic memory. Similarly, information stored in a rote code can also be subjected to logical analysis at a later time.