PSYCHOLOGY of LEARNING and TEACHING

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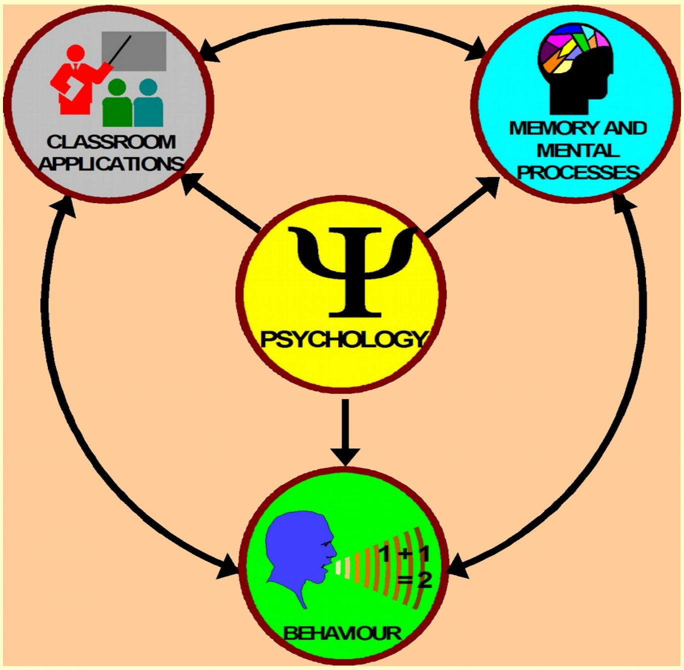
This project is based on courses of the same title given while I was at the Chinese University of Hong Kong. The students in these courses were either in-service secondary school teachers or pre-service secondary school teachers (recent graduates training to become teachers). Their specialities covered all the school subjects so the course had to relevant to all of these. For my lectures, in order for students not to waste time copying notes from lectures, I gave them a booklet containing a copy of all the visuals I used in which they could add any additional comments. This freed up time for more useful activities including discussions and even class experiments. The notes here are an expansion of those in the booklet.

The project follows naturally from the previous one "*A Guide to Cognitive and Social Development*". But this one deals with just the psychology of learning and teaching at the secondary level and is not concerned with cognitive development.

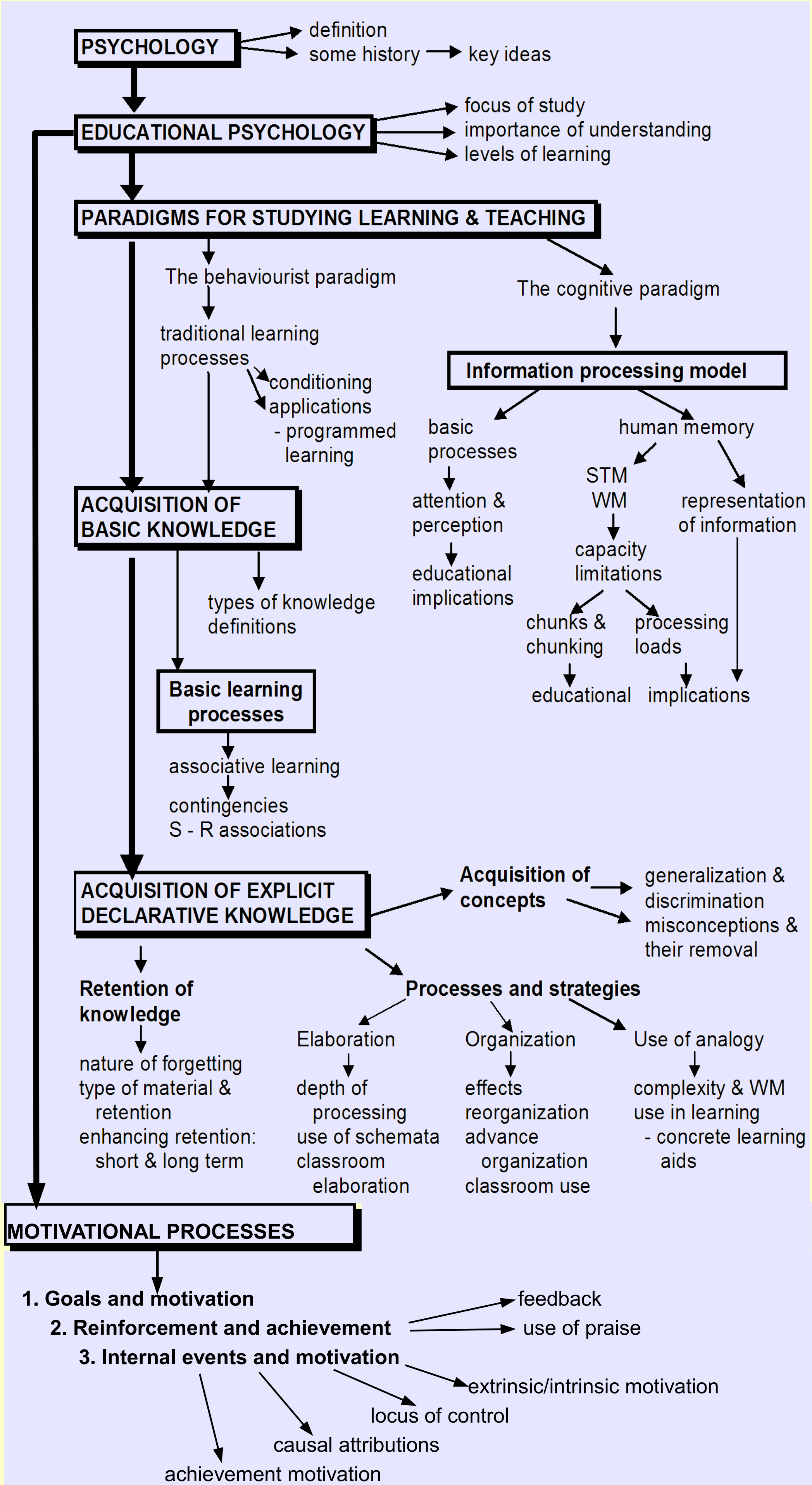


The picture on the left is taken from the cover of the lecture notes booklet. The symbol Ψ is the letter 'psi'/'psy' in the Greek alphabet and is the first letter of the Greek word for psychology, with 'psych-' meaning '*of the mind*'. The four nodes in the picture together with their interconnections symbolise the way knowledge may be represented in the mind and in addition show the major sections of the course.

Page 2 (below) shows a flow chart of course in the form of a network diagram (like that on the left) showing pictorially how the various topics in the course are related. Network diagrams have been shown to facilitate understanding and memory, and come into the course itself.

Throughout the text, red boxes are included; these contain a key concept that is to be discussed in the text and the page reference to this concept.

Flow chart of the course



PSYCHOLOGY

Defining psychology

The term *psychology* can be difficult to define precisely. Over time, there have been various definitions that tend to reflect the bias or philosophy of the definer. Here are two examples:

Behavioural psychology, pages 6, 9 - 15

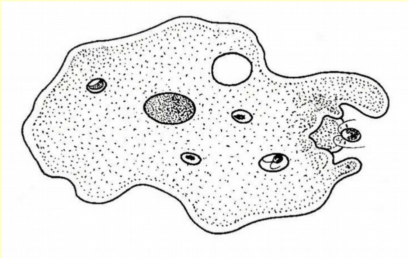
- ***The science of behaviour.***
  [The ideas behind "behavioural psychology" are discussed later.]
- ***The science of the mind. Just as the physiologist studies bodily functions, so the psychologist studies mental functions.*** (C. L. Burt).

As a compromise, psychology can be defined to include both of these. That is:

Cognitive psychology, pages 6, 16ff.

- ***Psychology is the study of mind and behaviour.***
  [This is the definition given in Wikipedia.]

Psychology (and especially Educational Psychology) is relatively unstructured but easily identifiable. Think of the analogy of a feeding amoeba. An amoeba can take various shapes/structures. When feeding, the amoeba projects itself towards to an item of food and consumes it to become another shape but is still recognisable as an amoeba. So too with psychology. It studies a new problem area, embraces a new theory, technique, etc., incorporates them and slowly becomes another "shape" though we still recognise it as psychology.



Analogies, page 42 ff.

Types of psychology

There are many types. Those of interest here are:

- **Behavioural psychology** – the study of *external* observable behaviour/actions.
- **Cognitive psychology** – a general approach emphasising *internal* mental processes.
- **Educational psychology** – the application of psychological ideas to learning and teaching.

Overlap occurs between psychology and other fields such as linguistics, computer science, philosophy, medicine and computer modelling. The whole field is often referred to as "**cognitive science**".

A little history

The **Ancient Greeks** (4th ~ 5th centuries B.C.) studied the nature and origin of *thought*.

"*Thought is impossible without images.*" (Aristotle)

Imagery, page 39

They also discussed the origin and nature of *knowledge* (a subject called **epistemology**).

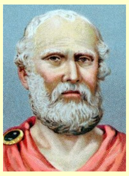
Two ideas as to where knowledge comes from are **nativism** and **empiricism**. A brief comparison of the two is given below:

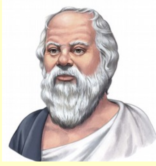
nativism

Claims that knowledge is *innate* (genetic/inborn) and that this knowledge influences thought and behaviour.

Proponents:

- Plato c. 420 BC (left of two)
- Socrates c. 400 BC (right)
- Descartes, Kant (19th – 19th centuries





Learning:

When we learn, we are just being *reminded* of what is already in our minds.

Questioning, pages 40 - 1

Socrates supports nativism by showing that by simply asking an uneducated slave the right questions, the slave can 'discover for himself' a version of the theorem of Pythagoras.

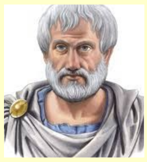
Nativism leads to the modern idea in educational psychology of **realism**.

empiricism

Claims that knowledge comes from *experience*, i.e., from observing things.

Proponents:

- Aristotle c. 330 BC (right)



- Locke (17th century)
- Hume (18th century)

Learning:

The mind is a *tabula rasa* ("blank slate"); the brain has inborn capabilities for learning from the environment but does not contain content such as innate beliefs.

Aristotle believed that anything we have to learn we learn by observing, by actual doing it and by using reason (i.e. thinking about It).

Empiricism leads to the modern idea in educational psychology of **constructivism**.

Construction processes, pages 36, 38

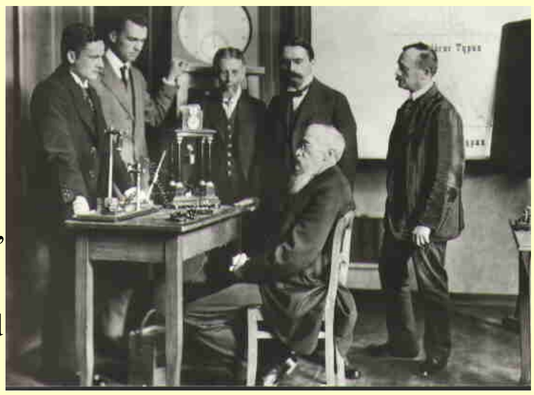
Psychology in 19th Century Germany

Johann Friedrich **Herbart** (1776 – 1841, pictured right) was a German philosopher, psychologist and founder of pedagogy (i.e. methods and practice of teaching) as an academic discipline. He was the initiator of modern educational theory.

Herbart emphasised:

1. the relationship between new ideas and previous/**background** knowledge,
2. a level of mind of which we are not conscious, and
3. that teachers use five formal steps: (i) Prepare a topic of interest to children, (ii) present that topic, (iii) question children so that they obtain new knowledge based on what they already know, (iii) summarise what has been learnt, and (v) relate the learning to moral precepts for daily living.

Background knowledge, pages 16, 25 – 30, 35ff.



Another German, Wilhelm **Wundt** (1832 – 1920), is noted for his use of the idea of **introspection** – the belief that the mind is open to self examination, especially through the used of (mental) images.

In a typical experiment, Wundt would present people with a word, e.g. "book", and get them to try to analyse their thoughts. Unfortunately, people would give conflicting reports; some would say that images were involved, others that images were not involved. This was the beginning of **cognitive psychology**. The picture (above right) shows Wundt (seated) with colleagues in his psychological laboratory, the first of its kind.

Psychology in the early 20th Century

John Watson

In the USA, introspection was not well accepted, mainly because the results were never consistent. John **Watson** (1878 – 1958) was a psychologist who rejected the idea that mental events should be studied in psychology. Instead, he believed there should be an emphasis on studying only observable behaviour, i.e. any observable response of a person. This established the psychological school of **behaviourism**.

Edward Thorndike

Following Watson, Edward **Thorndike** (1874 – 1949) proposed a theory of learning applicable to school situations (1913) based on the use of **reward and punishment** to achieve learning. He found that reward is a much more effective motivator than punishment. He also emphasised that the reward must come immediately after success on a task, or the lesson would not sink in.

In the 1920s, these ideas led to a behaviourist revolution. It was the major approach to psychology until the 1960s – 70s. The sole interest was on observing how people behaved/responded/acted in learning situations. There was no interest in what was going on in the mind.

Behaviourism, pages 6, 9 - 15

Success & motivation, pages 60 - 63

Paradigms in Psychology

A paradigm is a set of beliefs, including theories, research methods that make up a major field of study. In psychology, there tend to be three paradigms. These are:

- The **behaviourist** paradigm: Emphasises observable behaviour, not mental processes.
- The **cognitive psychology** paradigm: Emphasises the study of mental processes (i.e. what happens in the mind).
- The **neural** paradigm: Deals with processes taking place in the brain.

These paradigms account for human behaviour at different levels as in the following diagram:

1. Empirical (in the environment) → stimuli / observable actions / empirical laws → behavioural psychology

↕

2. Mental (in the mind) → (a) high level / (b) low level → cognitive psychology

↕

3. Neural (in the brain) → neurons (brain cells) and neural networks → neurophysiology

The interest in this course is on Levels 1 and 2a. Level 1 deals with the traditional behaviourist approaches to learning and teaching. Cognitive psychology studies mental processes but also, of course, involves Level 1. Note The double-headed arrows which show that one field of study affects others.

- **Behavioural psychology**

Input (Stimulus) → **Black box** → Output (Response)

S **R**

~~emotion~~ ~~conscious~~ ~~perception~~

Terms such as these do <u>not</u> come into behavioural psychology. The "black box" is the mind and what happens in it are of no interest to behavioural psychologists.

Research in behavioural psychology continued until the 1960s, and its findings still play an important role in teaching, learning, and motivation.

Information processing model, page 16ff.

- **Modern cognitive psychology**

Learners are *processes of information*. This happens in the "mind". Therefore we need to know how information is processed, that is, to find out what happens in the "black box" between the **S** and the **R**.

(S) Teaching / Instruction —influences or involves→

- Background knowledge
- Attention
- Motivation
- Learning methods
- (Mis)conceptions
- Language
- Personal beliefs, values
- ……. etc …...

—affects→ **Learning / Achievement (R)**

The terms in the box are examples of factors that need to be considered in order to understand how learning takes place. For example, if a student does not pay <u>attention</u>, learning is unlikely to occur. Why? In cognitive psychology, factors such as these are investigated. A large part of the rest of this course is devoted to looking at such factors.

EDUCATIONAL PSYCHOLOGY

Educational Psychology is the application of psychological ideas to learning and teaching.

Let us begin with the insightful quote by Donald A Norman, an engineer, cognitive scientist and psychologist:

> It is strange that we expect students to learn yet seldom teach them about learning. We expect students to solve problems yet seldom teach them about problem solving. And, similarly, we sometimes require students to remember a considerable body of material yet seldom teach them the art of memory. It is time we made up for this lack, time that we developed the applied disciplines of learning and problem solving and memory. We need to develop the general principles of how to learn, how to remember, how to solve problems, and then to develop applied courses, and then to establish the place of these methods in the academic curriculum.
>
> Norman (1980)

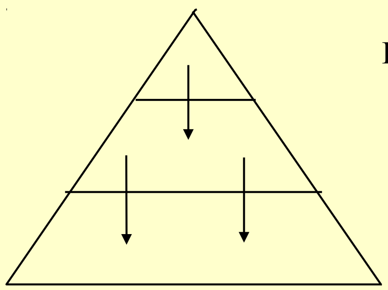
The Importance of Understanding

Understanding and how to obtain it are key emphases in educational psychology together with effective strategies for obtaining it.

Understanding confers a degree of autonomy on the learner, that is, with understanding, the learner can deal with problems on his own.

Levels of learning & understanding:

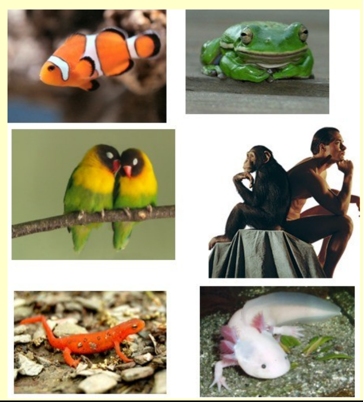
What is the best way to learn and remember ideas? Many students use rote repetition. This is not usually a good method. Repeating sentences, etc. sometimes helps us to remember. But usually what is rote learnt is soon forgotten. Further, rote learning does not help us to understand, and understanding is the key to effective learning *and* remembering. Think of the following triangle about "levels" of learning':



Level 3: Problem-based learning – enhances understanding

Level 2: Understanding – facilitates memory

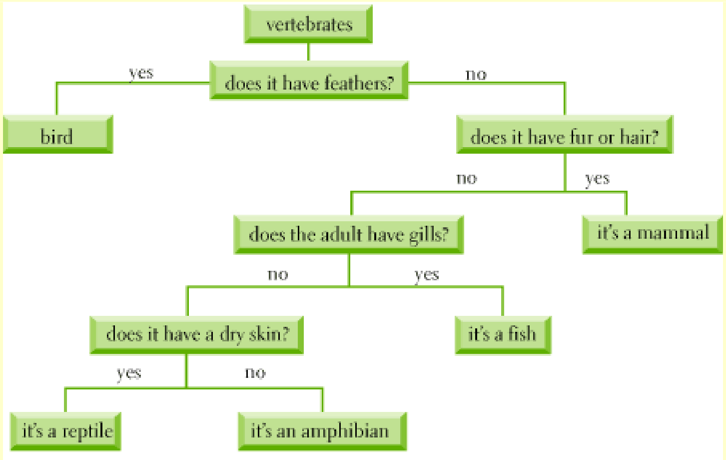
Level 1: Rote learning – easily forgotten



To illustrate how this triangle works, take the simple (school) topic of "Characteristics and classification of vertebrates".

Level 1: At this level, the teacher or textbook just tells the facts to the students – a whale is an animal, birds have feathers, etc., and students memorise the facts but probably will not understand them.

Level 2: The teacher/textbook may explain the characteristics and use a classification key (as on the right) to group vertebrates as mammals. birds, reptiles, fish and amphibians. In this way the learner sees logical links between groups of animals and can more easily understand how they are similar and how they are different.



Level 3: The teacher could give pictures of animals to students and ask them to describe the features then group the animals in any way they they like using knowledge they already have, e.g. grouping animals that “live on land”, “live in water”, etc. Students can then be given a problem-solving task using pictures of unknown animals and use their key to classify these animals. Most of this learning takes place by the students themselves and so is likely to be more permanent.

The Harvard Medical School and other institutions use some problem-based learning; for example, students have to work out and explain how and why a particular patient died rather than being merely told by a teacher.

Note that in the triangle above the arrows only point downwards. That is, rote learning/memory will not help you to understand, but a good understanding will make things easier to remember. Similarly, solving a problem enhances both understanding and so memory.

The emphasis in this course is on how to get learners to gain understanding. Even with problem-based learning, the material needed to solve a problem must first be understood.

The Behavioural Approach to Learning and Teaching

We all respond (**R**) to environmental stimuli (**S**), for example, yelling when we cut a finger, or stopping the car when we see a red traffic light.

The behaviourist (or behavioural) approach studies how we learn to link the appropriate **S** and **R**.

S ⟶ **Brain** ⟶ **R**

The brain links the **S** to the **R**:

S ⟶ **R**

The mental processes that occur in the brain are unimportant. All we need be concerned with is how organisms learn to respond to (desired) stimuli.

Example:

(sight of object) "pencil" (sound)

S **R**

Learning occurs when a link is made between the stimulus and the response:

S ⟶ **R**

As the learning improves, the link strengthens and the learning is more permanent, that is, less likely to be forgotten. This is represented by a thicker arrow between the **S** and the **R**:

S ⟶ **R**

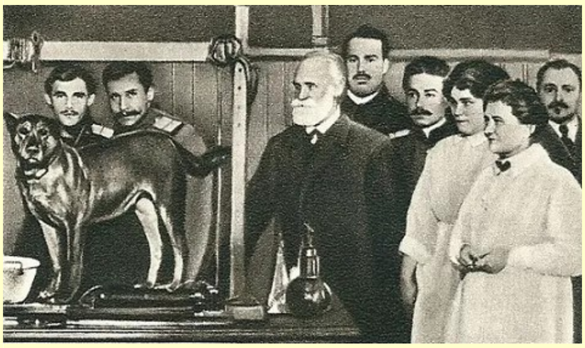
This learning results from **CONDITIONING**, which is defined as:
linking, by habit or training, an R to an S not naturally connected to it (such as the word "pencil" to the sight of a pencil). Providing the desired stimulus at the right time enables behaviour/learning to be controlled. There are two kinds of conditioning: **classical** and **operant**.

Classical conditioning

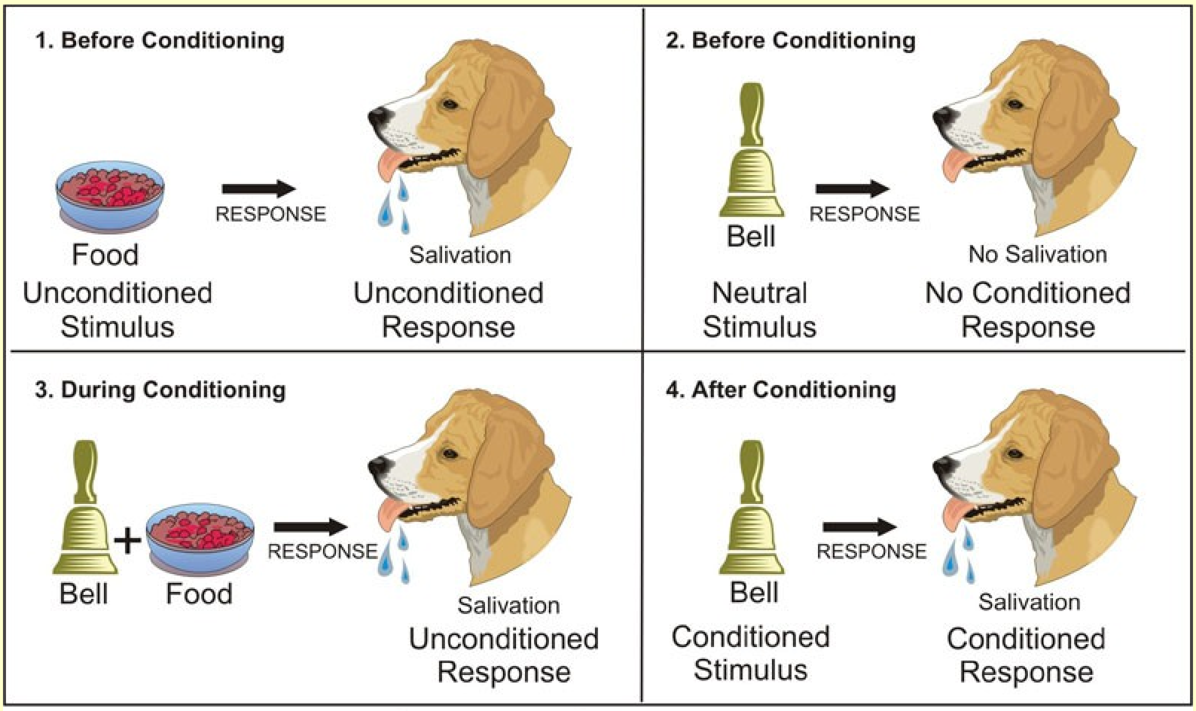
This arose from experiments done with dogs in the 1890s and early 1900s by Ivan Pavlov, a Russian physiologist.

Dogs *naturally* salivate at the sight of meat. This is a natural response. But Pavlov taught dogs to respond in the same way (i.e. produce saliva) but with an (unnatural) stimulus he provided, for example, a bell.

The pictures below show how this works:



Pavlov, middle with white beard, pictured in his laboratory.



Classical Conditioning

Unconditioned stimulus (**US**) ⟶ **R**
(sight of food) (salivation)
+
Conditioned stimulus (**CS**) - - - → (salivation)
(sound of the bell)

[the dotted line means <u>no</u> link has yet occurred]

This is repeated many times. Eventually, learning resulting from this conditioning occurs:

Sound of the bell (**CS**) ⟶ Salivating

That is, with just the sound of the bell, and no food, the dog will salivate. In this way, Pavlov has controlled the behaviour of the dog by getting it to respond to <u>his</u> stimulus (sound of the bell).

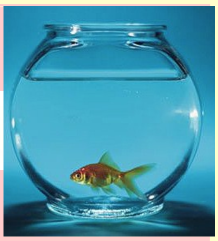
The learning will eventually be forgotten (called **extinction**), that is, the dog forgets to salivate when it hears the bell. Learning can occur again if the whole process is repeated (usually quicker this time) with the sound of the bell followed again by food (called **reinforcement**).

Reinforcement, pages 11 - 15

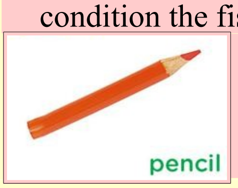
<u>Note</u>: 1. In classical conditioning, the **UC** – food in this example – is important, but the **UC** can be anything, for example, instead of a bell, it could be a light from a flash-light or a verbal command.
2. Classical conditioning is limited as a natural stimulus must first exist.

Reinforcement and motivation page 56ff.

Exercises:

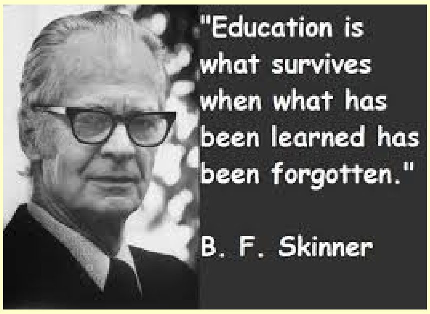


1. You have an aquarium with fish, a torch and fish food. How can you condition the fish to move towards the light when the torch is turned on?



2. On seeing a pencil, a child can correctly name it. But she cannot yet <u>spell</u> the word. How might you use classical conditioning with a picture card to teach her how to spell the word?

Operant conditioning



B.F. Skinner (1904 – 1990) is often referred to as the "father" of operant conditioning. His work is most often cited in connection with this topic. His book "*The Behavior of Organisms*", published in 1938, discusses operant conditioning and its application to animal and human behaviour. Operant conditioning was a major research area in the 1950s and into the 1960s including applications to classroom learning.

Definition: ***Operant learning is a method in which a link is made between a behaviour and a reward (reinforcement) for that behaviour. Thus a subject (animal/human) comes to associate the reinforcement with the behaviour.***

How does it work? Think of how to teach a dog to sit. You say "Sit!" Of course. the dog does not understand. Eventually, perhaps because it is tired, the dog will sit. As it starts to sit, say "Sit!" Follow this by giving the dog a piece of food – a "**reward**" for doing what you want.

After a while, do the whole thing again. At first the dog does not link the food with the command "Sit" but it soon learns to do so.

The reward – technically called **reinforcement** – links an **S** to an **R** (sitting) and increases the probability of the response occurring again:

S ("Sit") ⟶ **R** (sits) + **reinforcement**

The more this is repeated, the stronger the link. So the next time you say "Sit!", the dog will probably sit even without a reward/reinforcement. But eventually, extinction of the learning may occur and you will have to start all over again. Most dogs will remember to sit if you miss the occasional reward, but for really stupid dogs, you may have to reward it with food every time! (On the other hand, these dogs might not be so stupid; perhaps they have conditioned you to give them food every time!)

Another example, when a lab rat presses a blue button and receives a food pellet as a reward,

Notes:

1. In operant conditioning, it is the *response* that is important. The stimulis can usually be anything. For example, instead of (or in addition to) the command "Sit!", you might just grunt or point. Compare classical conditioning (above) in which an **UC** – food – must exist. Thus operant conditioning, which does not need any pre-existing stimulus, is more useful.
2. I have only commented on the simplest kind of operant conditioning. It is actually very complex, involving both positive and negative reinforcement as well as punishment (also positive or negative).

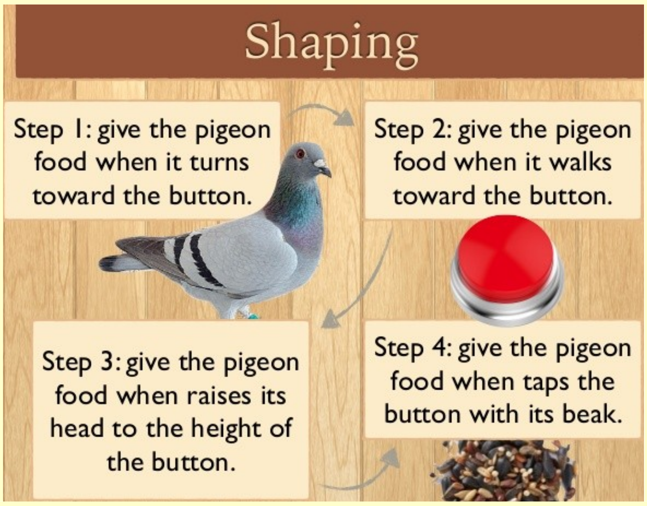
Websites

If you really want to know a lot more on operant conditioning, go to the Internet. Here are two possible sites:

https://en.wikipedia.org/wiki/Operant_conditioning

http://psychology.about.com/od/behavioralpsychology/a/introopcond.htm

Shaping of responses



Instead of just one response, a series of responses can be learnt for <u>one</u> stimulus. This is called **shaping**. and is an application of operant conditioning. The pictures (right) show to train a pigeon to press a button. Four steps are involved. The first step is rewarded when it is carried out successfully. This will require time and patience as you need to wait (in Step 1) for the pigeon to turn – unlike a human, you cannot just tell it to turn! When this can be done easily, proceed to Step 2. Wait for it to do the <u>two</u> steps then reward it with food. Similarly on to Step 3 and Step 4. This is a very slow process and requires a lot of time and patience.

The dolphins at Ocean Park are trained in a similar way. We see a dolphin (or several dolphins) doing a series of "tricks" with a simple command, such as a wave of the arm. On completion, it is / they are rewarded/reinforced with fish. But it can take many months to get dolphins to learn such behaviour.

From animals to humans

Operant conditioning applies to humans as well as to other animals. For us, rewards/reinforcers can be of two kinds:

- **concrete** (such as food, which satisfy physical needs). For example, giving sweets to students who answer questions correctly!!!
- **symbolic** (a substitute for concrete rewards). Examples include money (e.g. wages for working), smiling/praising students' answers, commenting on students' good classroom behaviour, a smiley face sticker on good written work.

<u>Note</u>: Smiley faces and similar stickers may seem to be suitable only for young children. But an experiment showed that they worked even for Form 7 students!!

Can you think of other examples?

Also, one reinforcer can take over from another. For example:

student answers questions correctly (**R**) + praise/grade (reinforcement)

↓

self satisfaction

Self-satisfaction and motivation, page 56

So after this, the student no longer needs any praise; self-satisfaction becomes the reinforcer.

Compared with animals. learning in humans is faster. Also, extinction (forgetting) is slower in humans than in other animals. Further, partial reinforcement is often more effective than continuous reward after each correct response as it seems to promote more – not less – resistance to extinction. (Imagine how irritating it would be if a teacher praised every correct response, especially for small things. instead of waiting until a whole series of things has been done correctly (cf. shaping).

Another example is practising basketball. It often takes many attempts to shoot baskets successfully. If we needed to be successful every time, we would soon give up. Even landing one in 10 successfully can be very rewarding. The reward here would probably be self-satisfaction; no-one is going to pay us for scoring baskets successfully (unless we are professional players).

Punishment

The purpose of punishment is to *decrease* the probability of a response through the avoidance of an unpleasant “reward” (Re). That is:

S ⟶ **R** + Re becomes **S** **R** (i.e. the link between the **S** and **R** is broken)

In a classroom setting, Re might be displeasure, a scolding, a black mark. At home, for a young child, it might be having to stand in the “naughty corner”. (If the pictures I saw on the Internet are correct, even pet dogs can be put into a naughty corner!)

According to behavioural psychologists, punishment has *unpredictable* results. It does not work if the teacher's “punishment” is interpreted by the student as getting attention he or she wanted,
which thus only strengthens the (mis)behaviour! What can the teacher do?

Programmed learning

This is one main application of operant conditioning. The learning is done with booklets, or on computers.

A program is created as follows:

- The topic is broken down into steps (called frames). The first frames are usually small and simple; later in the program they can be longer and more difficult.
- Each frame is posed as a question to be answered or a statement to be completed. The response is fixed and simple enough to be answered correctly. This is important as the learning is designed to be done without a teacher. Note: Initially, the responses are just one word. Later in the program – much later – longer answers can be required providing it is certain that the responses will be correct.
- The response given by the learner for each frame should be correct. Success is the reinforcer:

Information in frame (**S**) ⟶ Answer (**R**) + Success

- The learner proceeds one frame at a time.

An example of programmed learning on basic electric circuits is shown below.

Excerpts from a program designed to be used in a teaching machine*

Sentences to be completed	Word to be supplied
1. The important parts of a flashlight are the battery and the bulb. When we "turn on" a flashlight, we close a switch which connects the battery with the ________ .	bulb
2. When we turn on a flashlight, an electric current flows through the fine wire in the ________ and causes it to grow hot.	bulb
3. When the hot wire glows brightly, we say that it gives off or sends out heat and ________ .	light
4. The fine wire in the bulb is called a filament. The bulb "lights up" when the filament is heated by the passage of a(n) ________ current.	electric
5. When a weak battery produces little current, the fine wire, or ________ , does not get very hot.	filament
6. A filament which is less hot sends out or gives off ________ light.	less
7. "Emit" means "send out." The amount of light sent out, or "emitted," by a filament depends on how ________ the filament is.	hot
8. The higher the temperature of the filament, the ________ the light emitted by it.	brighter, stronger
9. If a flashlight battery is weak, the ________ in the bulb may still glow, but with only a dull red color.	filament
10. The light from a very hot filament is colored yellow or white. The light from a filament which is not very hot is colored ________ .	red
(17 items intervene here)	
28. The light from a candle flame comes from the ________ released by the chemical changes as the candle burns.	energy

In this program, the answers/responses are, of course, hidden and revealed after they are given. This is more difficult to do if the program is on paper but can be controlled easily on a computer.

Three key advantages of programmed learning:

1. Students are *actively* involved in learning.
2. *Immediate* feedback/reinforcement is provided.
3. Learning is *individual*; it proceeds at the *student's pace*.
4. Because it is done individually, the learning does not involve competition.

Competitive goals, competition & motivation, pages 57 – 58, 61

But, there are also criticisms:

1. They can still lead to competition. For example, students may compare each other's progress.
2. Programs are often very long and seldom 100% accurate. For this reason, teachers/tutors often need to be present to help learners overcome errors.
3. They are not good for learning that requires novel/creative responses.

Programmed learning is good for learning mechanical skills and factual material.

Classroom teaching can use the *principles* of programmed learning. The teacher can use (small) step-by-step questioning with answers prepared beforehand that are likely to answered correctly. But teachers should not use it for too long at any one time as it can become rather tedious answering many short-answer questions.

Exercise:

1. Try the program above for yourself. First, cover up the answers ("Word to be supplied"). Attempt Sentence 1 then uncover the answer (and only that answer). If the program is well-written, you should be able to complete the sentence easily. Then attempt Sentence 2 and so on.
2. Do a quick evaluation: Would you like to learn by such a method? Can you see any advantages and disadvantages? The complete program may have several hundred sentences/questions! Too long? Too boring? And what about the language? There is a lot to read. Too much?

The Behavioural Approach to Classroom Teaching

Based on the behavioural paradigm, the basic approach to teaching is to produce good results (**R**) (for classroom questions and also in tests) through the most effective teaching action (**S**). The approach aims to produce general and specific principles or implications for practice. For example it emphasises:

- The importance of *questioning* for effective learning. With questioning (**S**), students give answers (**R**) which the teacher then assesses and if correct, reinforces.
- The need for good *feedback* for correct responses, often immediate, such as *praise*. According to behavioural theory, the feedback reinforces/strengthens students' learning.
- The value of *reviews* at the beginning and/or the end of lessons; these provide additional reinforcement.

Questioning, pages 40 - 1 | Teacher praise, page 59

Remember, the aim is to find methods that always elicit correct responses from learners. What happens in the students' minds during learning is irrelevant; it is just necessary to find the best teaching methods to get the correct responses from learners.

Limitations of behavioural psychology for school learning

- The behavioural approach has had an important impact on the improvement of classroom teaching for both teaching and learning. However, it does not have any underlying theory about the mental processes involved.
- It focuses on the surface aspects of learning; stimuli introduced by the teacher/textbook and the answers that result.
- Early research was done in laboratories on animals; only later was research done in classrooms.
- Most learning is more complex than that studied in behavioural psychology.
- Behavioural psychology cannot explain why students learn or do not learn; it tells us nothing about the thought processes involved nor the effects of other factors such as background knowledge, attention, beliefs, etc. These and other factors are important in **cognitive psychology**.

We now turn out attention to cognitive psychology in education.

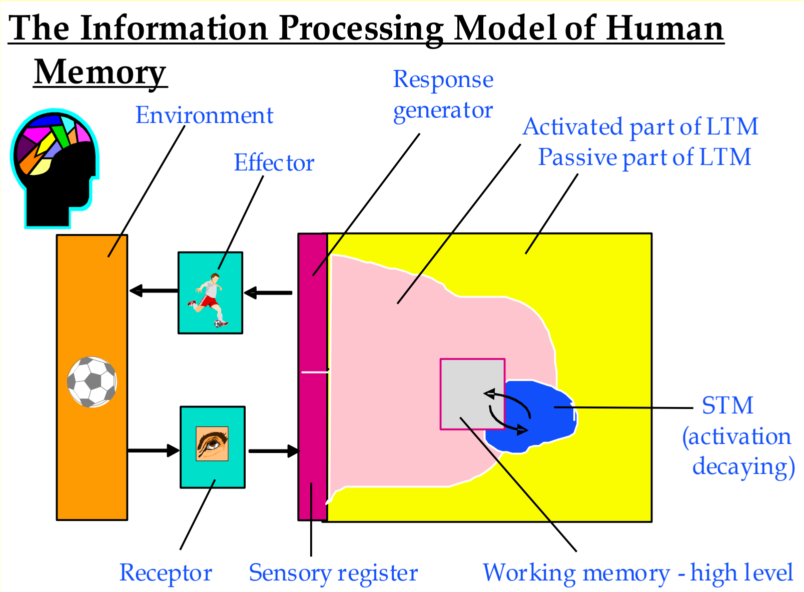
The Cognitive Approach to Learning and Teaching

The basic idea to this approach is that learners are processes of information. Therefore we need to know how information is processed. That is, we need to find out what happens to all the "mediating factors" in the "black box" between the **S** and the **R**.

(S) **Teaching / Instruction** — influences or involves → **Mediating factors** — affects → **Learning / Achievement** (R)

A lot of cognitive psychology deals with an understanding of **human memory** and the processes that take place in memory.

The Information Processing Model of Human Memory



The model shown in the diagram is a *psychological* model, not a physical (neurological) model.

STM = Short Term Memory (where information is stored for a short time while being processed)
LTM = Long Term Memory (where memory is stored permanently – unless it is forgotten)
WM = Working Memory (where the thinking/processing actually takes place)

The model of LTM, WM and STM is fluid. It is largely one memory system with the pattern of memory use changing depending on the task being processed at any one moment.

Receptors and Effectors

Receptors are our sense organs which pick up stimuli from the environment, that is, eyes (sight), ears (sound), tongue (taste), nose (smell) and skin (touch). Effectors are organs that carry out a response, in the diagram above, leg muscles that move to kick the ball.

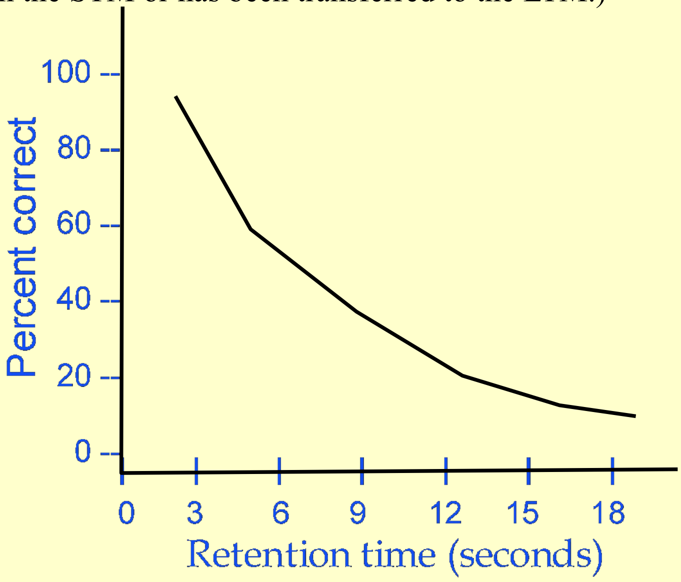
Sensory register

A lot of information from the receptors is stored here but only for a very brief moment. If the information is not attended to, it is lost. This information activates relevant information already stored in long-term memory, i.e. background knowledge related to the present situation, such as what to do with the ball that the person in the model has just detected with his eyes (sense receptor).

Short-term memory

- The STM is a “buffer” memory for temporary storage of information waiting to be processed in the working memory. The information is subconscious that is, we are not aware of it.
- STM is for storage, not processing.
- The STM helps to prevent an overload of information in the working memory, which has a limited capacity (see below).
- Information is held in the STM for a limited time unless rehearsed. If not, it is lost. I use the analogy of information, like water, “evaporating”. For very uncommon information (as in the experiment below) it will disappear in seconds without rehearsal. For more familiar information, such as people's names, it can be retained longer. (Some research suggests some information can be retained in the STM for hours though it difficult to say if this is actually in the STM or has been transferred to the LTM.)

Experiment on rehearsal (Peterson & Peterson, 1959) Subjects heard a trigram, e.g. P S Q, followed by a 3-digit number, e.g. 167. Subjects then had to count backwards by 3’s, e.g. 167 - 164 - 161 - … for a time between 0 & 18 seconds (determined by the experimenter). Subjects were then asked to recall the trigram. The graph shows how that the percent of correct responses decreased over time. After about 18 seconds, only a few subjects could recall the trigram; for most of them it had completely “evaporated”, i.e. had been forgotten.



The reason for the decrease is that it is difficult to rehearse (i.e. repeat to yourself) letters while counting. Therefore, the trigram disappears from STM very quickly and cannot be recalled into WM.

Note: A curve with the above shape is called a “**forgetting function**”.

Exercise:
Working with a partner, try the above experiment. The first person gives a trigam and a number. The partner begins the counting. The first person controls the time (any time up to 18s) and then says OK (or something similar). The second person then tries to recall the trigram.
The exercise could be repeated for different time intervals, and also reversing the roles of the two people.

Use of external memory

To help retain information in STM, we can use an external memory aid to help. The most common, of course, is pencil and paper, i.e. we write it down, such as when doing arithmetic problems. For example:

      36
x 27   (a) we do 7 x 6 = 42 in working memory
      2 → (b) we put the '2' into STM (and rehearse it), or on paper as is done here (and so rehearsal is not needed). [We might also write down the '4'.]

Working memory

This is the "workspace" (cf. a classroom chalkboard) where conscious processing is done, i.e. we are aware of what we are doing, as in the 7 x 6 example above.

The WM is said to be active (because things are happening) and having a high level of control of the processing (because we decide what happens and what doesn't). WM is associated with low level areas of activated LTM where the detailed subconscious processing is done, i.e. all the processing the brain is doing that we know nothing about.

For example, we are aware of saying '7 x 6 = 42' (high level conscious control), but not the actual computation details of the multiplication (which is low level, subconscious).

The WM has a very limited capacity in the amount of information it can hold. Only a few bits (or **chunks**) of information can be processed simultaneously:

~ 3 chunks (age ~ 5),

4 ~ 5 chunks (age ~12 up).

More on number of chunks and human memory limtations, page 20ff.

Thus, a Primary 1 child could cope with 1 + 2 = 3 without external aids (paper). A Primary 6 child who can work very fast *may* be able to do 36 x 27 completely in his head, holding in WM the numbers currently being processed, and in STM all the numbers that need to be temporarily stored until needed again in the WM to continue the calculation. But most of us cannot work this fast and the numbers in STM would "evaporate", so an eternal aid (paper) is needed to help us remember the numbers involved at each step instead of trying to hold them in STM.

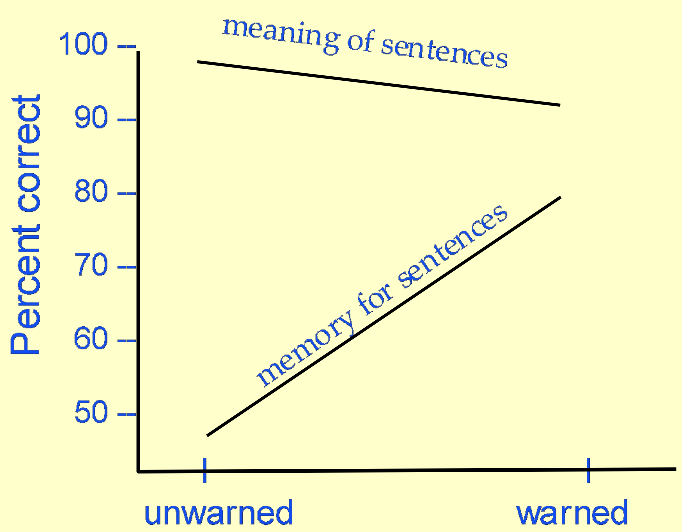
Exercise:
Can you do 36 x 27 completely in your head without writing anything down on paper? Try it.

Long term memory

This is for the long term (permanent) storage of information. The information is subconscious. When information from the LTM needs to be used by the WM, it is said to become "activated". Otherwise, the memory is passive, that is, no processing is done.

Language in LTM: This is stored not as exact words but as the **gist** (general meaning) of sentences.

Experiment for language in LTM:
(Wanner, 1968, cited in Anderson, 1980.)
Two groups of subjects heard a short paragraph. Later, they were *shown* two sentences:
(a) one from the original paragraph and
(b) another with different words but the same meaning, or different words and different meaning (see example below).
Subjects were tested for memory and meaning of the original sentence.



But one of the two groups was warned that the sentence was to be recalled later (i.e. that it was a memory test); the other group was unwarned.

The graph above shows the results. If warned, subjects memory for the exact sentences is good, probably because they rehearse/practice the sentences to themselves to help their memories.

But the real interest is with the *unwarned* group. Although they did poorly on remembering the sentences (as might be expected), they still scored high on memory for the meanings. Even if different words were used to express the same meaning, they could accurately state if the meaning was the same or different as in the original sentence.

Conclusions from this experiment are:
To retain information, aim to get the meaning; do not use rote memory.

When we read something and understand it, we remember the gist – the general idea – and not the actual words. That is why we can remember the meaning of a story for a long time but not the original words; we reconstruct the story with our own words when we need to talk about the story.

[Details about the experiment: Group I – unwarned Group II – warned it is a memory test
All subjects heard the following original sentence:
The dog chased the cat

Later half of Group I and half of Group II were shown:
The dog chased the cat (i.e. original sentence)
+
The cat was chased by the dog (different words, same meaning)
while half of Group I and half of Group II were shown:
The dog chased the cat (i.e. original sentence)
+
The cat chased the dog (different words, different meaning)]

Capacity limitations in human memory

The amount of information that can be held in the STM and WM is very limited.
Experiments tend to show that only 4 or 5 independent bits of information (called **chunks**) can be retained. Memory limits are measured by **memory span** tests.

Experiments on human memory capacity
Work in groups of two or more. There are several experiments you can do.
1. *Memory span for numbers*
- One person reads out a random/independent sequence of numbers at the rate of about one per second.
- Begin with just 3 or 4 numbers, e.g. 9 - 2 - 7 - 8. The others in the group then repeat these numbers (or write them down) in the correct order. (Most adults will get this correct.)
- Repeat using 5 digits, then 6 and so on up to 9 or 10. (By 9 or 10 some folks will have trouble recalling them accurately.) The number of digits a person can recall accurately is called the **memory span**.

2. *Memory span for numbers in the reverse order*
- Now repeat the whole thing again (with different numbers of course). But this time, the numbers are to be repeated backwards. For example, if 5 - 8 - 1 are given, the response is 1 - 8 - 5.
- Again, increase the number of digits to be memorised.

3. *Memory for meaningful words*
- Read out 3 or 4 simple words, e.g. cat – book – car, again at the rate of about one per second. Subjects must repeat the words in the same order (orally or in writing).
- Again, increase the number of words. How does memory span for words compare with that for digits?

3. *Memory for nonsense words*
- Read out 3 or 4 short nonsense words, e.g. DAX - MOT - RIN. Subjects must repeat the words (again, orally or writing) in the same order. (If writing, don't worry about accurate spelling.) What is the memory span for subjects? How does it compare with meaningful words?
- Again, increase the number of nonsense words. Is this more difficult?

STM limits measured by memory span tests: Independent digits (~ 9 forward / 6 backwards), independent nonsense syllables (~ 4, e.g. DAX), independent meaningful words (~ 6 one-syllable words).

Note the use of the word independent. This is important. Thus 5 - 8 - 1 are probably independent (unless, say, they are the first three digits of your telephone number!). But 1 - 2 - 3 - 4 …… are not independent and we can all probably recall accurately the numbers from 1 to 1000 and beyond.

Why are there capacity limits? When we try to remember a list of numbers/words, most people rehearse them, that is, repeat them over and over in their minds. Each time we say one number/word, it is in our WM because we are conscious of it. The others are temporarily stored in STM and we are unaware of them. If we are too slow to recall them, they "evaporate" from STM and so are lost/forgotten. This will happen with a long list as it can be many seconds before we need to recall items in it – long enough for them to be forgotten.

To measure the WM limits is more difficult. This is the number of independent chunks that must be *processed at the same time*. This is difficult to measure as it is related to the complexity of a task. For example, to memorise:
"Alan is taller than Bill" involves perhaps 3 chunks – Alan, Bill, taller.
"Alan is taller than Bill. Bill is taller than Colin. Who is tallest?' requires perhaps 3 chunks for Alan, Bill and Colin, taller and 1 or 2 chunks for the order. So, perhaps up to 5 chunks, which is getting to the limit.

The number of chunks can be increased by by a process called **chunking** (see below).

Chunks and chunking

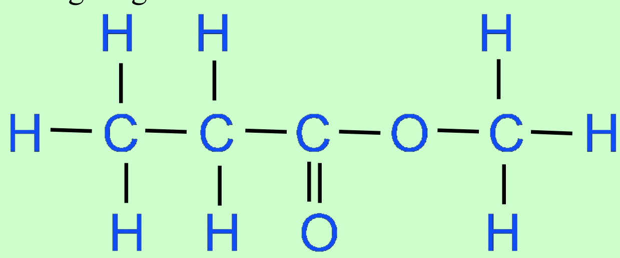
A chunk is a unit of memory for:
- processing at any one time – in WM.
- for storage in STM.

Chunking is the conversion of a larger amount of information into a smaller number of units/chunks (with each unit containing several bits of information all linked together).

Class experiment

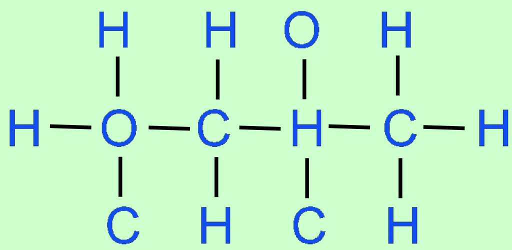
This is an experiment I used to do in my Psychology of Learning and Teaching classes.

Students were shown the following diagram for a few seconds then asked to reproduce it on paper.



As this is a chemistry formula, most of the chemistry student-teachers in the classes got it 100% correct. Most of the student-teachers in <u>other</u> subjects were floundering and many did poorly.

Then, for the second part of the experiment, I showed the following:



This time, most of the non-chemistry student-teachers did just as badly as with the first diagram. But the interesting result was with the chemistry student-teachers. Because this diagram is **not** a chemical formula, many of the chemistry group did just as poorly as the others. But, some did even <u>worse</u>. The reason was that they <u>thought</u> it was a chemical formula and wasted a lost of time before they realised it wasn't and by then there was insufficient time remaining to remember much of the information.

The results of the experiment show:

1. A chunk can be of arbitrary size. Subjects could not possibly remember every letter and stroke separately; there is just too much information. So, they try (usually without thinking) to find patterns or larger units to remember, e,g, the letters are in three rows (1 chunk?), and that all the links are single except in one case (1 more chunk?). Exactly how many chunks they create is almost impossible to know, but for those who answered correctly it cannot be more than 4 or 5.
2. The size of the chunk differs according to expertise. That is why most chemistry teachers get the first formula completely correct. Just a few seconds looking/thinking/processing and they recognise it. Many chemistry student-teachers even gave the name of the substance – methyl propanoate – which has probably reduced all the information to just <u>one</u> chunk.
3. Chunking is a <u>natural strategy</u> used when lots of information need to be processed so that it can all be held in WM and STM.
4. Chunking, and therefore more efficient processing/learning, occurs more easily when the material being learnt is well understood (as with the chemistry teachers using the chemical formula).

Examples of chunking

- Simple multiplication: 6 x 7 = 42 probably 3 or 4 chunks
- Transitivity: a > b, b > c ---> a > b > c (See the Alan, Bill, Colin example above.) Perhaps 5 chunks.

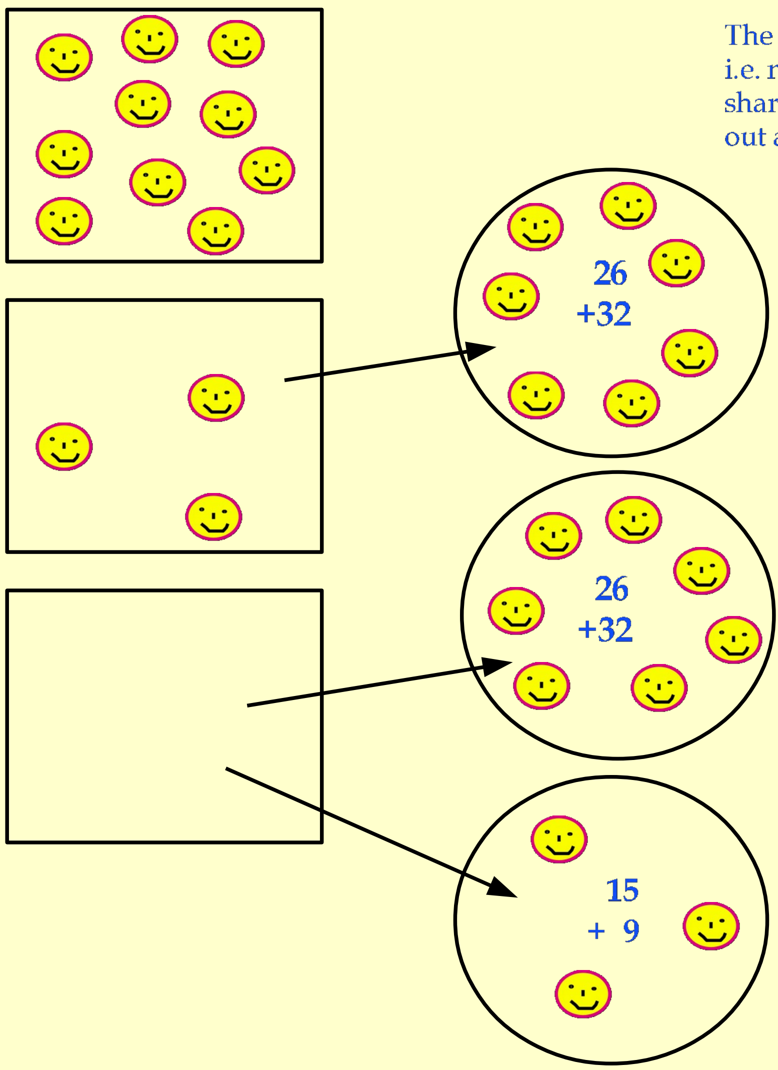
- Language:
  "Max is a cat." (spoken) One idea, 1 chunk (probably)
  "CAT" (on paper) – for a child, 3 letters separately. 3 chunks
  – for others, one word unit. 1 chunk
  "Jimmy Carter, a former president of the United States, wrote a book about his life at the White House." As this is a <u>meaningful</u> sentence, perhaps 4 ~ 5 chunks to and so can be held in WM.
  "Ya lybly kneegee." A meaningless sentence (unless you understand Russian!) – perhaps up to 6 chunks, e.g. ya / ly / bly / k / nee / gee. (Incidentally, translated it means "I love books.") <u>Note</u>: In Russian it is written "Я люблю книги" which for non-Russian readers would be almost impossible to reproduce exactly as the amount of information is just too great – trying to remember the strange letters, the numbers of words, the number of letters in each word, the actual letters in the correct order, etc.

Why are there capacity limitations?

Attention, page 24ff.

Assumption: The Information Processing System (IPS) has limited mental <u>resources</u> to perform tasks. Mental resources approximate to **attention**. A task with more information/details requires more attention.

An explanation using an analogy of "demons" for attention may (or may not!) illustrate this:



The mind has a fixed amount of resources i.e. number of 'demons.' These must be shared amongst all the tasks being carried out at one time.

Enough resouces are available for this *one* addition task in WM.

One problem <u>can</u> be processed; the other can't as it has insufficient resources.

So, we are imagining that out minds have 10 little demons to do all our mental work and that 7 of these are needed to attend to the one arithmetic problem. In the second case, with two (similar) problems, there are sufficient resources/demons/attention to do one problem, but insufficient to do the second. We could, of course, switch our attention to the second problem but then we would had insufficient resources to do the first.

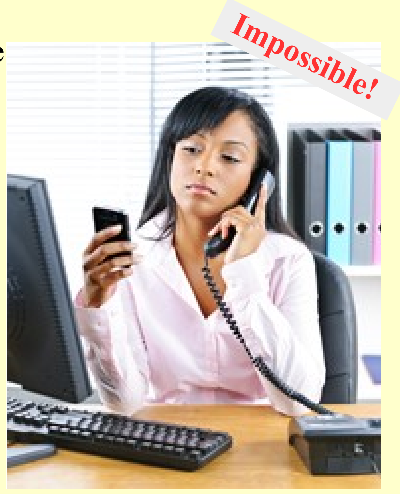
Overloading working memory

We cannot do two addition problems at one time. One of the tasks suffers when too many resources are required. Adding while reading or talking is a similar situation.

The more ***automatic*** a task is, the less attention/resources is/are required. Well-practised physical skills, such as walking, are an example. Other examples:

- Learning to drive (attention demanding) versus skilled driving (automatic).
- Walking (automatic) while talking (demanding, but will probably still have sufficient resources).
- Skilled driving and talking until you notice some emergency ahead, then you ask the talking passenger to stop talking so you can "focus all your attention" on what is happening ahead. This allows more resources/attention to be available for what you might need to do.

Multi-tasking



Therefore, the so-called "multi-tasking" is often a load of nonsense as people are not doing several automatic tasks at the same time. but several "high-level" non-automatic tasks, each of which requires a lot of resources/attention ("demons"). For example, using a computer + speaking on the telephone + listening to music + listening to someone else in the room is impossible. What tends to happen is that one of these tasks is done for a short time (with all the others being ignored), then attention switches to another single task. If this switching happens quickly, it gives the impression that several tasks are being done simultaneously, which is not the case. So it is really ***single-tasking*** with switching from one task to another.

Unfortunately, by doing this, each task is not being done very well as insufficient time is being used for each. It is far better to do just focus on one task and forget the others (i.e. put all your attention into this one task), which may mean telling people trying to speak to you to be quiet!

Website
For more on the multi-tasking myth, here is one of many websites, which is talking about the things I mentioned above. Note that this articles has 14 pages.
http://www.health.com/health/gallery/0,,20707868,00.html

Limits on memory: Classroom implications

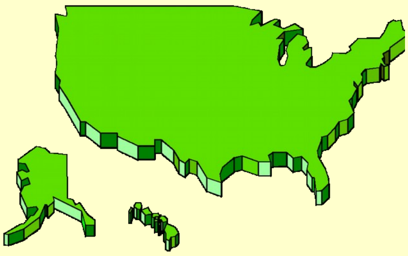
Overloading memory leads to errors, inaccuracies, increased solution/thinking times, poorer recall.

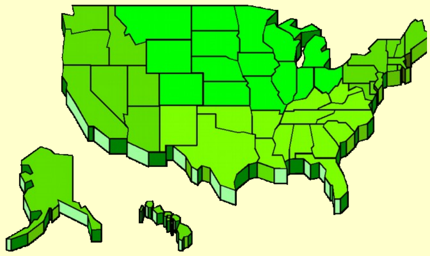
External memory aids can be used to assist STM. Here are examples:

- Put information on the chalkboard, rather than presenting it only orally, especially detailed instructions/information.
- Get students to write key points on paper instead of trying to memorise them.
- Make learning **meaningful**. This allows for larger chunking (which will tend to happen automatically when something is understood).
- Give material with fewer chunks by reducing amount of detail. For example:

  HO – C – C – C – C – OH reduced to HO – – OH if the extra detail is not relevant or important.

In the following example, if only the outline of the US is needed, use the map on the left instead of the one on the right as it has no detail that might distract students.





Segmentation: Break learning tasks/problems into steps of manageable chunks/size which can then be processed serially. Look back at programmed learning which does this.

Teachers (and perhaps also students) should understand the strategy of chunking and how it operates.

Two Basic Processes

Selective attention (or just Attention)

The sensory memory (or sensory register), which contains details of what we see, hear, etc., holds a lot of information but only for a brief moment as there is far too much to process. So we focus selectively on just a few of the incoming stimuli. Different people will focus on different stimuli, which means no two people will perceive (see) exactly the same thing even if they are all looking at the same thing, especially if the thing being observed is very detailed, such as a view of the surroundings.

What stimuli are affecting you right now? Are you looking at something? Hearing something? Smelling something? Are people with you recognising the same things?

Other stimuli are not completely ignored. Consider, for example:

- A conservation at a party. There is a lot to look at, a lot of noise, maybe also the smell of food cooking. But how much of this are you actually conscious/aware of? Very little. But it is not completely ignored. Suppose you are talking to a person. You may think you are not paying attention to other people. But if someone else suddenly says your name – even quietly – you probably hear it very easily, largely because it is meaningful to you.

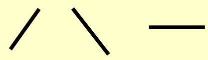
- A teacher calls the name of an inattentive student. Again, the name is very meaningful so he/her stops doing all the other things and looks up at the teacher.
- A student copying a diagram (inaccurately). Diagrams contain a lot of information and we often "overlook" many of the details. But suppose there is a smiley face right in the middle of the diagram, even if it is inappropriate. Few people would fail to see it.

Perception / Pattern recognition

Perception is the recognition of patterns among incoming stimuli. It gives sense and meaning to the stimuli.

How do we perceive?

Information in sensory memory is matched with information in long term memory. Two main processes are involved:

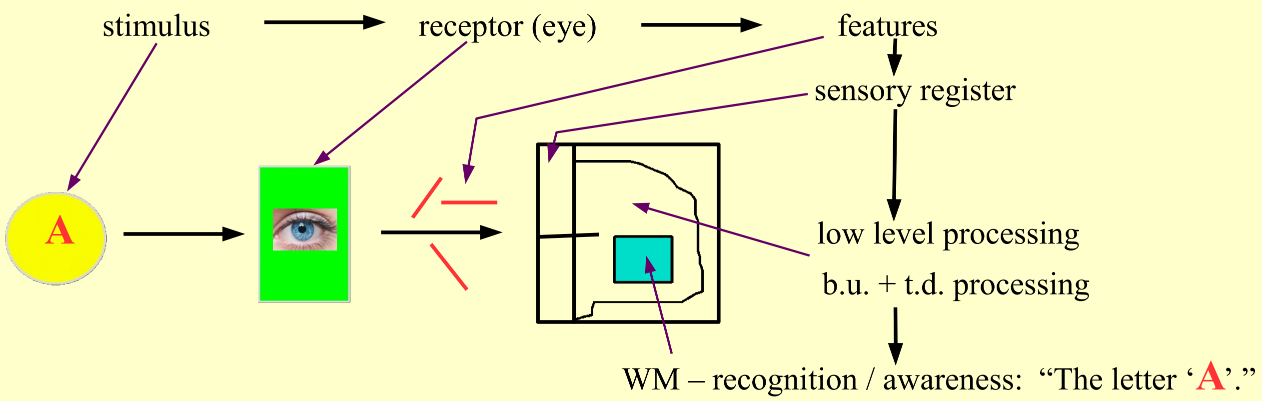
Bottom up processing: Small bits of information are assembled into larger bits. E.g.  combine to form the letter '**A**'.

Top down processing: Background knowledge is searched to see if there is a match with the assembled pieces. If we have previous experience of the letter '**A**' in our LTM, this will be matched with the assembled letter. When a match occurs and is recognised, perception/pattern recognition is complete. If no match occurs, we recognise a new shape and store the '**A**' in LTM as new knowledge.

Analogy of a jig-saw puzzle:

We assemble the small pieces ('bottom up' processing) →

← We continually compare the assembled pieces with the picture on the box ('top down' processing)

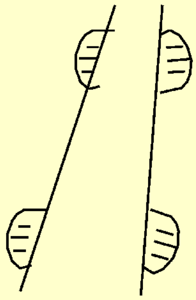


Note: Perception is not the same as learning, but just recognition (as background knowledge is already in LTM) but is necessary for learning to occur.

What is actually perceived depends on both the physical stimuli and by *many* top down factors including:
- background knowledge,
- expectancy, i.e. what you expect the object to be,

- context,
- motivation,
- being told what something is (similar to expectancy).

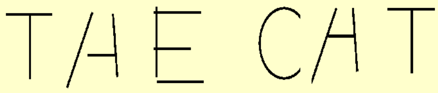
Examples



?

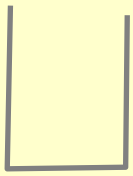
Being told helps recognise the above shape

Context helps perception



? Very young child

? Adult reader



? In an English lesson context

? In a Chemistry lesson context

A **B**

A **B**

In each set of pictures, who is taller – A or B?

We learn the constancy of depth at an early age which allows us to recognise that the size of a person walking towards/away from us does not change.

[Answers: But don't cheat. Try to answer the above questions yourself first.

- The first diagram shows a bear holding on to the back of a tree. By telling you this, do you see this?
- The young child, who is learning to read, will focus on the letters and perceive that the 'H' in THE is the same as the 'A' in CAT. Adults, with a lot of background knowledge of letters – and especially badly written letters – as well as words, may not even notice that the letters are the same and will just sat “The cat'.
- In an English lesson, the letter 'U' may be perceived; in Chemistry, a beaker may be perceived.
- In the left-hand picture, **A** appears taller than **B**. In the right-hand picture, the road provides depth and we are more likely to perceive **A** and **B** as being about the same height.]

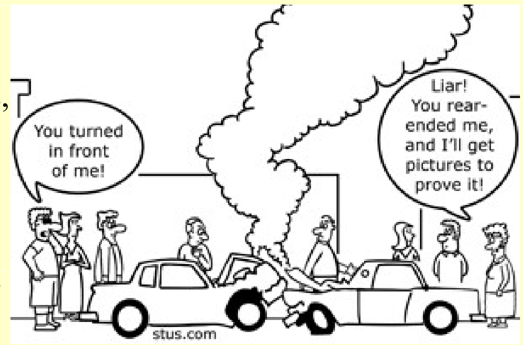
Both bottom down and top down processing must occur together for perception to take place. If only top down processing occurs, we are delusional, that is, we are seeing things that are not there, because we are just using any convenient knowledge in our LTM without matching it with the incoming information. Doing only bottom up processing is probably impossible as matching seems to occur naturally.

Because our background knowledge is important, perception is an act of considerable intelligence. All our knowledge and experience is needed to interpret what we experience in the environment.

When too much information/stimuli enters the sensory memory, attention focuses on information likely to be informative to us because of our background and experience. Therefore:

– Students don't "see" details in a diagram because their background knowledge is poorer than ours and so only recognise details that are already familiar to them, i.e. in their LTMs.

– Witnesses to an accident "see" different things according to their prejudices, etc. That is, they tend to observe some events and fill in the other details, e.g. colour of vehicles, man/lady driver, speed of vehicles.



Overall, perception is extremely complex and is believed to be the most difficult thing we do with our brains.

Website
The following website contains some interesting examples about accident witnesses and also how young children can "recollect" things when asked leading questions, even though the events never actually occurred.
http://tonks.disted.camosun.bc.ca/courses/psyc110/memory/memory.htm

What classroom practices facilitate attention & perception

1. Physical characteristics of stimuli. Examples:

LARGE size

bright colour,

bold,

underlining,

use of boxes,

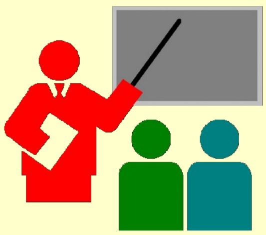
loud sounds.

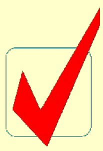
Note: Television uses many of these characteristics. No wonder it can easily attract out attention!

2. Use a reduced amount of stimuli – spoken or written, so that key information will be attended to.

Examples:

- Limit chalkboard material. **Clean often**.
- Consciously **point things out**. This will narrow the range of stimuli a student focuses on and only relevant stimuli are likely to be attended to.
- **Reduce detail** in diagrams.
- **Build up diagrams** bit by bit.
- **Remove unnecessary material** from the table/bench which often distracts students.





- **No mixed activities**, that is, two or more things at the same time ("**multi-tasking**"!), e.g. copying notes + listening (which is very common in Hong Kong). Students cannot easily attend to both, i.e. they cannot do multi-tasking. Compare the two classrooms in the pictures below. Individual notebook computers / iPads can so easily to lead to mixed activities. So, the slogan I try to impress on my teacher trainees is that when teaching "**One activity at one time**".

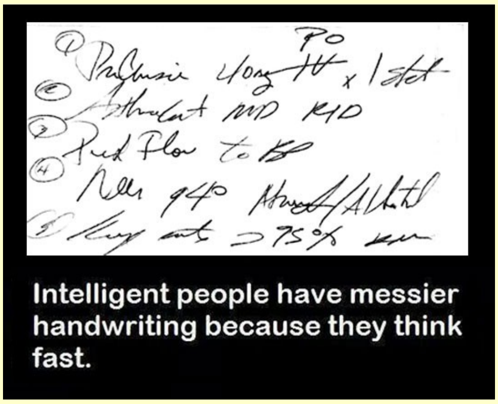
Good example - not one student writing; all are involved in one activity, the discussion.

Bad example - many students are focusing on their computers while the teacher is talking to them.

- Enhance physical characteristics, e.g. underlining, shading.
- Use rehearsal strategies. These help recall but not understanding. Use with other strategies (see later).

Strategies, page 35, 39ff.

- Good handwriting. This will facilitate accurate and rapid perception, e.g. reading an '**H**' instead of an '**A**' (as in the CAT example above). Can you read the handwriting in the picture? If that were the handwriting of your teacher, you would be unable to copy it accurately – if at all!
- Ensure students get good background knowledge. This will allow for better top down processing the next time the ideas are met.



?

What we perceive of the world depends on both bottom-up and top-down processing. These are never perfect. So, a question to think about:

What is reality?

ACQUISITION OF KNOWLEDGE

Definitions of learning

Two (of many) examples:

1. *The process of acquiring knowledge.*
2. *Learning is a relatively permanent change in the behaviour of a person that occurs through experience.*

Which of these definitions would be closer to (a) the behavioural paradigm, (b) the cognitive paradigm? Why?

Types of knowledge

There are three types, which are not always independent:

1 **Declarative knowledge** or knowing "that". This includes the facts we know and relations between facts. For example, in arithmetic, we may know the facts but be unable to use them in calculations.

2 **Procedural knowledge** or knowing "how". This includes skills and strategies for doing things, e.g., walking, cycling, arithmetic calculations. We may not understand the knowledge needed for these procedures or be able to explain them.

These categories are artificial. Knowledge is often both, for example, speaking fluently (procedural knowledge) requires an understanding of the grammatical rules involved (probably subconscious) in constructing the sentences we speak (declarative knowledge).

3 **Metacognitive knowledge**. This is "knowledge about our knowledge". That is, the knowledge we have about our learning or how to to things to achieve certain outcome. Examples:

- Knowing one's strengths/weaknesses when doing a task and which of these will be successful.
- Knowing what strategies (methods) may be best to solve a problem or to memorise something.
- Monitoring and controlling our comprehension during reading, e.g. read a paragraph again if we don't understand it (many children do not do this!), look up the meaning of a word not understood if it is important and knowing when to ignore a word because it is not important.
- Monitoring or evaluating progress when doing a task and changing strategies if necessary, e.g. work

in a quiet library rather than at home where there are many distractions.

- Knowledge that different tasks require different demands, e.g. to read and comprehend a science text may (or may not!) require more time than it would for you to read and comprehend a novel.

Levels of knowledge

Knowledge may be **implicit** or **explicit**.

- Implicit knowledge is subconscious, fast, effortless, efficient. For example, walking, counting, recognising objects in the environment, predicting (e.g. where a ball will land). A large proportion of our knowledge is implicit.
- Explicit knowledge is conscious, slow, requires more effort, can be modified and linked to other knowledge. A greater dependence on language and formal learning.

For understanding, knowledge must be explicit. Implicit knowledge can change to explicit knowledge – informally or through social input, especially teachers or parents helping learners/children to verbalise (speak out in their own words).

Therefore an important part of teaching is to uncover students' implicit background knowledge of a topic to make it explicit.

- **Implicit <----> explicit occurs**. Examples:
  - language <----> grammar rules. (i.e. explaining what we say in terms of the underlying grammar, and learning grammar rules then using them to construct sentences).
  - skills <---- practice of a physical/mental skill. For example, a swimming teacher breaks down swimming into separate skills; students practice separate skills then put them together.

  - attitudes/beliefs <----> observing/listening/discussing to clarify or get attitudes/beliefs.
  - knowledge of teaching ----> this course! That is, understanding why some of the teaching methods you use are good or bad; learning about educational psychology in order to teach well.

What we acquire

	declarative knowledge	procedural knowledge	
implicit knowledge	environmental associations	S-R associations	basic learning processes
explicit knowledge	network structures	strategies / skills	

Note: We will be looking mainly at acquisition of explicit declarative knowledge

includes:
- strategies for problem solving
- strategies for acquiring
- declarative knowledge and understanding

ACQUISITION OF EXPLICIT DECLARATIVE KNOWLEDGE

- Three aspects:
  1. Acquisition of concepts
  2. Understanding of declarative knowledge
  3. Retention of declarative knowledge
- Good explicit knowledge forms a **network** of concepts and the relations between them.
- Two ways of acquiring explicit knowledge are by:
  1. Explicit instruction with new information.
  2. Using existing implicit knowledge and making it explicit.

1 *Acquisition of concepts*

Two key processes: **Generalisation** and **discrimination**

A key idea: To acquire concepts, it is necessary to present or observe a range of examples/situations.

Generalisation

Consider a child acquiring the concept "cat". This would be learnt implicitly through environmental examples well before the child goes to school. The child sees an object (which a parent or caregiver will say "cat") and subconsciously detects various features such as the following:

This object:

moves / small / fur / four legs / says 'meow' / called 'Toby'

------> 'Cat

The child now sees a second cat:

moves / small / fur / four legs / says 'meow' / called 'Max'

------> 'Cat'

child generalises

Anything that:

moves / small / fur / four legs / says 'meow' ------> 'Cat'

Generalisation is done by ***deleting conditions***. In this case, the name (Toby / Max) is irrelevant to the concept of a cat and so is deleted.

Generalisation can also be done by ***changing conditions***. For example, after seeing a cat with three legs, a child generalises:

moves / small / fur / any number of legs / says 'meow'

------> 'Cat'

Second example: The concept 'square' is most likely learnt by <u>explicit instruction</u> at school through the teacher's examples:

Example 1:

two-dimensional / four sides / all sides equal / red

------> 'square'

Example 2:

two-dimensional / four sides / all sides equal / blue

------> 'square'

Then, by generalisation, the child deletes colour which is irrelevant to the concept of square to give:

two-dimensional / four sides / all sides equal

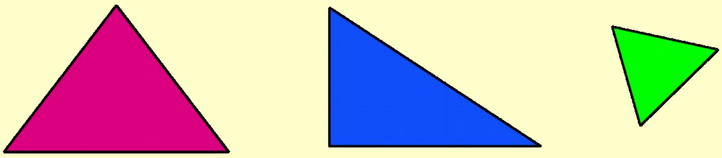
------> 'square'

Teaching for generalisation

- Present successive examples which differ widely on irrelevant details.
- Point out the common features.

Examples:

Concept of 'triangle':

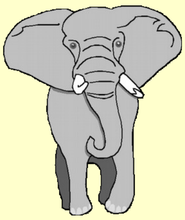


two-dimensional, number of sides, closed are *common*.

colour, size, length of sides, right angle, etc. are *irrelevant*

So, a triangle is a closed geometric figure with three sides.

Concept of 'placental animal':



<u>Elephant</u>: mammal / large / eats plants / hair / has a placenta

<u>Rat</u>: mammal / small / eats rubbish / hair / has a placenta

Placenta and hair are *common*.

Size and food are *irrelevant*.

So, a placental animal is a mammal (all mammals have hair) which has a placenta (at least females do)

A <u>whale</u> and a rat are better examples because one lives in the ocean and the other on land. This provides examples that differ more widely. <u>Note</u>: As a placenta is not visible, students would have to know some additional biology.

Discrimination

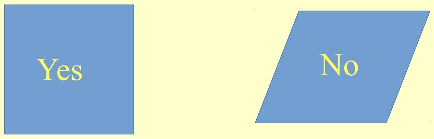
This *decreases* the range of examples. It does this by ***adding or changing conditions***.

Consider 'square' again. From above:

two-dimensional / four sides / all sides equal ------> 'square'

New examples are presented:

All "higher" animals, such as apes and even birds, can form concepts, though they do not have words to describe them.



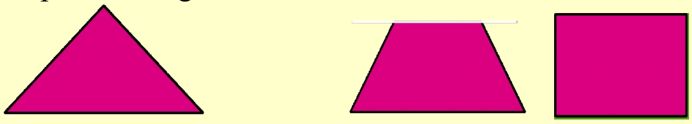
two-dimensional / four sides / all sides equal / four right angles ------> 'square'

Teaching for discrimination

- Simultaneously present examples and non examples, especially 'controlled' examples. (Controlled example are exactly the same except for <u>one</u> feature.)
- Point out differing features.

Examples:

Concept of 'triangle':



example controlled non examples (only shape is different)


an opossum

Concept of 'placental animals':

Rat: small / tail / placenta / hair / eats rubbish / ....

Opossum: small / tail / no placenta / hair / eats rubbish / ....

Exercise:

Take a concept from your subject and show how to teach it using generalisation and discrimination.

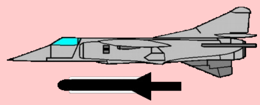
Misconceptions in learning declarative knowledge

Inadequate or insufficient examples can lead to misconceptions.

Do you have any misconceptions? Try the following exercise.

Exercise:

1. Draw the path of the bomb from the aircraft to the ground



<u>Note</u>: Even graduate students (including some in physics) have misconceptions about motion and answer this incorrectly!

2. Water is heated and changed into steam. Which of the following statements is/are <u>true</u>?

A Steam particles are hotter than water particles

B Steam particles are larger than water particles

C Steam particles are lighter than water particles

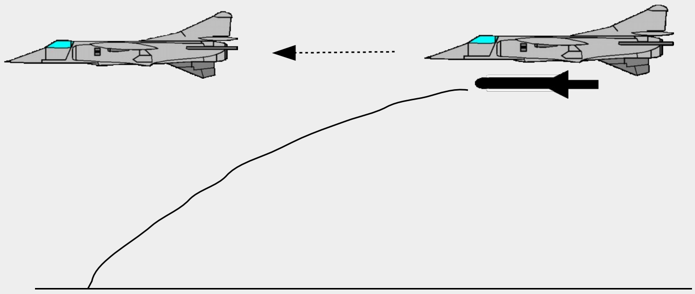
D Steam particles are further apart than water particles

3. Subtraction. What <u>incorrect</u> <u>rule</u> is being used?

9 1	2 1	9 1	513 1
402	333	504	643
-137	- 126	-325	-255
365	207	279	388

[Answers: But again, don't cheat. Try to answer the questions yourself first.

1. Many people draw a *vertical* line from the bomb to the ground. This is wrong! The path should be a *curve* and, as the bomb falls, its position will be always directly under the position of the aircraft (which, of course, still flies horizontally).



2. Only 'D' is correct. All the others are misconceptions. Only the distance and speed of water particles/molecules change. (I could have added another option about the speed increasing which would also be correct).

3. The fourth one (I think), but I cannot remember why! Any mathematics teachers out there?

Some causes of misconceptions

- Inadequate or insufficient examples. In the above Example 1, everyday misconceptions on motion. We know things fall vertically when we drop them. Images – still or video – (such as that on the right) seem to show bombs falling vertically. (Think: The bomb at the bottom was actually released when the plane was far to the right of the position shown in the picture.) A better example is to flick a coin off a table; the coin falls in a curve until it hits the ground.
- Incorrect use of analogy. For example, speaking English using Chinese grammar; water flow for electric current. No analogy is perfect and we often remember the irrelevant parts of the analogy. Thus electricity "flows" in a wire because water "flows" in a pipe. Electricity does not actually flow!
- Invention when solving problems. For example, the subtraction example above – students actually make up rules while solving problems using existing knowledge which is usually inappropriate for the new situation.
- Use of language by teachers/experts. For example, current "flows" (it doesn't – see above); Ions "carry" a charge (they don't); The sun "rises". (However, what other simple words would we use?) Also, the Chinese characters for "fig" (a fruit) are 無花果 ("fruit no flower"), which is wrong as all fruit come from flowers).
- "Blocking" that is, previous experiences that add no new information do not lead to learning (and may interfere with it.). Example of a misconception about motion that is affected by blocking:
  - "*Moving objects slow down by themselves*" (*implicitly* learnt by observing many objects stopping).
  - In physics, students learn *explicitly* that without any external force, objects do not slow down. But this is not always really understood and though it can be used to correctly answers questions in examinations, it is not part of the students' "real" knowledge.

- Implicit knowledge is strong, as it appears to predict or confirm common experiences. Therefore, in the physics example, physics knowledge may not be really learnt/understood, at least for everyday phenomena. The implicit knowledge is so strong that it blocks new learning. And after the exams are over, the "school" learning may be forgotten and students revert to their everyday (but incorrect) knowledge of moving objects rolling to a stop by themselves which still remains!

Other examples of misconceptions

- Physics: Examples on motion, electricity.
  Blocking: (As discussed above.)
- Chemistry: The nucleus of an atom is hot (it isn't!).
  Analogy: Incorrect comparison of an atom with the solar system. Analogies, page 42ff.
- Mathematics: Subtraction, e.g. 0 - 6 = 6
  Invention: Students, who were having difficulties doing subtraction, have been observed to make up the rule $0 - x = x$, which is wrong.

  Incorrect analogy: $(a + b)^2 = a^2 + b^2$; $(a * b)^2 = a^2 * b^2$ is correct. So, by analogy, changing multiplication (*) to addition (+), which is wrong.
- English: "Although he is old, but he is ....
  Analogy with other uses of "but". However, "but" should not be used in this sentence.

Overcoming misconceptions

Accurate conceptual knowledge depends on background knowledge.

> **"The most important single factor influencing learning is what the learner already knows; ascertain this and teach him accordingly."**
>
> Ausubel (1968)

Always check students prior learning. If misconceptions are found, try to find and use disconfirming / discrepant experiences to break down / weaken the incorrect learning.

How might this be done in the previous examples?

Exercise:
1 Identify one misconception of students in your classes.
2 Suggest how it might have formed.
3 Plan an exercise to give a discrepant experience(s) which will lead to "breakdown" of the misconception and replace it with the correct concept.

2 *Understanding of declarative knowledge*

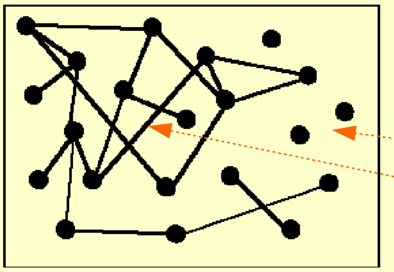
Understanding is the key to effective learning.
There are a variety of **strategies** for effective teaching and learning to ensure understanding.
A conscious use of strategies is important (look again at the comments by Norman).
The key to understanding is in one word – **elaboration**.

Elaboration

Elaboration is the adding of information to other information.

For learning, elaboration results in mental network structures. that are stored in LTM

The diagram below is a simple model of knowledge as a network structure in LTM. It consists of many concepts with links between the concepts.



● = idea/concept

—— = link/association/relation/elaboration

poorly-linked ideas → poor understanding

well-linked ideas → good understanding

Understanding refers to the network of relations between ideas.

The process of elaboration occurs in working memory. Thus it is an active, conscious, **constructive** process. The learner must construct/create relations and join/link pieces of information. The resulting network is stored in LTM.

Elaborated material is (a) more meaningful (because of the links between the ideas), and (b) easier to access/retrieve from memory.

Experiment 1

This experiment was also carried out during class time.

Student-teachers were told that they were to write two words for each of the following 10 stimulus words, one in each of the blanks that follow it. There are two types of stimulus word – '**A**' words and '**B**' words. After each '**A**' word, they are to write the stimulus word twice. For example:

Stimulus word	Responses	
A BOOK	book	book

For a '**B**' word, they are to write any word that comes into their heads when they look at the stimulus word. In the second blank, they are to write the stimulus word. For example:

Stimulus word	Responses	
B CAR	driver	car

A	TELL	____________	____________
B	LOOK	____________	____________
A	RASH	____________	____________
B	GRIND	____________	____________
A	PAIN	____________	____________
B	BOIL	____________	____________
A	EACH	____________	____________
B	MEND	____________	____________
A	CHIP	____________	____________

B POST ____________ ____________

Then, after a brief internal, the experimenter surprises the class by telling them to turn over their papers and write down the 10 words from memory!

The '**B**' words were easier to recall because students had to actively construct elaborations for the given words. For the '**A**' words, memory is probably just because of rote repetition of each pair of words.

Elaboration is a natural process. We often automatically link new information to background knowledge.

Experiment 2

The story of Carol Harris

The class was separated into two halves. One half left the room. Then the following paragraph was read to the first half of the class that remained in the room:

Carol Harris's Need for Professional Help

Carol Harris was a problem child from birth. She was wild, stubborn and violent. By the time Carol turned eight, she was still unmanageable. Her parents were very concerned about her mental health. There was no good institution for her problem in her town. Her parents finally decided to take some action. They hired a private teacher for Carol.

The second half returned to the room and the first half exited. The same paragraph was then read to the second half of the class with one change: The name "Carol Harris" was replaced by "Helen Keller".

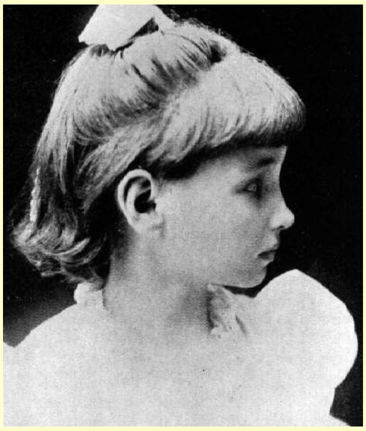
One week later, several questions were put to both groups and they had to answer 'Yes' or 'No' if they had heard the sentence the previous week (pronouns were used instead of Carol or Helen). For example:

- She was a problem child from birth.
- Her parents hired a private teacher for her.
- She was deaf, dumb and blind.

Nearly all the students answered 'Yes' to the first two statements. Most of the second group (the *Helen Keller* half) and one or two from the first group (the *Carol Harris* half) answered 'Yes' to the third statement. Why, as that statement was not in the paragraph?

Conclusions:

1. New information is linked to our previous knowledge of a topic. Many in the *Helen Keller* half had heard of her and so already had background knowledge in their LTMs about her. During the week, the information in the paragraph became mixed/linked with that about Helen Keller in LTM and was was then difficult to separate this from that in the paragraph. Hence, these students were answering based on all the linked information about Helen Keller in their LTMs and not just that from the paragraph, information that included the fact that she was deaf, dumb and blind.
2. The more effectively new information is related/linked to background knowledge, the better our elaboration, and therefore the better our memory and comprehension.



Helen Keller (1880 - 1968), pictured at about 8 years of age

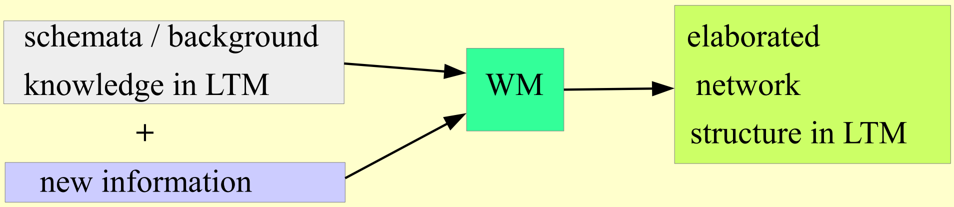
3. Elaboration is often difficult to prevent. However, this is less common in school learning because of poorer background knowledge.

Schemata

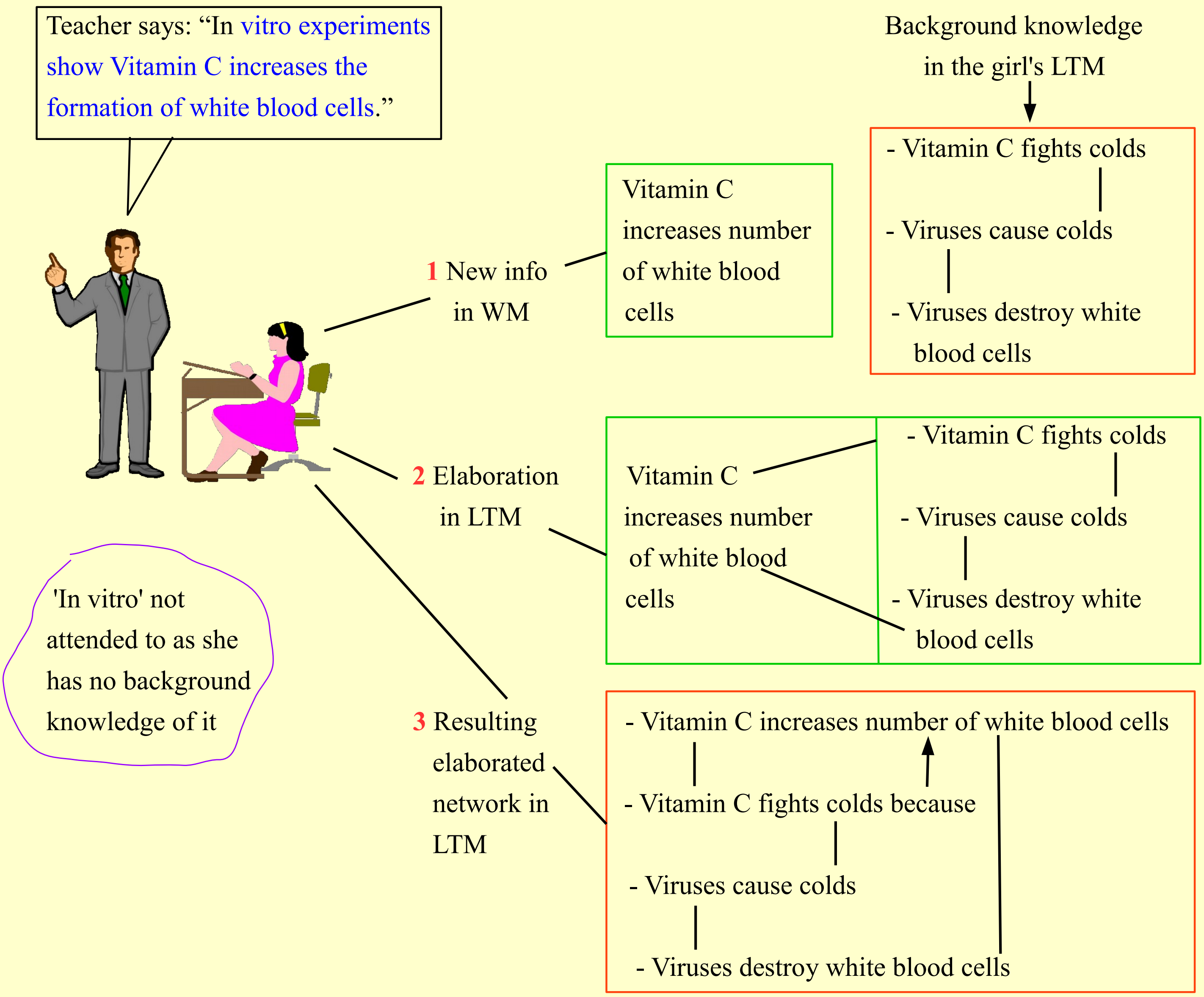
Our background knowledge about an object, event or situation is called a **schema** (plural schemata). Schemata can be used for recall. Some examples:

Construction. Incoming text/information is interpreted with respect to a larger body of background knowledge already in LTM. This is an active process. Meaning is constructed.

Distortion. New information can link with existing biases, prejudices, limited experience/knowledge to give a meaning different from what others get.



Classroom example of elaboration



Elaboration strategies for teaching & learning

Strategies for basic tasks (mainly words or similar)

Mnemonics (from an ancient Greek word meaning 'of memory')**:**

Used to make less meaningful material more meaningful. For example:

Harry **He**ung **Li**kes **Be**ef **B**ut **C**andy **N**g **O**rders **F**ish

Recognise this? The letters in **red** are the symbols for the first nine chemical elements in the Periodic Table. As the sentence is meaningful and easy to recall, the symbols of the elements can be recalled.

Memory is not improved using mnemonics if the material is already meaningful. (For example, ***I*** do not need a mnemonic to remember/recall these none elements as I have been a chemistry teacher.)

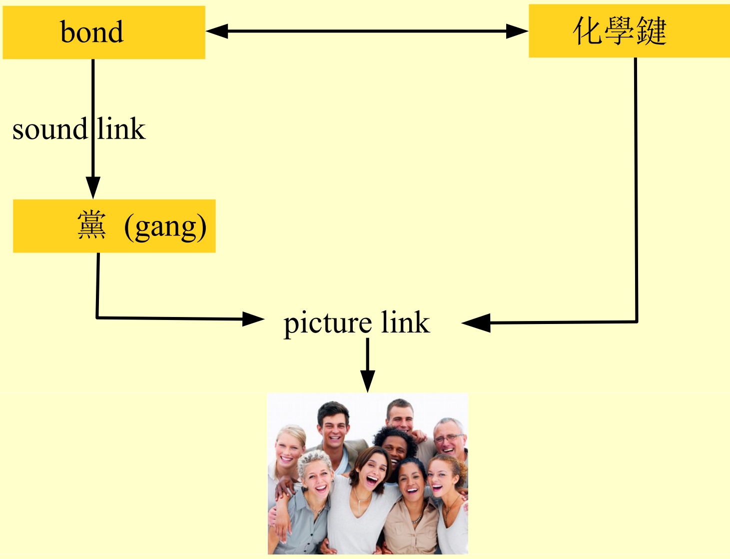
Use of imagery:

Mental images are easy to remember. Get students to picture/visualise objects, concepts, processes, etc.

Giving / getting examples:

Keyword method.

Example 1: To remember the English and Chinese terms for the chemical term “bond”.



a 'gang' of friends forming a friendship bond

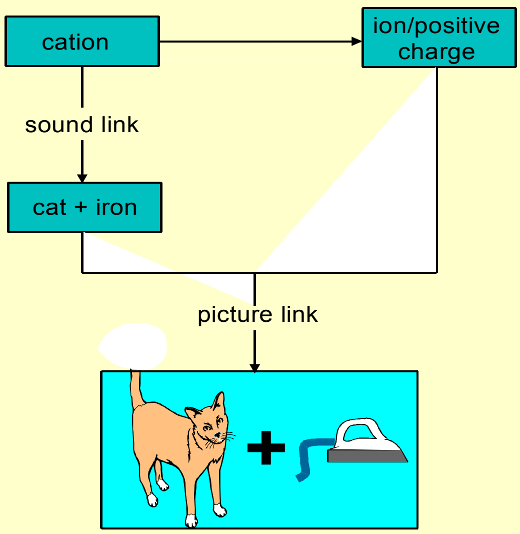
In this example, sounds of words and pictures are elaborations

To remember the picture is easy. From the picture, the English and Chinese terms can easily be recalled.

Example 2 To remember the meaning of terms/words.
For example: “cation”.

A cation is an ion with a positive charge.

As in the previous example, there is a considerable amount of elaboration involved. As a picture is easy to recall, the meaning and thus the definition could be readily recalled or constructed.



a cat + an electric iron

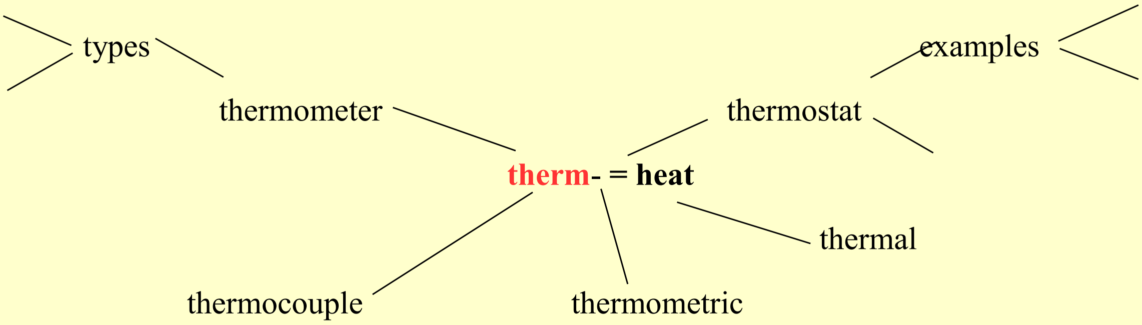
Using word sets to explore interrelationships:

Many words are related to other words. When possible, learn sets of related words together with their meanings.

Example: Words containing ‘therm’:

thermometer *thermostat* *thermocouple* *thermal* *thermometric*

As these words are related, what you are doing is building up a mental network of the terms and their meanings. For example:



As the diagram shows, you can extend the network – and your understanding – by making further links (see the “Elaboration” strategy below.)

Elaboration can be further enhanced by:

(1) getting students to construct sentences using these words (see “Depth of processing” below). and

(2) discussing the meanings of the parts of words, e.g. *therm*-, -*meter* and asking students for examples of other words having these parts (e.g. altimeter, speedometer).

Depth of processing, page 42ff.

Strategies for more complex learning tasks (paragraph / text level)

- The strategy of fundamental importance is the ***questioning technique*** to help students connect pieces of information together.
- Making inferences / Drawing conclusions.
- Getting *students* to generate / construct, for example:
  - explanations.
  - summaries.
  - paraphrases.
  - notes.
- **Creating analogies** (see below)
- Completing tasks
- **Elaborative questioning**:

(a) In the classroom:

Here are general examples of question stems that a teacher could use during a lesson:

What is ...?
What is the definition of ...?
What is the meaning of ?
What is a use for ...?
What is the formula for ...? And what is the unit for ...?
Explain why ….
Explain how ….

What is the difference between ... and ...?
What causes ...?
What is an example of ...?
Draw/Sketch a graph/diagram to show ...
Draw a circuit diagram ….
What would happen if …?
Describe an experiment to show ….

Here are some specific questions using these.
What is a solenoid?
What is a thermocouple used for?
What is the formula for power? And what is the unit for power?
Sketch a graph to show Hooke's law?
Draw a circuit diagram of an experiment for Ohm's Law.

Use in a classroom lesson – one example for a double-period lesson (70 minutes)

1. (50 min) Normal lesson (including teaching strategies discussed in these notes!).
2. (5 – 7 min) Students generate questions on their own about the lesson with the help of the above general questions (or others) printed and distributed. They write down their questions.
3. (5 – 7 min) Students work in pairs and quiz each other using their own list of questions.
4. (Remaining time) Class discussion on questions students couldn't answer.

(b) During self-study:
When studying a topic, ask yourself questions and try to answer the questions. This can be used for any learning – words as well as ideas from paragraphs. You could also work in pairs or small groups; try to answer each other's questions and discuss the answers. This will greatly improve your understanding and memory.

In addition, questions could be asked before you read a text. If you have to study a chapter, flick through it quickly, looking at headings, pictures, etc., and write down a list of possible questions. Then as you go through the text, you can look for answers for your questions. Also, if any questions remain unanswered, check the chapter again. Of course, some of the initial questions may turn out to have been irrelevant.

But a warning: Don't just answer your list of questions only – there will be many other points in the chapter you will need to understand for which no questions were asked.

Notes on elaboration strategies:

- Student elaboration is needed rather than teacher elaboration. Consider the Chinese proverb:
  "Obtain knowledge yourself and it is yours!"
- Acquisition of knowledge using elaboration takes time but is is very effective in helping understanding and memory.
- While elaborating, knowledge takes up space in working memory. Therefore do not teach too much at any one moment.

- Elaboration is more likely to occur spontaneously the more background knowledge and understanding a learner already has. Our students do not have extensive knowledge (at least in the subject we teach them). Thus teachers must get students to build up effective, integrated network structures.

Depth of processing

Elaboration works because, in part, it increases the "**depth**" to which a person processes (thinks about) information. Both terms refer to the same thing – it is just that different researchers used different terms.

An **experiment** was carried out to show the effect of "depth" of processing. It involved connecting noun-object pairs of words. such as dog – apple.
(a) The sentences were generated by the experimenter.
(b) The sentences were generated by subjects themselves.

Recall: Later, subjects were given the stimulus word (first word of the pair) and had to state the object (the second word of each pair).
Group (b) scored higher because, by constructing meaningful sentences themselves, they had to think more deeply (or elaborate by combining the words into sentences).

Learning strategies compared with the intention to learn

An experiment was carried out to investigate this using two groups (Hyde & Jenkins, 1973).

Experiment:
A list of 24 words was presented at the rate of one every 3 seconds.

Group A: Asked to state if the words contained 'e'.
Group B: Asked to rate the "pleasantness" of each word.

Half in each group were told the true purpose of the experiment was to learn and to recall the words. Thus the students in these two halves had the intention to learn.

Results:	Group A	Group B
Intentional (told)	43	69
Incidental (not told)	39	68

(scores are % of words recalled.)

Conclusion: Intention alone to memorise/recall is not enough. Deeper processing/use of strategies gives better results which is why the subjects in Group B scored higher.

The Use of Analogy

The term *analogy* covers both analogies and metaphors, though there is a lot of overlap in the usage of the terms.

Analogies are of fundamental importance in human cognition. They are widely used in everyday communication as well as for teaching. Some everyday examples:

"As pure as snow."
"I wandered lonely as a cloud, ..." (Poetry)
"He gets under my skin!" (Idioms)

Definition:

An analogy is a mapping from one structure (the 'source') which is known, to another (the 'target') which has to be inferred or discovered.

<u>Example</u>:

Source:  cat -------- *parent of* -------> kitten 

Target:  dog -------- *parent of* -------> puppy 

Both the source and target consist of two elements/nodes and relations between them.

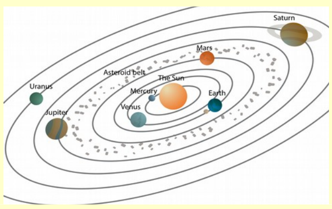
Some characteristics of analogies:

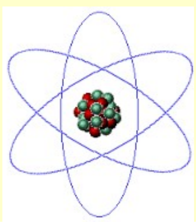
- The goodness of an *analogy* depends on the correspondence between the relations rather than the source and target nodes having similar attributes.
- The goodness of a *metaphor* depends more on attribute similarity. E.g. "He is a lion".
- Relations or attributes are mapped selectively.
- In teaching, students must see and map the relations between two structures.
- Superficially dissimilar situations can be linked.
- The <u>source</u> information must be <u>well known</u> to make comprehension effortless. Otherwise analogies are difficult to use.
- Ways analogies can be used in the classroom include:
  - as an aid to learning
  - for understanding
  - for the transfer of knowledge
  - for problem solving.

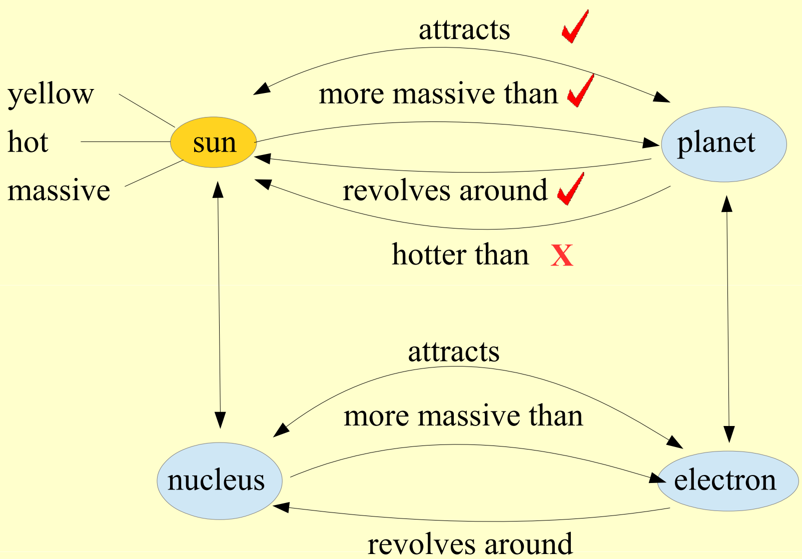
Classroom example of an analogy

The analogy for learning the **structure of an atom**. The source is the solar system (known to students) and the target is the structure of the atom (unknown).

Source: Solar system







Target: Structure of an atom

This analogy contains a lot of information. When teaching it, use chunking and segmentation (introduce relations one at a time).

Concrete learning aids

These are a form of analogy. Concrete material is mapped onto abstract material. Before introducing abstract ideas, always teach concretely first using real-life, physical things. Then show how they are related to the abstract ideas.

Advantages:

- The concrete analogue organises/structures the material to be learned.
- Facilitates the retrieval of information from memory.
- Reduces learning effort (as the concrete material is usually likely to be familiar).

Disadvantages:

- Increases the load in working memory (as do all analogies as there is a lot more information from both source and target).
- Incorrect mapping can lead to misconceptions. (Cf. earlier work again.)

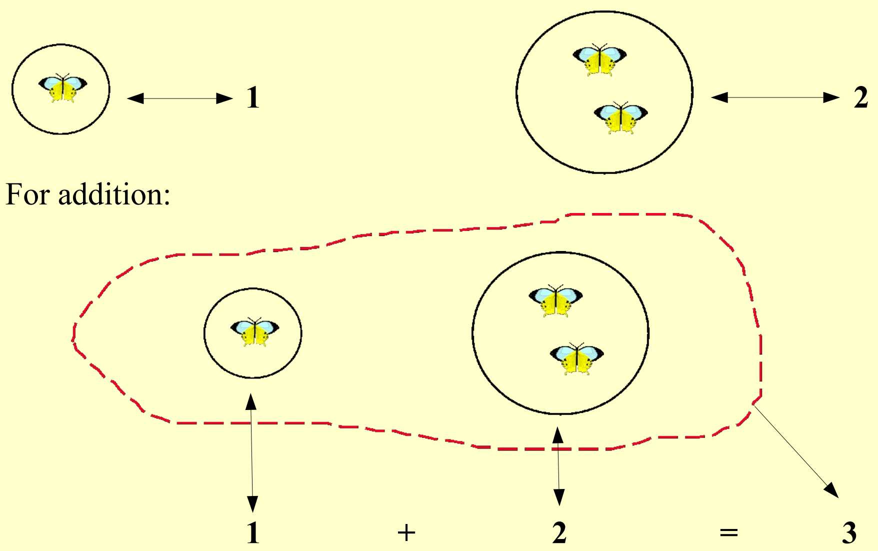
Examples of types of concrete aids:

Concrete	↔	Abstract
- Real object(s) practical demonstrations		symbols / theories / equations / ...
- models / pictures / images	↔	theories
- photographs	↔	simplified drawings

Examples of good and bad concrete aids:

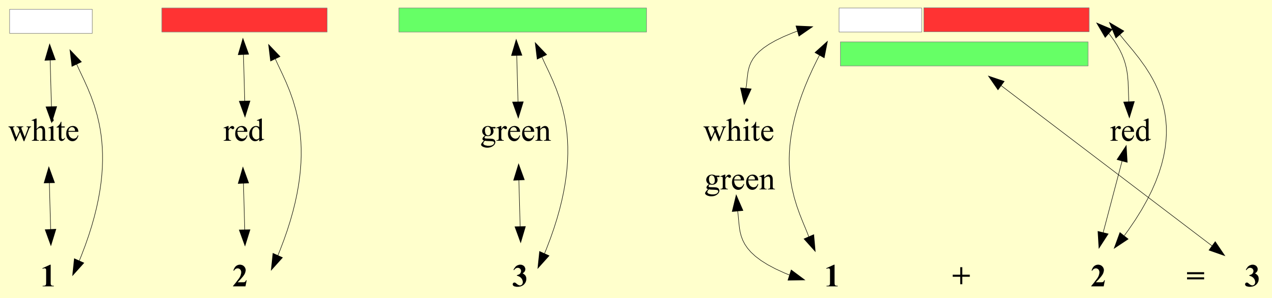
Example 1: **Addition**. Which of the following is better – (a) or (b)? Why?

(a) Using sets

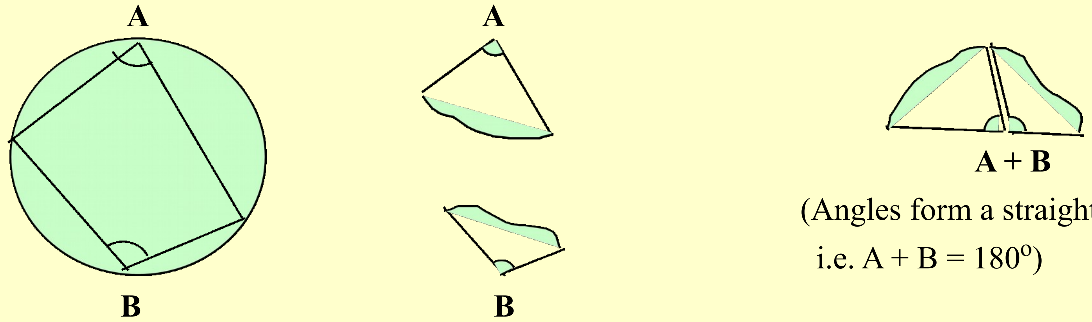


(b) Using Cuisenaire rods

[set of coloured number rods created by the Belgian primary school teacher Georges Cuisenaire (1891-1975)]



Example 2: **Geometry proofs**



(Angles form a straight line, i.e. A + B = 180°)

The formal/abstract proof can then be mapped onto this concrete analogy.

Concrete/real-object aids are well within the experience of people are so are readily understood. Use them to teach students to think about more abstract/symbolic/theoretical relationships. Cf. Michael Faraday, who suggested the concrete idea of "lines" to represent how the force of a magnet acted:

> (Faraday) saw the stresses surrounding magnets and electric currents as curves in space, for which he coined the name "lines of force", and which, in his imagination, were as real as if they consisted of solid matter. He visualised the universe patterned by these lines – or rather by narrow tubes through which all forms of "ray-vibrations" or energy-radiations are propagated. This vision of curved tubes which "rose up before him like things" proved of almost incredible fertility; it gave birth to the dynamo and the electric motor; it led Faraday to discard the ether, and to postulate that light was electromagnetic radiation.
>
> In A. Koestler (1964), *The act of creation*

Exercise:
Identify one concrete analogy for use as a teaching learning aid in your subject. Describe how you would use it, being careful not to overload students' working memories.

Organisation

Like elaboration, organisation is another strategy that helps understanding and memory tremendously. It is useful also for linking ideas in topics/chapters.

Class experiment for memory of word lists:

This experiment was carried out with students in my "Psychology of Learning and Teaching" classes. They were given 30 seconds to study the following list of words before attempting to recall it:

cat book pen tree ship hill paper glass desk ball tape box

This was repeated with a second list of words as follows:

apple shoe car hat lemon train coat shirt orange truck pear bus

The second list of words was easier to recall. The 12 words in the first list are unrelated and must be remembered individually. As working memory can only hold a small number of words, it is soon overloaded and it becomes difficult to keep them in STM. (Look back at limits on WM and STM.) The 12 words in the second group can be organised into three groups – can you see what these are? Thus students have to remember these three categories (which will not overload WM and STM) and then the four words in each. Still demanding, but easier than for the first list.

Experiment on organisation (Bower et.al. 1969)

Subjects studied the following tree and 3 others – 112 words all together. They then attempted to recall the 112 words!!! The experiment was repeated four times. One group was given the diagram below in which the words are logically organised. For second group, the terms in the diagram were all rearranged in a random disorganised way.

MINERALS

- **METALS**
  - **Rare**: platinum, silver, gold
  - **Common**: aluminium, copper, lead, iron
  - **Alloys**: bronze, steel, brass
- **STONES**
  - **Precious**: sapphire, emerald, diamond, ruby
  - **Masonry**: limestone, granite, marble, slate

Results: Average number of words recalled:

Trail	1	2	3	4
Organized	73.0	106.1	112.0	112.0
Random	20.6	38.9	52.8	70.1

What conclusion can you reach about the effectiveness of organisation? After three attempts, the "organised" group could recall all 112 words. Hard to believe! And even on the first attempt, the "organised" group scored higher (73.0) than the "Random" group after four attempts (70.1). So, organisation definitely helps learning and recall.

Reorganisation

Reorganisation enhances the effects of an earlier organisation.

Study on reorganisation (Shimmerlik & Nolan, 1976)

High School students read a long passage describing four primitive societies. Two versions of the text were used:
Version **A**: Each society was presented in turn.
Version **B**: The same content as in version A but organised according to relevant topics, e.g. customs, food, housing.

The study was designed as follows:

Instructions	Version of passage	
	A	**B**
Take notes using organisation in passage	Group 1	Group 2
Reorganise using opposite type organisation	Group 3	Group 4

A test was given after a period of study. Groups 3 and 4 scored much higher. They also scored higher in a delayed test. This shows that while organisation helps memory and recall, reorganising the same material another way enhances this even more.

Advance organisation

This refers to an introduction to the structure of the information to be taught/learnt. It provides a mental framework onto which new information can be added.

Experiment (Glynn & DiVesta, 1977).

Two groups of students read a passage about minerals.

Group **A**: Studied an outline of the classification of minerals before reading the passage. The chart served as an "advance organiser". (The chart was actually the same as that above for minerals.)
Group **B**: Just read the passage.

Students were then given a recall test from the passage.
Group **A** had a better recall of the details suggesting that the advance organiser helped.

A minimum advance organiser for a lesson is just an oral/written statement of the purpose of the lesson. This can help learners to activate relevant background knowledge in their LTM which can be linked to new material in the lesson as it is introduced.

Organisation strategies for teachers and learners

The examples below can serve a variety of purposes:

1 To *begin* a lesson / unit / topic. For example, a teacher might:

- use a skeletal diagram (advance organiser).
- add to this skeletal diagram (i.e. elaborate) at appropriate points as the lesson / unit / topic proceeds.

2 *During* a lesson – building up organisation/network diagrams

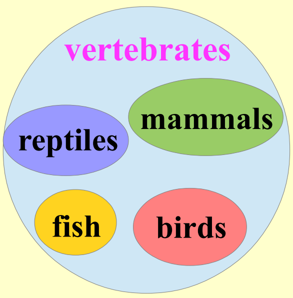
3 As a *summary*. For example:

- Students can make their own organisational chart.
- Students can finish off or be given some (appropriate) organisation task to do, e.g. put information in a table.

4 As *homework*. For example:

- Complete a given organisational diagram. (Organisation)
- A project to prepare their own chart. (Organisation)
- Reorganise material (e.g. from a textbook) using headings / points devised by the teacher or themselves. (Reorganisation)

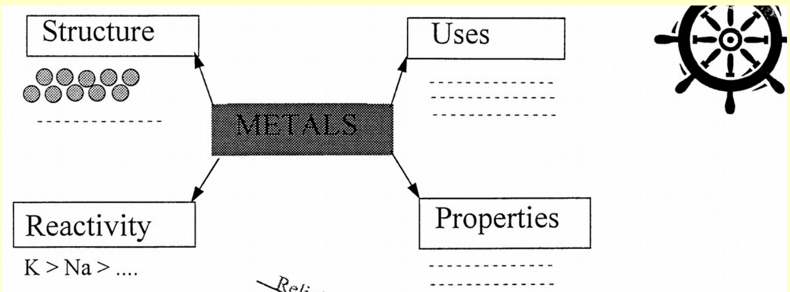
Set diagrams



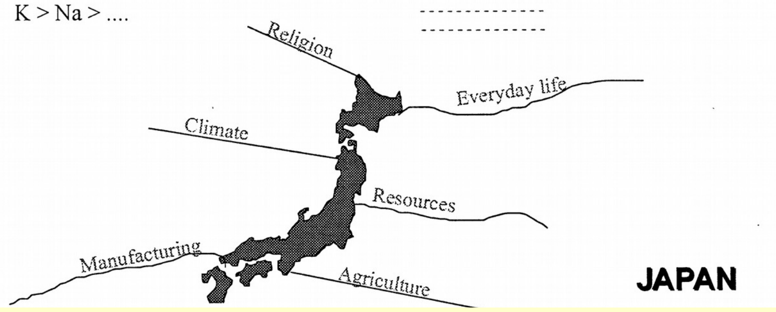
Wheel-and-spoke / network / organisation diagrams concept diagram (choose which name you like)

Two examples:

1. Lesson on "**Metals**" in Chemistry.



2. Lesson on "**Japan**" in Geography.



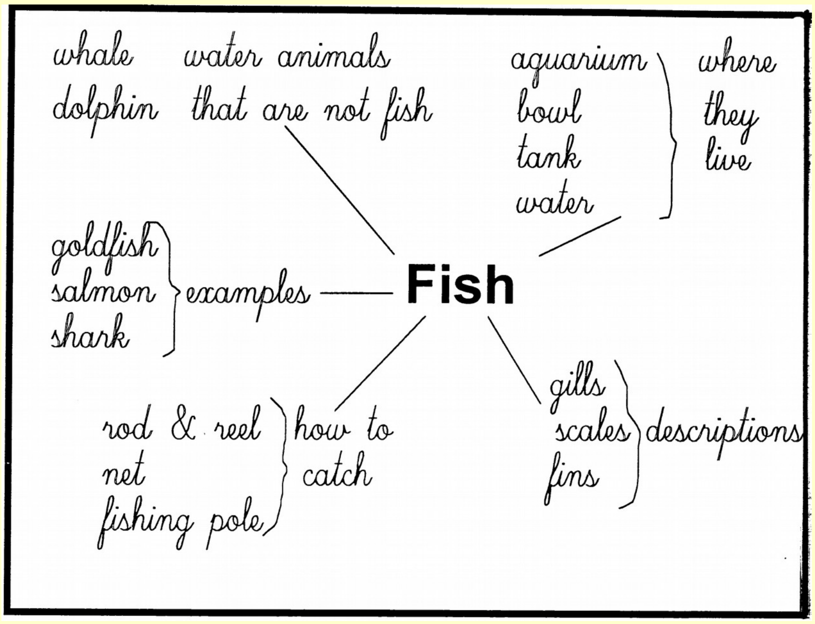
In the example on "Japan", the diagram on Page 50 shows the detailed wheel-and-spoke diagram actually prepared by a student. Instead of conventional homework (e.g. "Go home and learn it!"), the teacher asked the class to prepare a wheel-and-spoke/network/organisation diagram.

3. Diagram for "Fish"

This diagram below was prepared by a primary school class in California, USA. To help the students, the teacher wrote the following words in a column on the left-hand side of the board:

whale salmon shark dolphin goldfish net fins scales gills aquarium bowl water rod

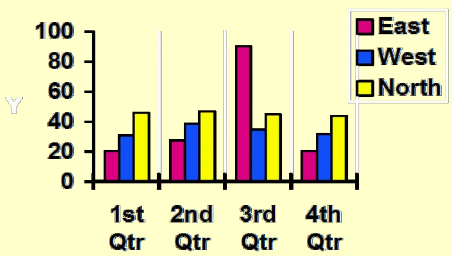
She then wrote the large word "**FISH**" and got the class to suggest categories for these words, e.g. "examples", "where they live", which she wrote on the board and got the class to fill them in as shown. This occupied the whole lesson. (It was a good lesson and the class was very interested; I know, because I was sitting at the back of the room observing!)

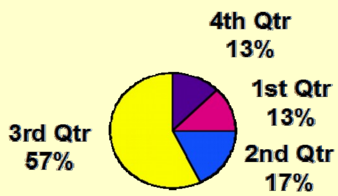


Tables

	Mammals	Birds	Reptiles	
Feathers		√		
Live on land	√	√	√	
….				

Graphs / Bar charts





Others:

Time lines

Flow charts

Classification hierarchies

Tree diagrams (These are the inverse of hierarchies)

Outlining

For example, text passages using major and minor points; alternatively as an array (table).

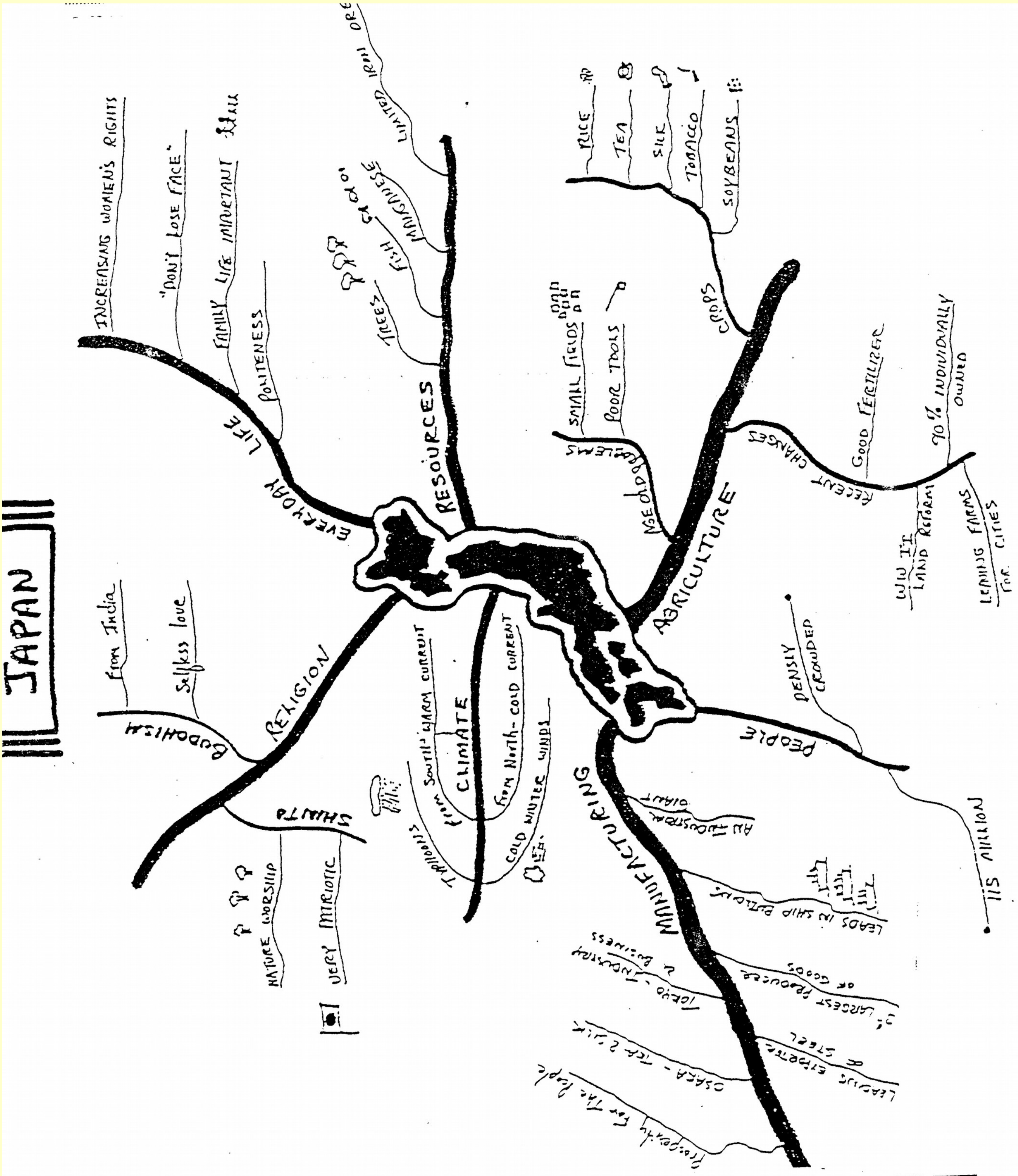
Text structure

- The content of different kinds of texts has definite kinds of structure. For example, stories have: setting, theme, plot, resolution.
- Analysing the structure can lead to better understanding and recall.

Exercise:

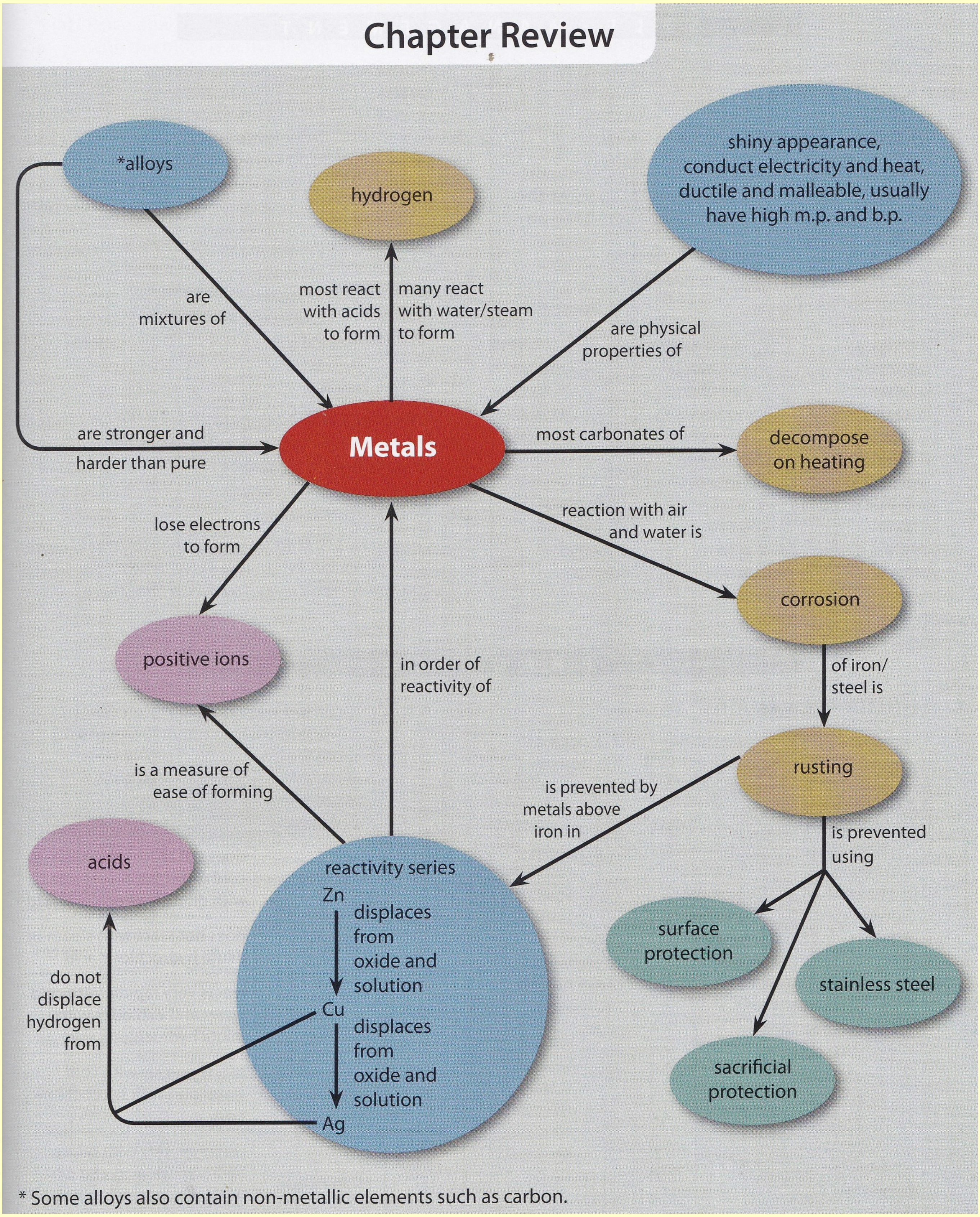
Take a variety of organisation strategies and in your subject, show: (a) how teachers might use them, (b) how students might use them for their own study/learning.

Student network diagram on "Japan":



Network diagram on “Metals”:

On Page 37 of an earlier article “*A Guide to Cognitive and Social Development*”, there is an example of a memory strategy which comes from the end of a chapter in one of the Chemistry books I wrote. Although this diagram is provided for the students, they are also encouraged to create their own. It is a very effective strategy for organising and summarising a large amount of material. Go to this article and have a look at the diagram and related discussion. For convenience, the diagram is repeated below.



3 *Retention of declarative knowledge*

Learning is not always permanent. We forget!

Types of memory and forgetting

→ Sensory memory and STM: a process of (neural) decay / ”evaporation” Information is completely gone!

→ LTM: – memory “loss” not due to decay.
– loss is a failure to retrieve material once it is encoded (cf. “distortion” again.)

Note: We do not forget information that is in working memory; if we did, we would not be able to do anything. Most of the loss if from STM where information is stored temporarily when not being used at that moment by the WM.

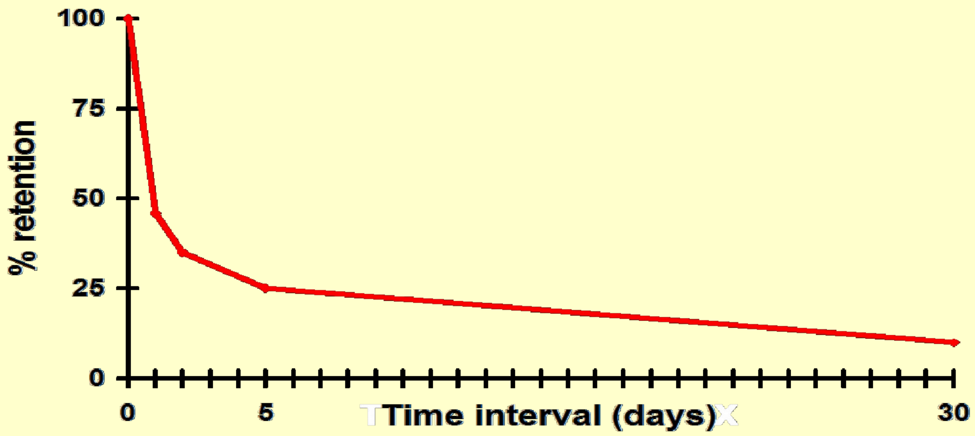
Forgetting function

This is for information lost from LTM.

Experiment by Ebbinghaus (1885).
He used himself as the subject. He learnt a list of nonsense syllables, e.g. SAX, LOC, BUP until he could repeat them twice without error. After a time interval, he tried to recall the list.

He repeated the experiment using different lists at different time intervals.

Here is a graph of his results:

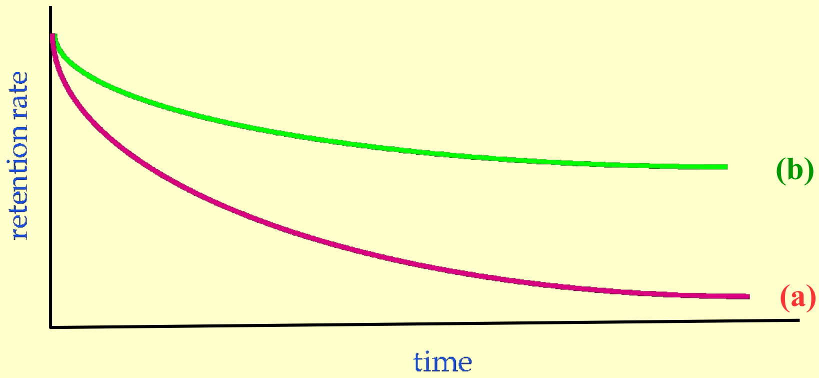


Therefore there is rapid initial forgetting; however, some information remains for long time periods.

This kind of curve is called a “**forgetting function**”.

The forgetting function differs for different kinds of learning:
(a) For meaningless material or rote learning, and
(b) For meaningful material ----> **gist** of material/information stored in LTM.

Refer to the graph below. Meaningless material or things learnt by rote are forgotten very quickly. (This is probably the experience of all of us!) We still forget some meaningful material but less.



Enhancing retention of declarative knowledge already acquired

Teaching/Learning should always be for meaning and understanding and not for rote learning.
To help with this, use the learning strategies described previously.

Alo, use **overlearning**, that is. extra practice/study of material already learnt.

Another **experiment** by Ebbinghaus:
Using a one-day interval only, he learnt lists for twice repetition (as before) but then repeated the lists an additional 30 times (i.e., overlearning). This greatly improved his retention.

Experiments also show that students spend less time than they should relearning or practising material; they tend to assume this as unnecessary if they have done it once. The teacher can help by giving **constructive** repetition/revision/extra practice, rather than merely telling students to go home and learn it! For example: If information is in a table, get students to re-write it in conventional paragraph format. Or, convert the information in a table into a network diagram.

Overlearning for long-term retention can be enhanced by using:
- the **spacing effect**, and
- the **cyclic (spiral) syllabus**.

The importance of spacing

Memory improves with the increase in lag (delay) between study episodes, providing that the lag is not too great. Can you suggest why? This is known as the **spacing effect**. This is a very robust finding, and can also be applied to all kinds of learning, including individual study using a textbook.

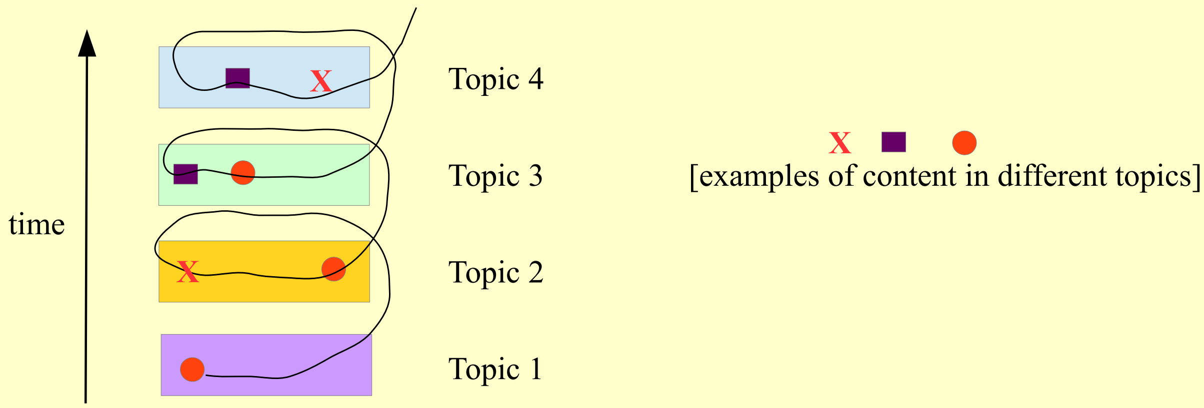
Therefore spread out practice with not too much at once. Vary the context/examples with the new study sessions.

Cyclic (spiral) learning

This has similarities with the idea of spacing. Design a teaching syllabus so that more advanced topics build on the mastery of earlier content. Spacing and overlearning will then take place automatically. For example, multiplication builds on addition, division on subtraction, so there is built-in overlearning/revision of addition and subtraction when doing multiplication.

Introduce a new topic by (briefly) revising the relevant earlier content and building on it. In this way (parts of) a syllabus will be covered several times before examinations.

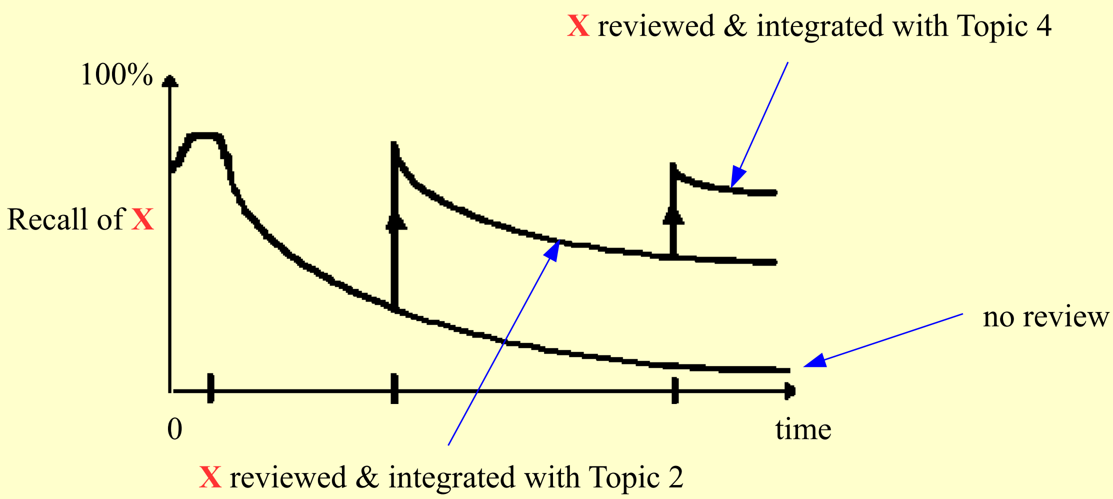
Important note: Although teaching using a cyclic approach takes more time, the learning is much more efficient and less time is needed for revision later. For too many teachers, examination "revision" turns out to be "re-teaching" rather than revision, as the material was not taught/learnt properly the first time. With the cyclic approach, any problems with earlier work can be detected and corrected when the next related topic is to be taught. Examination revision then becomes mainly that – revision (which means *looking again*, re- = *again*, vision = *looking/sight*) – as the content has already been learnt and understood earlier.



With the cyclic approach, the same content is covered several times at spaced intervals.

Because the topics are not the same, the context varies, and so the content is not just repeated but is linked to new information. This ensures a high degree of elaboration of concepts.

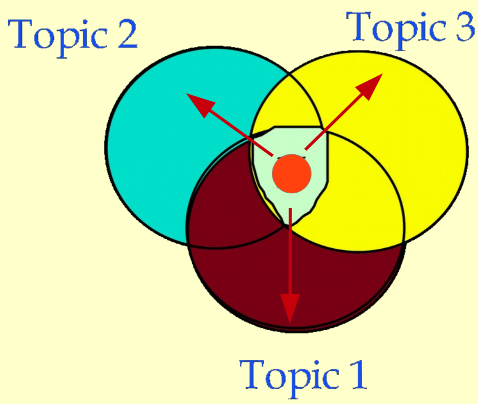
The graphs below show how content of X (for example) can be remembered/recalled over time with no review and with built-in review of X in later topics.



Note the slight increase in recall just after time zero, that is, when the learning session has ended. For about 10 minutes or so after the end of a learning session, recall seems to actually *improve*; perhaps it takes some time for the information to be stored effectively in LTM and is thus available for recall. But after that, with no review/revision of X (which is what seems to happen with many students), the amount of information retained in LTM decreases rapidly until after some time (varies according to how meaningful/difficult the material is), almost all of X has been forgotten. With the cyclic approach, the quick revision of X during Topic 2 brings all the learning back again and the loss over time is now much less. And, after a second revision, during Topic 4, very little of X is lost over time.

Usefulness of cyclic approach for examinations

In regular tests, say every week, the test questions are only on the content from the previous few lessons. But in an end-of-term or end-of-year examination, questions can be set that require content from the whole term or the whole year. This is where the cyclic approach is very helpful. In the diagram below, a question in an end-of-year examination might involve content Topics 1, 2 and 3, all of which include ● . If ● was only taught in Topic 1 and never again, a student would have difficulty answering the examination as ● is linked to ideas in Topics 2 and 3, which are required to answer the question effectively. (In a test of just Topic 1 say, this integration is not needed and so a class test on just Topic 1 does not require this integration. That is why students can do well on regular class tests but poorly in examinations, and especially in public examinations.)



Concept ● linked/integrated to ideas in all three topics

Teaching in a cyclic way way takes more time than conventional teaching does – but is far more effective. Less time is needed for formal revision (as revision is built in during the course throughout the year).

Exercise:
Write out the key ideas for <u>one topic or unit</u> in your syllabus.
Now look for the same ideas in later topics/units.
Suggest how you would integrate the earlier ideas when you come to teach one (or more) later topics or units.

Websites
Learning strategies:
The following two websites appeared in the article "*A Guide to Cognitive and Social Development*" (page 37). If you have not looked at this article, you may like to do so.

1. Learning strategies in Chemistry:
   https://drive.google.com/file/d/0B-VrJkhrRpl8UW1PdzJrLVFudms/view?pli=1
2. Some strategies for learning, understanding and remembering:
   https://drive.google.com/file/d/0B-VrJkhrRpl8STg5ZXNrSnl1bFU/view?pli=1

MOTIVATIONAL PROCESSES

Possible definitions of motivation

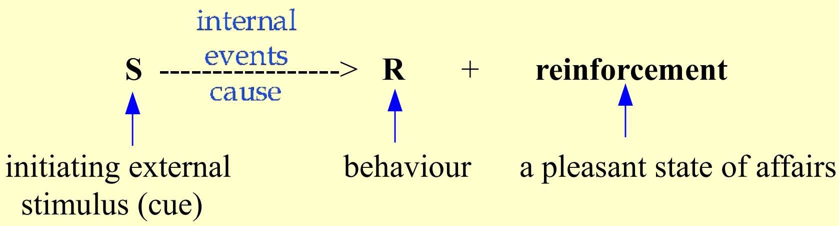
Motivation is that which gives direction and intensity/drive to behaviour.
An internal state of an organism that impels or drives it to action.

Learning theories explain the how and what of behaviour. Motivational theories explain the why, the causes of behaviour.

There are behaviourist and cognitive theories of motivation, though a lot of overlap.

Behaviourist view

Remember – organisms respond in ways reinforced in the past.

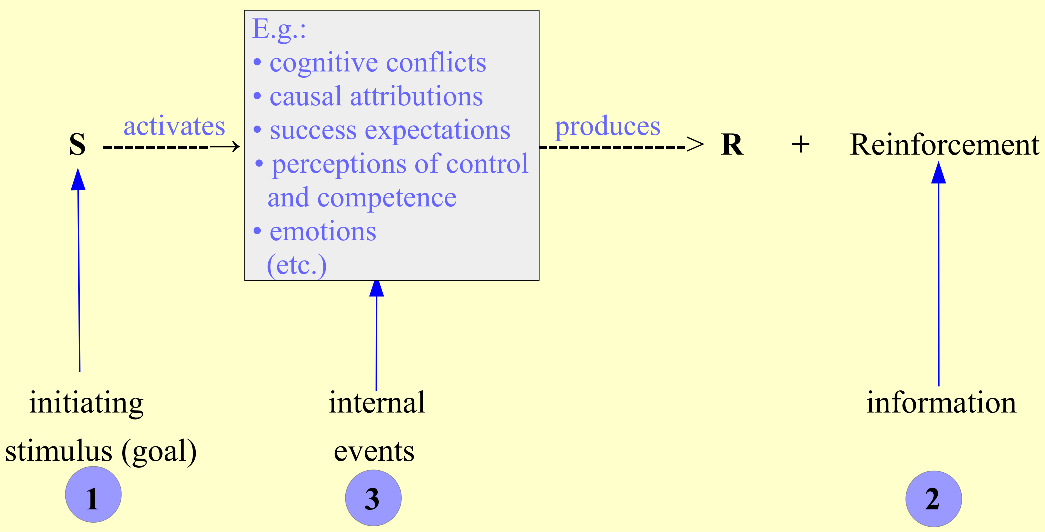


This explanation is often more successful in accounting for out-of-school behaviour (rather than school learning) by success, satisfaction, etc.

It often fails in the classroom situations, for example, two similar students learning a difficult topic – one persists, the other gives up. A pure **S** $\rightarrow$ **R** approach cannot explain why. To provide an adequate explanation, we need to know more about what is happening in their minds, that is, we need a cognitive view.

Cognitive view

This approach believes that thoughts, emotions influence the direction and intensity of observed behaviour.



1 Goals and achievement

Goals may be **external** (e.g., "Do problems 1 – 6 for homework."), or **internal** (e.g., "I'd like to know more about motivation!")

Goals give direction for achievement.

- Teachers need to know precisely what goals students are to attain. Therefore, write lesson objectives on in your lesson plans.
- Give students goals in the form of task descriptors, outlines, advance organisers, especially at the start of the lesson. (Don't give your lesson plan objectives, which tend to be written in a more formal, technical way.)
- Goals should be specific, for example, "The physical properties of metals" rather than just "Metals".
- Goals should offer a challenge.

Setting specific goals will lead to higher levels of **effort** and **achievement**.

Kinds of goals

- **Individual goals:** Independent of other students (cf. programmed learning / individualised instruction).
- **Cooperative**: Goals of individuals are linked – individual rewards are proportional to the quality of group work; the individual achieves goals only if the group does.
- **Competitive**: The individual gets a maximum reward at the expense of those who cannot (fully) attain the goals

Kinds of achievers

- ***High-need achievers***: Such students prefer/choose goals having a moderate risk of failure. The goals involve a challenge. On success, feel good; on failure, feel bad.
- ***Low-need achievers***: Such students prefer/choose very easy goals (to avoid failure) or very difficult tasks (if fail/pass, they can say they were too difficult/easy; no control, no negative emotion).

How difficult should goals be?

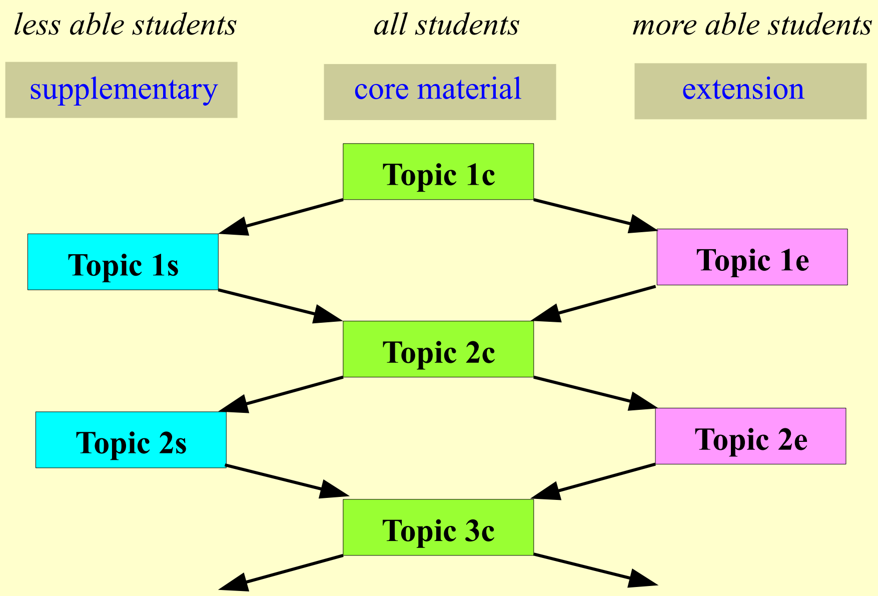
Goals should not be too difficult or too easy or difficult as these are not motivating. Goals should offer a **challenge**, meaning that it is just difficult enough to motivate a person to try. Compare the "high jump" on sports day! If the bar is set too high, no-one will attempt it as they can see that it is too difficult and so impossible. If set too low, it is too easy and rather ridiculous. Again, no-one will try. But if the bar if set at a height that offers a challenge, people will attempt it. There is a risk of failure but people are motivated to try. For tall and short people, the bar will not be set at the same height, as what might be a challenge for a tall person would be impossible for a short person. Note: Almost never would the bar be set differently for each individual; normally students are put into several groups (or age/height levels, with most in each group being of similar height). The same is true for the setting of learning goals.

Goals and mixed ability classes

Many classrooms have students with a range of ability from less able students to those of high ability, with most of the class probably being in the middle. The temptation is for teachers to “teach to the middle”, ignoring the needs of the less able and more able students. Different students need intellectual goals at different levels while still providing a challenge, just as the bar for the high jump would be set at different heights for tall or short competitors.

There should be more emphasis on **cooperative/individual goals** rather than competitive goals (cf. target-oriented-curriculum) and worksheet use.

A (tested, but demanding on the teacher for implementation) model for teaching mixed ability classes is:



Topic 1c is taught to the whole class. The class is then split into the “less able” and the “more able” students, with each given different work/activities. As this is happening at the same time in the classroom, the two groups of students would probably need to work from worksheets, with the teacher moving round the class offering help to individual students. The class them comes together again for Topic 2c, etc..

Variations of the above mode are possible. For example, instead of splitting the class into two groups, three groups could be used – though that means much more preparatory work on the part of the teacher!

2 Reinforcement and achievement

Feedback (= reinforcement)

Behaviourism – reinforcer works because it provides pleasant feelings.
Example: **Praise** is a reinforcer because it makes people “feel good”.
Therefore **avoid** critical feedback.

Cognitive psychology – reinforcer works because it provides **information** about desirable consequences.
This is believed to be more important than pleasure!

- Teachers should provide specific, informative, critical feedback.
- Rewards and punishment (if used) should inform rather than control behaviour. (Informative punishment increases perceptions of control – see later).

- Use praise carefully and informatively – see sheet below, which is included in the students' booklets.

Teacher praise

Most learning theories would predict that praise (social/verbal "reinforcement" or expressions of approval, admiration, etc.) would enhance student motivation and performance. But the research clearly shows that in *general*, there is little or no relationship between teachers' use of praise and students' performance. Why is this?

1. Most people like praise but it is not used enough in the classroom.
2. Praise is often the wrong kind of reinforcer. (E.g., "Keep the praise just give me a raise.")
3. Praise is an extrinsic reward and may be irrelevant or even reduce motivation to a person who is intrinsically motivated.
4. Praise can lose its impact is overused. (Cf. partial reinforcement again.)
5. Praise is often given inappropriately to high ability students, e.g., praising effort for good examination results which are due to ability alone.
6. Not finding things to praise in less able students, E.g., an improvement from Grade 'F' to 'E' is worthy of praise.
7. Praise is often given without thinking to praise-seeking students. Therefore it is being used in a way not intended by the teacher.
8. Praise is often not informative and is often given in global, general terms not clearly linked to what a student actually did, e.g., just putting "Good" at the bottom of an essay. Be specific!
9. Praise from teachers can have less impact on students if they are strongly peer-oriented.

Praise isn't used very often or very effectively. However, it isn't necessarily desirable to use it too much as it is an extrinsic reward. However, praise *can* be effective if it is used informatively and selectively and contingent on good performance.

3 **Internal events and motivation** (remaining notes)

Intrinsic and extrinsic motivation

Intrinsic: Motivation comes from *within* a person, for example, interest, useful, satisfying.
Extrinsic: Motivation comes from *outside* a person, for example, words of approval, marks, money!

Locus of control (Rotter, 1954)

This is a theory that describes people in terms of their tendency to ascribe success or failure to intrinsic/internal or extrinsic/external causes. [locus = *place*]
It characterises learners as "**internals**" and "**externals**" (see table below).

Locus of control emphasises the need to give students/learners a higher perception that they are in control of what is happening. **Examples**: Using student ideas for projects and in discussions, and to get (groups of) students to create presentations.

Internals ◄──►	**Externals**
Take personal responsibility for learning	Do not take personal responsibility for learning
Blame *themselves* for failure	Blame *external* causes for failure
High perception of control, i.e. able to sense that they can control/change the environment (the things around them)	Perception of being powerless, helpless, cannot control events (cannot do things for themselves)
High perception of competence (i.e. can achieve their own goals) and self-worth	Low perception of competence and self-worth

Note: The table shows extremes for internals and externals. Most people will show characteristics of each at different times and in different tasks.

Examples of how students (or anybody!) can put the blame on external causes for failure:
- "Noisy so I could not concentrate."
- "I had other work to do."
- "The syllabus is too difficult."

Exercise:
Give more examples of
(a) how teachers can increase student perception of control, and
(b) how students might blame external causes for failure.

Causal attributions of success and failure

Attributions: These are the explanations people give for why they and others achieved success or failure.

Success or failure is attributed to any of four causes (Weiner, 1979):

Internal	*External*
Ability (intelligence, skill, or lack thereof)	**Difficulty** (task easy or difficult)
Effort (hard work, self-discipline, laziness, distraction, lack of time)	**Luck** (good or bad)

Of the four factors, only **effort** is controllable.

People 11 years or older can make these four attributions.
Children under 9 cannot distinguish ability and effort.

Attributions determine:

1. people's feelings about themselves (over success and failure).
2. people's predictions of future success.
3. whether people will or will not make a greater effort at future tasks.

Examples:

1. Attribution of failure to **ability** (worst possible case):
   low ability (not controllable) → feel incompetent → predict future failure → less effort → give up!
2. Attribution of failure to **effort**:
   lack of effort (controllable) → guilt/shame → predict future success → make a greater effort.

Therefore, **effort** is the most desirable attribute for students to use as it is controllable. Teachers must encourage students to make an effort. That is why the world is full of people who are not all Newtons or Einsteins, but through the application of effort have achieved success.

Exercise:
What would happen for (i) prediction of future success, (b) effort exerted for:
(a) attribution of present success to (high) ability?
(b) attribution of present failure to bad luck?

Teacher behaviour and attributions

Teacher behaviour affects student attributions.
Bad example: Teacher asks challenging questions to high-ability students but very easy questions to less-able students. If students (high or low ability) perceive differential treatment because of *ability*, they may fix on ability attributes which they cannot control and so might give up (especially less-able students).

Good example: Teacher with a mixed-ability class gets students to work in mixed-ability groups when setting tasks or questions to answer and encourages all students to contribute and for the group to accept all comments and not to dismiss them as "stupid". Although the less academically able may not speak as much, they can still feel they are making an effort, feel more in control and can share the group success. (Note: If all so-called "stupid" comments were dismissed, many great discoveries would never have been made!)

Children can also distinguish between **pity** and **anger**.
- Teacher pity (especially for less-able children) can lead to attribution of low ability and so students believe they cannot control the outcome and become poorly motivated to even try.
- Teacher anger can be perceived by a student that he is able to control an outcome but didn't make an effort.

Classroom goals and attributions

- **Competitive** goals lead to **ability** attributions.
- **Individual** and **cooperative** goals lead to **effort** attributions (see "Good example" above again).

Hence, teachers need to avoid situations that involve competition, for example, praising (high ability) students who did well on a test/exam while deriding (low ability) students who did poorly (but may not have done well but may have scored much better than expected). Look again at the notes on "Teacher praise", especially points 5 and 6.

Achievement motivation and attribution

People can often be classified as **low-need achievers** or **high-need achievers**. (See above again under "(1) Goals and achievement".)

Low-need achievers:

– behave as if they are more afraid of failing than being desirous of success.
– choose tasks/goals that are either very easy or very difficult.
These are explained by attribution theory:

(a) For a very easy task: If successful, a student may attribute success to questions being too easy, which is the reason he could answer them. He thus perceives himself as having no control in getting the answers correct and so will have no positive affect of his attitude to learning.

(b) For a very difficult task: If failure occurs, this is attributed to the task being too difficult. Again, the learner senses no control and so again is not to blame. He takes no responsibility – "There is nothing I can do about it! It was too difficult."

*Therefore low-need achievers are **externals**.*

High-need achievers:

– choose tasks of **moderate** risk, i.e. not impossibly difficulty or ridiculously easy.
According to attribution theory:
(a) Success is because of skill/effort (which is good for motivation).
(b) Failure is due to personal factors for which responsibility can be taken, e.g. "I was a bit lazy!"

*Therefore high-need achievers are **internals**.*

Some educational implications

Overall: Teachers should change students from:

externals ---------> internals

SUCCESS is a key word in motivation. Success is the great motivator. If people get success, they will do anything (no matter how daft or irrelevant it might be!!).

Repeated **success** leads to:	Repeated **failure** leads to:
• Positive self worth • Perceived competence • Possible attribution of success (or failure) to effort • Personal responsibility for outcome	• Negative self worth • Perceived incompetence • Attribution of failure to external factors (and perhaps to low ability) • No personal responsibility for outcome

[I always ended my courses, by saying to my classes that even if they forget everything I have taught them, ensure that their students get **success**.]

Appendices

Aims of the course

1. To provide some key skills needed for use in your teaching and learning.
2. To provide a theoretical background for learning and teaching which can be used to increase the effectiveness of your instruction.
3. To supply background knowledge in order for you to reflect on the nature of learning so that over time, improvements may be made in the teaching of your students.

Aims 1 and 2 should be achieved in the present course. Aim 3 is a long-term aim, intended to provide material that can be used not only during the course but in subsequent years.

General approach to course work

1. Individual study: Before each class session, you are expected to have looked over the notes and to have attempted any exercises.
2. Class sessions: These will include lectures, some experiments and discussions.
3. Test and project: A multiple-choice in-class test and a project are included (see below). On the completion of each lesson you should give thought as to how ideas introduced in that lesson can help in your project. Each lesson will contribute something and you are strongly advised to begin work well before the deadline.

Course outline

1. Psychology

- Defining psychology
- A brief history of the subject
- Paradigms in psychology: behaviourist (behavioural) and cognitive

2. Educational psychology

- The key role of understanding in learning; Levels of learning
- The traditional (behavioural) approach to learning and teaching
  - Conditioning and reinforcement in learning
  - Limitations to the behavioural paradigm
- The cognitive approach to learning and teaching
  - A information-processing model of human memory
  - STM and its limitations
  - WM and processing loads
  - Chunks and chunking
- Two basic processes – selective attention and perception

3. Acquisition of knowledge

- Definitions of learning.
- Types and levels of knowledge.

4. Acquisition of explicit declarative knowledge

- Acquisition of concepts
  - Generalisation and discrimination
  - Misconceptions in learning; correcting misconceptions
- Strategies for acquiring understanding declarative knowledge
  - Elaboration, and introduction to schemata
  - Elaborative strategies for teaching and learning
  - Organisation, reorganisation and advance organisers
- Retention of acquired knowledge
  - Memory and forgetting
  - Enhancing retention including overlearning, spacing and cyclic learning

5. Motivational processes

- The nature of motivation
  - Meanings of motivation
  - Behaviourist and cognitive views
  - Basic components of the process
- Goals and achievement
  - Kinds of goals
  - Goals for students in mixed ability classes
- Reinforcement and achievement
  - Behaviourist and cognitive views
  - Rewards and information; the use of praise
- Internal events and motivation
  - Intrinsic and extrinsic motivation
  - Locus of control
  - Causal attributions of success and failure
  - Achievement motivation and attribution
- Some educational implications

Course assignment

In order to assess students on the course material, a project entitled "*The application of psychological ideas to learning and teaching*" was set as described below.

- For this project, work in groups of two or three with others from the same subject discipline.
- Choose 10 ideas introduced in this course. Select a variety rather than many that are closely related. Take each idea in turn, discuss its meaning and show how the idea can be applied to the teaching of any part of your subject.

  Then discuss how the 10 ideas can be applied in the teaching of one (or two) specific lessons. Some form of lesson plan(s) should be included to show where the ideas are used.

  Notes:

  1. The emphasis is on the application of psychological ideas to education; projects that do not do this will receive little credit (e.g. projects that concentrate on subject matter rather than psychology.)
  2. More credit will be given for a well-integrated discussion of the ideas rather than a discussion of each idea separately, i.e. how ideas overlap and relate to each other.
  3. The project should be organised/structured in a manner that facilitates reading and comprehension. For example, you might like to use some of the organisation strategies taught in the course.
- The project can be typed or neatly handwritten.
- Length of project: About 12 pages (excluding any appendices you may wish to include).
- The method of assessment is as follows:

Assessment point	Marks		
1 (a) The variety of the psychological ideas selected, and the appropriateness of these to the subject matter. (b) The organisation and integration of the ideas	1	2	3
2 Your understanding of the ideas and their general application to the teaching of your subject.	1	2	3
3 The application of the ideas to the specific lesson(s)	1	2	3
4 Possible bonus for special quality (not quantity).	-	½	1

Marks: 3 = good, 2 = satisfactory, 1 = weak.   Maximum possible mark = 10

All members of the same group get the same mark for the project.

- **Warning**: *Do not copy or use any material from another student, a book or an article as if it were your own. This is plagiarism which is a serious offence and penalties are in place for anyone caught committing it. Note however that excerpts from other work may be used if proper reference or acknowledgement is included.*

Reading list

There are no set books for the course. The booklet should provide most of the material you need. However, a brief list of library books and articles is provided in case you wish to do further reading.

Books

Anderson, J.R. (1980 or 1990). *Cognitive psychology and its educational implications*. San Francisco, CA: Freeman & Co.

Gagne, E.D. (1985). *The cognitive psychology of school learning*. Boston, Mass.: Little, Brown.

Klatzky, R.L. (1980). *Human memory: Structures and processes.* San Francisco: W.H. Freeman.

Halford, G.S. (1993). *Children's understanding: The development of mental models*. Hillsdale, N.J.: LEA.

LeFrancois, G.R. (1988). *Psychology for teaching*. Belmont, CA: Wadsworth.

Lindgren, H.C. and Suter, W.N. (1985). *Educational psychology in the classroom*. 7th Edition. Brooks/Cole.

Mayer, R.E. (1987). *Educational psychology: A cognitive approach.* Boston, Mass.: Little, Brown.

Slavin, R.E. (1991). *Educational psychology: Theory into practice.* Boston, Mass.: Allyn & Bacon.

Wittrock, M.C. (1986). *Handbook of research on teaching*. Washington, DC: American Educational Research Association.

Woolfolk, A.E. (1993). *Educational psychology.* Boston, Mass.: Allyn & Brown.

Articles

Allport, D.A. (1980). Attention and performance. In G. Claxton (Ed.), *Cognitive psychology*, 112-153. London: Routledge and Keegan Paul.

Bower, G.H., Clarke, M.C., Lesgold, A.M., and Winzenz, D. (1969). Hierarchical retrieval schemes in recall of categorical word lists. *Journal of Verbal Learning and Verbal Behaviour*, 8, 323-343.

Dansereau, D.F. (1985). Learning strategy research. In J. Segal, S. Chipman, and R. Glaser (Eds.), *Thinking and learning skills, Vol. 1: Relating instruction in research.* Hillsdale, N.J.: Erlbaum.

Derry, S.J. (1990). Learning strategies for acquiring useful knowledge. In B.F. Jones and L. Idol (Eds.), *Dimensions of thinking and cognitive instruction*, 347-379, NCREL/Erlbaum.

Glynn, S.M. and DiVesta, F.J. (1982). Outline and hierarchical organization as aids for study and retrieval. *Journal of Educational Psychology*, 69, 89-95.

Halpern, D.F. et.al. (1990). Analogies as an aid to understanding and memory. *Journal of Educational Psychology*, 82(2), 298-305.

Hyde, T.S., and Jenkins, J.J. (1973). Recall for words as a function of semantic, graphic and syntatic orienting tasks. *Journal of Verbal Learning and Verbal Behaviour*, 122, 471-480.

Johnsey, A. et.al. (1992). Using elaboration strategies training in computer-based instruction to promote generative learning. *Contemporary Educational Psychology*, 17, 125-135.

Miller, G.A. (1956). The magic number of seven, plus or minus two: Some limits on our capacity to process information. *Psychological Review*, 63, 81-97.

McCloskey, M. (1983). Naive theories of motion. In A.L. Stevens and D. Gentner (Eds.) *Mental models*, Hillsdale, N.J.: LEA.

Peterson, L.R. and Peterson, M. (1959). Short-term retention of individual items. *Journal of Experimental*

Psychology, 58, 193-198.

Pressley, M. et.al. (1989). Good information processing: What it is and how education can promote it. *International Journal of Educational Research*, 13, 857-867.

Pressley, M. et.al. (1992). Encouraging mindful use of prior knowledge: Attempting to construct explanatory answers facilitates learning. *Educational Psychologist*, 27(1), 91-109.

Reder, L.M. (1980). The role of elaboration in the comprehension and retention of prose: A critical review. *Review of Educational Research,* 50, 5-53.

Rundus, D. (1971). Analysis of rehearsal processes. *Journal of Experimental Psychology*, 89, 63-77.

Shimmerlink, S.N., and Nolan, J.D. (1976). Reorganization and recall of prose. *Journal of Educational Psychology*, 68, 779-786.

Shulman, L.S. (1986). Paradigms and research programs in the study of teaching. In M.C. Wittrock (Ed.) *Handbook of research on teaching*, 3-36. Washington, DC: American Educational Research Association.

Thomas, J.W. and Rohwer, W.D. (1986). Academic studying: The role of learning strategies. *Educational Psychologist*, 21(1 & 2), 19-41.

Thorndike, P.W. (1977). Cognitive structures in comprehension and memory of narrative discourse, *Cognitive Psychology,* 9, 77-100.

Vosniadou, S. and Schommer, M. (1988). Explanatory analogies can help children acquire information from expository text. *Journal of Educational Psychology*, 80(4), 524-536.

Weinstein, C.E. (1982). Training students to use elaboration learning strategies. *Contemporary Educational Psychology,* 7, 301-311.

Weinstein. C.F., and Meyer, R.F. (1986). The teaching of learning strategies. In M.C. Wittrock (Ed.), *Handbook of research on teaching*, 315-327. Washington, DC: American Educational Research Association.

Wittrock, M.C. (1974). Learning as a generative process. *Educational Psychologist,* 11, 87-95

Wittrock, M.C. (1986). Students' thought processes. In M.C. Wittrock (Ed.), *Handbook of research on teaching*, 297-314. Washington, DC: American Educational Research Association.