Draft:

Concepts in Innovation and Change

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Chapter 4: Knowledge and Learning – Part A – *Static Learning*

Summary
This chapter describes in some detail the connections between knowledge and learning. A brief description of the micro/neuronal processes and changes that occur during learning is described, as these processes can be readily mapped into our macro/systems description of learning. A systems model is then used to depict the various ways that 'learners' and 'knowers' interact. While procedural knowledge can be explicit or tacit, teaching and learning can be either 'conscious' or 'sub-conscious', or a mixture of both. While the initial descriptions only deal with 'how' learning occurs in an individual, the final example in the chapter illustrates how these ideas apply at an organisational level. We call this 'how' *static learning* – as compared with 'how much', or *dynamic learning* – which will be dealt with in the following chapter. The connections to innovation and change are made throughout the chapter.

Introduction
So far, we have looked at the system-of-interest as a *container of knowledge* that is:

- an *explicit* system, with fully-described elements and relationships; or
- a *tacit* system, which is not described – or describable in whole or in part; or
- a system that may contain both explicit and tacit elements and relationships.

In each case, the system's contents and structure *give it the capacity to act* – it is a *knowledgeable* system. However, as this book is about *innovation – the process of transforming systems*, we need to go beyond the *static* picture of what the system *contains*, to examine *how* the system acquires the knowledge embodied in its elements and their relationships- ie *how* it *learns*. In the next chapter we will look at *how much* and *how fast* the system learns.

Learning – a basic definition
Learning is usually thought of as an activity of all sentient (living) systems – as though the person, dog or amoeba has a 'will' to acquire the capacity to act – the *self-induced* act of survival or reproduction. For our purposes, we will widen the concept of learning to be:

- **Definition: *Learning is the acquisition of knowledge by a system – ie the acquisition by the system of the capacity to declare or to act*.**

The words *acquisition of knowledge* may be understood to be *a change in the elements or relationships in a system that enables it to act or fulfil its purpose*. Normally, *acquisition* connotes 'adding to', but in our case, the *acquisition of knowledge* may, in fact, mean that there are *less* elements and relationships than previously – just that the elements that are left will better enable it to act as intended. Further, for our purposes, acquisition may be *wilful*, ie instigated by the system (usually a person or organisation), or applied by an external system without the need for the system to have its own will. A simple example of the latter case is the manufacture by a person, of an inanimate object, such as a hammer or a computer or a pencil.

Establishing the basic 'learning system'

We have also taken an *evaluative* view of the system: the knower has had to justify his or her knowledge to us as though we were judges observing some performance – ie, we are interested in – but not interactive with – the knower. The outcome of this passive setting is that *we* will *know-that* the purported knower knows something (or not). There is also a tacit assumption that we are in a position to evaluate the knower's performance – like a quiz-master or ice-skating judge or a quality assurance inspector, where *we* already know the particular knowledge and are testing the claims of the knower – *they are justifying that their belief in their abilities is true*.

Although this is a useful starting point, most demonstrations of knowing take place in a more interactive setting – the observer of the knower *really* wants to know what the knower knows, or even more basically, the knower is actually generating new knowledge – *ie innovating*. In these cases, the observer/judge/inspector is not passive, but is also an active learner. We will see that the learner may also be the knower, or another party. We will also find that the learning can occur in a number of different ways.

Knowers and Learners

Plato's definition of knowledge as 'justified true belief' implies that knowledge is *not* a private thing – it is something that is *justified*, or displayed to someone else other than the knower. We will call that 'someone else' the 'learner'. And as the learner learns, they gain knowledge and also become a 'knowledge system'.

The basic situation of knowing and learning can be readily mapped into a simple system, as in *Fig 4.1*. The main system is comprised of the following elements:

1. A ***Knower***- this is the person who claims to know something. In *Fig 3.3* this is depicted by the interaction where the Knower proclaims to the Learner that they believe 'A ® B'- eg 'I (A) can (know how to) chop (®) wood (B)'.

2. A ***Learner***- the person(s) who ask(s) the Knower or observes the Knower's claims and demonstrations of his knowledge.

3. The **relationship** between the Knower and the Learner. This

relationship communicates the question or assertion. This may be direct, ie *verbal* or *visual*, or *indirect* by the knower recording what he knows.

4. The **relationship** between the Learner and the observation of a demonstration or justification of the knowledge- ie between the learner and the relationship between the Knower and the knowledge. This relationship is the *justifying* his belief.

5. The **Learner learning** a) that the Knower's belief is justified by observing the Knower's actions and b) how to do the particular action that is the basis of the knowledge. The learning can be *conscious analysis* or *sub-conscious absorption* of the knowledge (see *tacit learning* below).

We shall examine this diagram in detail as we proceed.

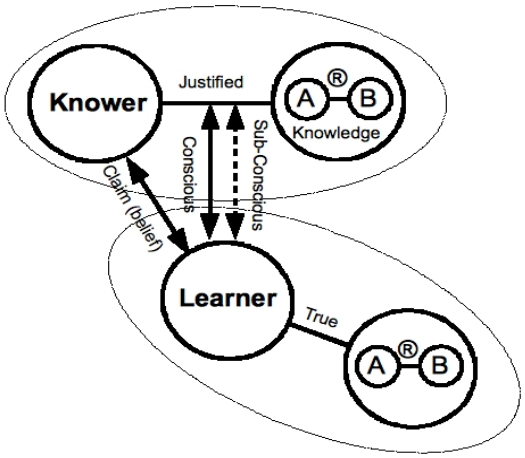


Fig 4.1: **The basic Knower-Learner system:** The Knower justifies his belief that he knows A®B, while the Learner observes him (consciously and/or sub-consciously) and verifies that the Knower's belief is true.

We can now better envisage a learning situation, which comprises the learning-system connected to its environment – ie it has a *relationship,* or a number of relationships, with its super-system. (See *Fig. 4.2*). When we think of learning, we usually think of these relationships as *communication*- ie a two-way interaction. In the case of wilful systems, we think of the person, dog or amoeba having an 'experience' whereby it receives and sends signals to its environment – *eg*, a teacher and student establish a dialogue; the dog receives a reward for particular behaviour and eventually learns to beg for food or do tricks; the amoeba learnsto avoid certain chemicals in the petri dish *etc*. In the case of a person interacting with an inanimate system – artefacts – we generally think of the interaction as one-way- *eg*, we apply sub-systems and relationships between those sub-systems to a computer chassis to build up a functioning computer; a research

physicist looks at the effects of different magnetics fields applied to a new alloy. Even in the case of inanimate systems, we can think of the system as communicating with its maker – at least *visually*, and perhaps with the other senses – tactile, olfactory or auditory. In all of these cases, the comm unication is an *interaction* – with *action* and *reaction*. As in physics, all elements in a system's interaction are changed by the event – so in this analysis, we really cannot think of a teacher-innovator-super-system that only *imparts* knowledge without itself learning, and, conversely, we cannot think of a student-innovation-system that only *acquires* knowledge (learns) without imparting knowledge to its maker.

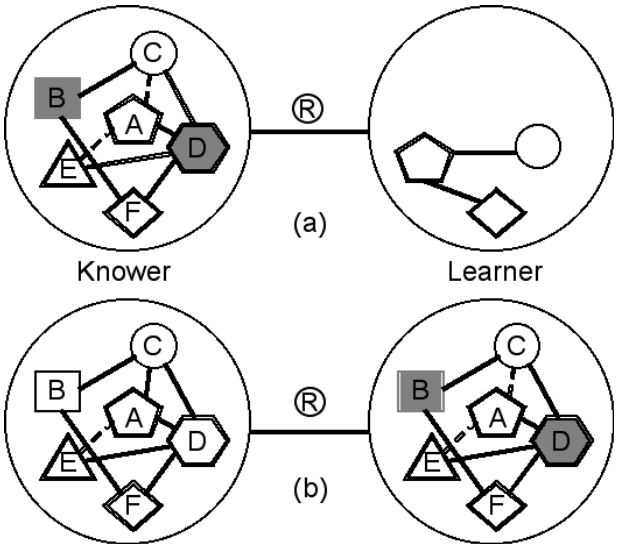


Fig 4.2: **A typical *knower-learner* system:** (a) before and (b) after the learning relationship/interaction. Note that the *knower* has also been changed by the relationship – the knower can now can now *explicitly* describe elements B and D and relationship A-C, which were previously *tacit*.

('To teach is to learn twice' - Joseph Joubert[1]) In general terms, the innovator learns how to make a system that more closely fulfils its intended purpose, or learns how to make a system more efficiently (see below section xxx); the innovation, of course 'learns' how to more closely fulfil the purpose intended by the innovator.

As the interaction/communication between the innovator and innovation can be by any – or more than one – of the five senses, it can vary in the extent to which it is codified or tacit. We can usually provide greater codification to visual or auditory interactions than to smell, taste and touch. As we will describe later, when there is more than one communication channel, the learning process can become complex, with some of the learned knowledge becoming tacit while other parts become explicit.

In the case of the two parties being people, the teaching/learning interaction is

described as *formal, informal or technical*, depending on the mix of tacit and codified knowledge transferred in the interaction (see later this Chapter).

Different systems-levels of learning

Although the intention of this book is to focus on the types of descriptions that are most useful for innovators and managers of innovation, it is worthwhile reflecting for a moment on the different levels at which the process of learning can be described:

- The *physical* or *atomic* level – essentially, everything is 'just atoms and space'
- The *biochemical* level – how different chemicals are secreted, interact and are transformed in response to stimuli to the senses.
- The *physiological* level – how different cells – particularly neurons – change in response to new information – 'what fires together wires together'
- The *psychological* level – how our cognition changes with perception of information;
- The *educational or inter-personal* level – how we combine, impart and receive particular information;
- The *management* or *organisational* level – how we use new information to make decisions;
- The *sociological/cultural* level – how groups and organisations respond to new information;
- The *philosophical* level – how we give meaning to information.

This is depicted in *Fig. 4.3*. While we will mainly focus on the psychological, educational and management levels of learning, it is helpful to look briefly at what is happening at the more microscopic levels.

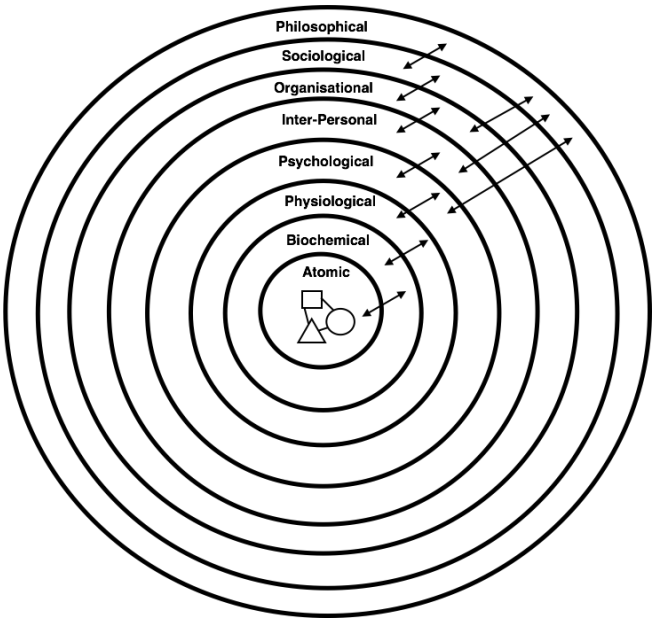


Fig. 4.3: The different levels of organisation of purposeful systems and some of the interactions between levels that can be considered as knowing and learning.

Learning and modern science

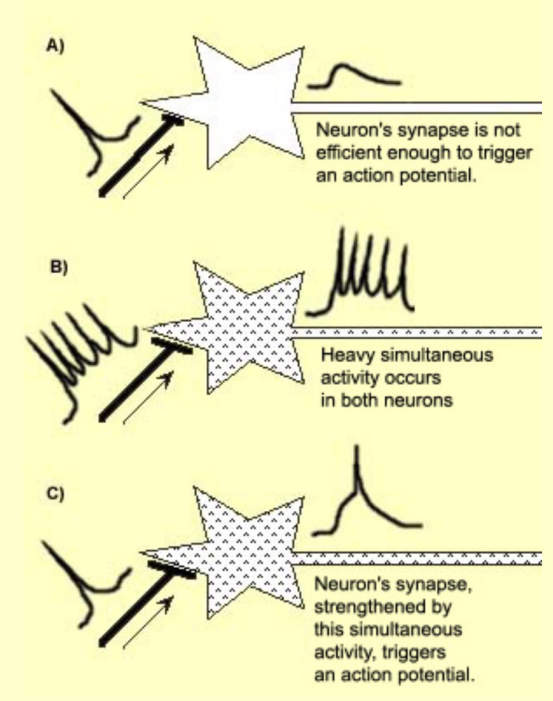
How the learner learns in this situation is still a matter of active research by cognitive psychologists and neurophysiologists. As 'knowledge' involves the invoking of relevant neuron groups in our brain, the question arises as to *how* these patterns are established in the first place. Donald Hebb[2], in 1949 first described (or hypothesised) the process:

> *When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A' s efficiency, as one of the cells firing B, is increased.*

Hebb's theory is summarized in the statement:

- ***Cells (neurons) that fire together, wire together.***

However, this summary should not be taken too literally. Hebb emphasized that *cell A* needs to *take part in firing cell B*, and such *causality* can only occur if cell A fires *just before*, not at the same time as, cell B. The theory attempts to explain *associative* or *Hebbian learning*, in which (almost) simultaneous activation of cells leads to pronounced increases in synaptic strength between those cells, and provides a biological basis for errorless learning methods for education and memory rehabilitation.



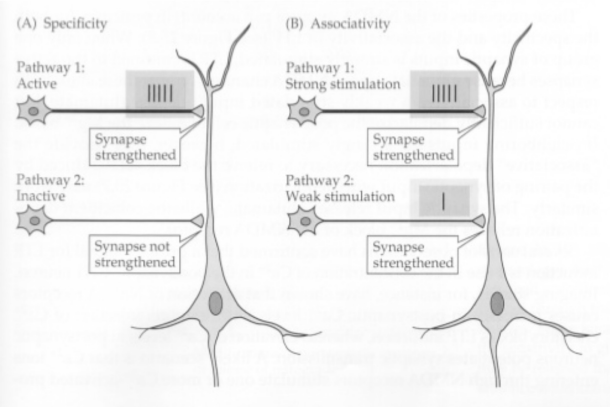


Fig 4.4 a) and b): The basic "Hebbian model" of developing a neuronal connection related to a particular stimulus. ii) a) Illustrating a specific simple learning (strengthening) and b) how association, or indirect learning occurs.

We shall see below that the two (or more) signals might not be received at the same 'level' of consciousness – that is, the receiver (learner) might only be paying attention to one signal while another signal is also present.

Recent research suggests that *mirror neurons*[3] in the learner are activated by perception, enabling the learner to 'internalise' the observation in a kind of neuron-map that the learner can then wilfully activate to 'play back' the observed action[4]. How well the learner 'plays back' the observation is another matter. The observed action may be complex and radically different from the learner's previous experience, or it may be simple and similar, or anything in between. Further, the playback will depend on the learner's innate abilities to perceive and imitate- ie their 'intelligence'.

In most cases, the learner will try to evaluate their performance and, based on that evaluation, they will try to improve it – *ie*, more closely 'reflect' or 'mirror' the original perceived performance. This may be easy if the outcome is simply binary – *ie*, yes, the performance was achieved, or no, it wasn't – for example, learning to switch on a light. In many cases, self-evaluation is more difficult if there is a 'quality' to the performance – such as a ballerina's grace, the imitation of a foreign accent, etc. In these cases the learner's evaluation may be different from the performer's, or that of a third party. 'Justification' and 'truth' of the 'belief' (That the learner 'knows' something) is therefore a matter of personal opinion – ie, it is 'subjective'.

The Types of Learning

From the forgoing discussion we could deduce that there are three main *dimensions* to learning, each with two *modes*:

1. ***Imitation cf exploration*:** In this mode, the knowledge to be learned is either already known, or, alternatively, is being created by the learner: In the case of *imitation*, the learner endeavours to embody an identical set of procedures to the person or image or set of instructions that they are imitating, on the assumption that once embodied, the learner will have the same capacity to act as the instructor. With *exploration*, the complete information is not available, so the learner proceeds by trial-and-error,

(hopefully) eventually producing some approximation to their initial objective.

2. ***Solitary cf interactive*:** The learner is either learning by themselves, or with interaction with others;

3. ***Focal cf subsidiary awareness*:** The learner's mode is either *deliberately* setting out to learn the knowledge that has their attention or, alternatively, *incidentally* acquiring the knowledge by being exposed to it. We have used Polanyi's descriptions of *awareness*[5] rather than the more familiar *conscious* and *unconscious*, as we can be conscious (awake) but not focused on a particular matter and a strict definition of unconscious is that the senses are not functioning.

   Although this distinction between *focal* and *subsidiary*, or *deliberate* or *incidental*, can provide a useful model for our purposes, it is likely that the actual (ie physiological) process of learning is not so bi-modal.

   Further, while we may *claim* that we are consciously focused (*attending*) on a particular thing, cognitive psychologists[6] assert that a large proportion of our time is spent either perceiving (ie using our five senses) something else in our environment or thinking about something else rather than the matter at hand. Sometimes we are possibly 'parallel processing' eg typing while listening to music. We tend to view this wandering attention as 'distraction', but, although it *can* be dysfunctional, it seems to be natural and common.

   The outcome of this is that what we *think* that we are learning – *ie explicit/declarative* knowledge – is only part of what we are 'absorbing'. For example, when we hear something spoken, we may be focused on the explicit meaning of the words, but the words are spoken in a particular language with a particular grammar, syntax, accent and intonation that is in part unique to the speaker. Thus, we not only learn to speak in that language, but also with a style that reflects the extent to which we are exposed to the particular subsidiary aspects of the language. Further, the visual behaviour of the speaker is also perceived and gets absorbed as part of our personality.

   Beyond this, the wider spatial and temporal contexts are perceived and integrated to some extent with the rest of the information that becomes our knowledge – *ie our capacity to act*. It is like focusing on the first violin in a symphony – the sounds of the rest of the orchestra are also absorbed as well. Thus, our capacity to act *intentionally* – *ie* to carry out explicitly declared actions – may be affected – either enhanced or impaired – by this 'subsidiary' knowledge. As we shall see, 'learning' may therefore become as much an exercise in 'un-learning', or de-coupling, some actions from other actions to improve our capacity to act as we intended.

The three dimensions, each with two modes, *provide eight alternative ways to*

learn. For clarity, these three dimensions are reduced to two in Table 3.3, below. Although, in practice, much learning will be a mixture of modes, it is theoretically possible for learning to take place in a single mode. The following will describe each of these modes.

	Solitary	**Interactive**
Imitation-Focal	Attentive observation	Focused teaching
Imitation- Subsidiary	Subsidiary infusion	Subsidiary inferring
Creative-Focal Exploration	Deliberate trial and error	Focused teamwork
Creative-Subsidiary	Accidental discovery	Emergent properties

Table 4.1*:* The eight ways to learn.

1. ***Solitary/Focal/Imitation*:** In this case the learner, alone, consciously sets about to learn-how-to by simply attempting to copy someone else's (the 'teacher/knower') knowledge. Examples include trying to learn to play golf from a book or how to dance by watching a dancer on TV – the knower and learner do not have any interaction with each other – the knower simply performs or describes the performance and the learner does their best to imitate the performance. Another familiar example would be a student in a large lecture theatre, where the student is listening and taking verbatim notes – the lecturer and student have minimal interaction.

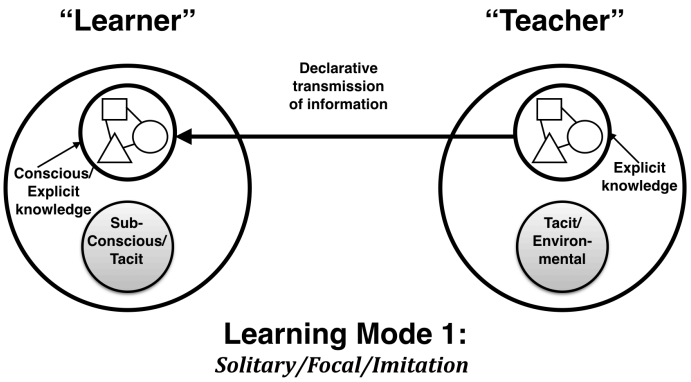


***Fig 4.5 a)*:** Learning *Mode 1*.

2. ***Interactive/Focal/Imitation*:** In this case, the learner and knower relate

to each other- the learner attempts to imitate the knower's demonstrated knowledge and the knower informs the learner of any variance between the imitation and the knower's performance: *eg* 'No – swing the golf stick back slower – yes – that's right'; or 'Quite good, but more emphasis on the first vowel', *etc*. Thus, with confirmation of having demonstrated the ability to imitate correctly, the learner can proceed to ingrain the knowledge by *repetition*. This is the most common modality of teaching, coaching and tutoring. Consistent attention is required from the knower, which is not always the case in large classes, where an individual learner's variance may remain unnoticed – making the modality more like Mode 1, above.

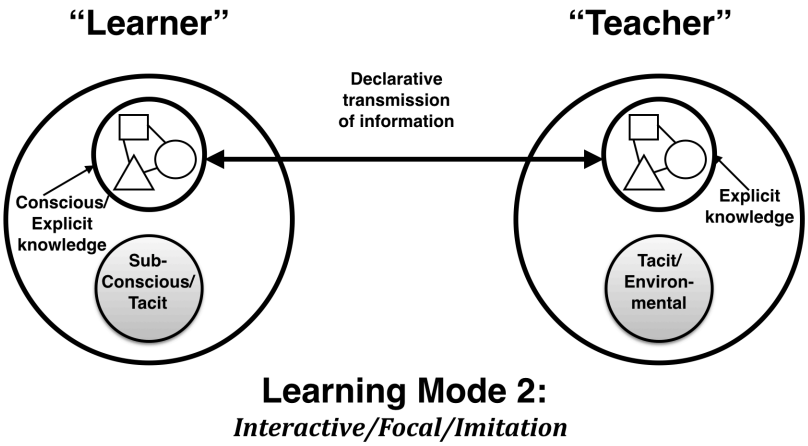


***Fig 4.5 b)*:** Learning *Mode 2*.

3. ***Solitary/Subsidiary/Imitation*:** This is the mode where tacit knowledge is most likely to be acquired. While the learner is focused on some particular action, information is *also* being perceived by their subsidiary awareness. To use an example from Polanyi, while the focus is on the hammer-head and the nail, the subsidiary awareness is on the 'feel' of the hammer's handle and the 'feel' of the impact of the hammer on the nail. It is the context, or wider environment that is usually not perceived focally, but nonetheless this information is assimilated and becomes part of the learner's knowledge – the way that they act in response to the focal information. This is the basic tenet of *behaviourism*[7], where the subsidiary information is learned associatively (the *conditioned* response in Pavlov's terms).

   The subsidiary knowledge may enhance the performance of the focal knowledge, or hinder it. The best known simple example is the traditional learning of multiplication tables in a sing-song voice. A more complex example, the literal meaning of language could be considered focal while the accent (broad environment) and intonation (family or narrow environment) are acquired peripherally from the learner's environment and may impede the comprehension by a listener (*eg*, 'he speaks in a thick, angry foreign accent') or enhance it (*eg*, 'I love listening to that

sweet Irish lilt').

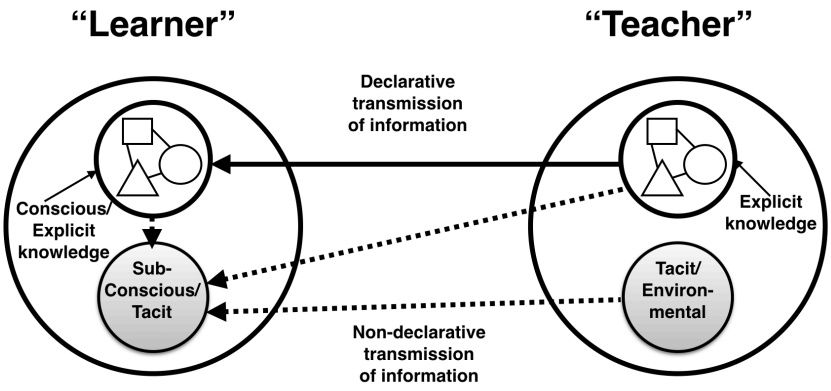


***Fig 4.5 c)*:** Learning *Mode 3*.

4. ***Interactive/Subsidiary/Imitation*:** In this mode social/cultural behaviour and skills are developed. Interaction is often by subconsciously-perceived approval/rejection which is not usually explained, attended by feelings of discomfort if social norms are transgressed and *vice versa.* This is the classic 'non-verbal communication'.

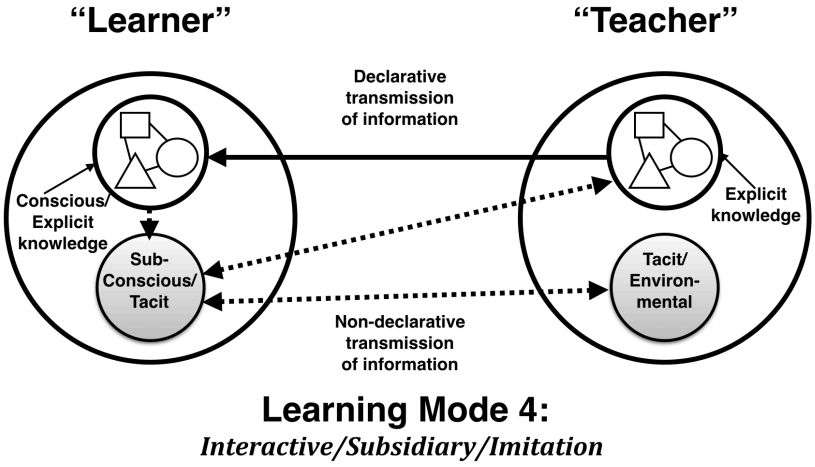


***Fig 4.5 d)*:** Learning *Mode 4*.

5. ***Solitary/Focal/Exploration*:** Examples include learning to bake a cake by trial-and-error in the kitchen or perhaps a scientist experimenting alone in the laboratory. In the case of learning by personal experiment, the learner can be either deliberate in their actions, or spontaneous. In the case of deliberate actions, the learner imagines a series of actions leading to a desired outcome and then endeavours to perform those actions. An achievement of the desired outcome may lead the learner to believe that the whole course of actions were the correct actions, although

compensating mistakes may have been included as well - a right outcome for the wrong reasons - or some of the actions may have been redundant. This will be examined in greater depth below in Section xxx. Again, the evaluation of the quality of the outcome may differ between different parties.

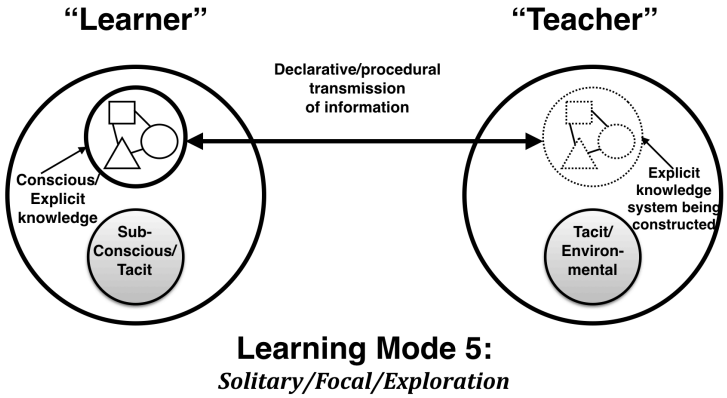


***Fig 4.5 e)*:** Learning *Mode 5*.

6. ***Solitary/Subsidiary/Exploration*:** Spontaneous, accidental or non-deliberate actions also lead to learning. This is a dominant learning mode for young humans and other organisms and is also present in most adults. If the outcome of a non-deliberate action is desirable to the learner, they may attempt to repeat it – with or without focus. The challenge for the learner is to know what precursor actions actually led to the outcome, and what were irrelevant. Having achieved the outcome in the context of some actions, the learner may be motivated to consciously or deliberately experiment with those actions to see which of them is associated with the result.

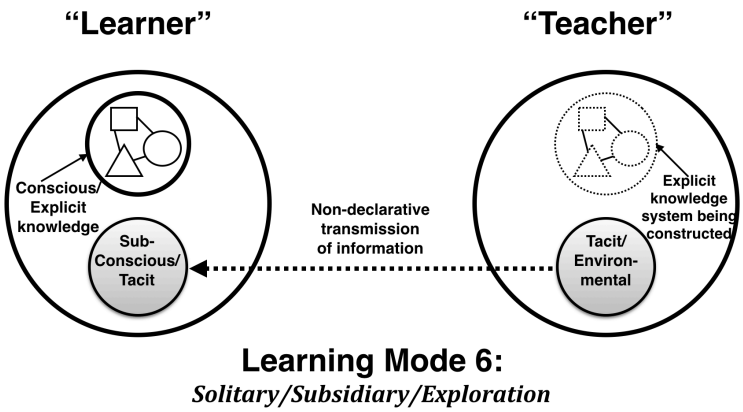


***Fig 4.5 f)*:** Learning *Mode 6*.

7. ***Interactive/Focal/Exploration*:** In this case a number of people (at least two) deliberately interact to solve a problem or achieve a goal. The interaction between the individual learners may enable Mode 2 learning from each other, thereby forming a larger common (factual and

procedural) knowledge base to solve the problem. Some members may hypothesise/conject/suggest new elements and/or relationships (novel combinations) while others work through the detail of the viability of the suggestions. This is the basis of goal-directed teamwork, which includes team sports, group research and most activity within productive organizations.

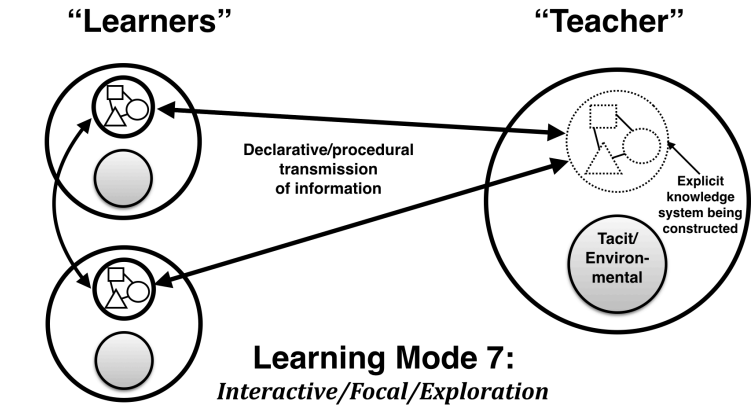


***Fig 4.5 g)*:** Learning *Mode 7*.

8. ***Interactive/Subsidiary/Exploration*:** Importantly, while the focus of the group may be on the achievement of the explicit goal, there is inevitably a subsidiary awareness of the dynamic of the group- ie how the relationships that are established or enhanced affect achievement. While notionally these relationships are intended to be 'positive' *ie*, improve goal achievement, they may in fact be dysfunctional and thereby reduce the likelihood of goal achievement.

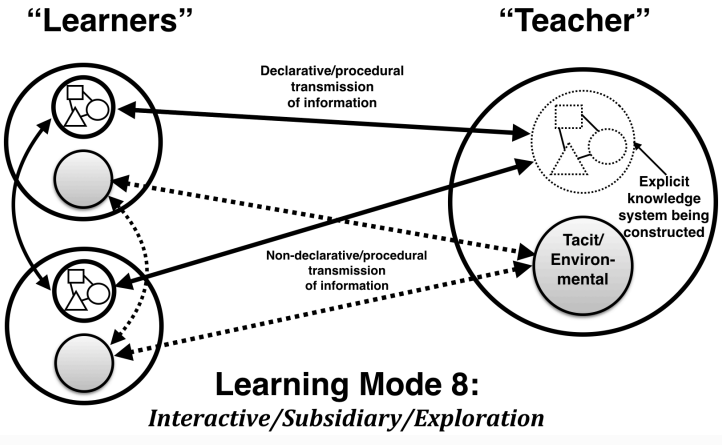


***Fig 4.5 h)*:** Learning *Mode 8*.

Summary of the Learning Modes

Although it might be inferred from the above discussion that learning only occurs in one mode at a time, in reality, some of these modes are often mixed together. In particular, *subsidiary learning* invariably occurs along with *focal learning* – *ie* while we are deliberately trying (*ie focused*) to learn something

particular, we subconsciously absorb some of the information/knowledge that is in the field of our perception. How this occurs has been a matter of intense debate and research for more than a century. Nonetheless, as a model of behaviour it has been used as the basis of much teaching, coaching, advertising and propaganda. The most obvious forms are called 'classical conditioning' or 'operant conditioning', where at least two different items of information are associated with an action (*eg* Pavlov's dog[8] - ringing a bell and offering food), giving rise to the 'subject' responding to one item of information even if it is not logically connected to the action (eg Pavlov's dog salivating when a bell rings in the absence of food). Less obvious is the 'intuitive' understanding of facial expressions and other body language that accompanies verbal communication.

In essence, all knowledge that is acquired by humans and other life forms is in a *context*. This context may enhance the use of that knowledge- *eg* paired association[9] can help recall of facts (*eg* mnemonics) or actions (*eg* dancing to music) but it can also inhibit – *eg* by creating redundant behaviour or dysfunctional relationships between staff in an organisation. As we shall see in the next chapter, improved performance is as much about the elimination of redundant actions as it about providing additional elements of knowledge.

A succinct summary from David Brooks, columnist of the New York Times:

> *The problem is, this individualist description of human nature seems to be wrong. Over the past 30 years, there has been a tide of research in many fields, all underlining one old truth – that we are intensely social creatures, deeply interconnected with one another and the idea of the lone individual rationally and wilfully steering his own life course is often an illusion.*
>
> *Cognitive scientists have shown that our decision-making is powerfully influenced by social context – by the frames, biases and filters that are shared subconsciously by those around. Neuroscientists have shown that we have permeable minds. When we watch somebody do something, we recreate their mental processes in our own brains as if we were performing the action ourselves, and it is through this process of deep imitation that we learn, empathise and share culture[10].*

Edward T. Hall on Knowledge

In part, the foregoing description of learning modalities reflects the learning classifications devised in the 1950s by the anthropologist Edward T. Hall and described in his book *The Silent Language*[11]. In summary, Hall divided learning into *informal, formal, and technical*.

- ***Informal learning*** takes place as unstructured exploration and imitation without (third-party) feedback, as in modes 1 and 3 above.
- ***Formal learning*** is essentially *focal imitation* with feedback; and
- ***Technical learning*** uses *explicit procedural information* and instruction.

Hall's model assigns all *declarative procedural knowledge* to *technical learning*, whereas, in our model, we assert that one can learn recipes or formulae by rote and use them correctly without necessarily 'understanding' them (*eg* learning multiplication tables in grade school).

Hall's book describes how different cultures vary in their mix of the three modes of learning, with so-called 'traditional' cultures emphasising informal learning – imitating the actions of hunting, gathering and weaving – with a certain amount of formal teaching – admonishing the learner (usually a child) for incorrect behaviour. Traditional *apprenticeships* use much the same methods; in reality Hall sees the 'American (or Western) way' of technical learning and teaching as being at the other extreme, with the emphasis on written or spoken data and instructions (declarative knowledge). These data and instructions might be extremely detailed, with the expectation that the 'educated' person – *ie* one who has been subjected to years of focused attention to declarative knowledge – has the ability to quickly translate these images and words into action, like a musician playing music straight from the sheet, that they have never seen, heard or played before. This approach relies on the basis of education being the ability to apply 'basic principles' (declarative procedural knowledge) to new situations- ie to 'abstract' the important aspects of the new situation and relate them to the aspects of 'basic' systems. This is the modality of researchers working in new areas.

Activity/Mode	**Formal**	**Informal**	**Technical**
Learning	Correction	Example	Principle
Awareness	Unaware	Automatic	Conscious
Patterns	Tradition	Custom	Convention
Insight	Experience	Intuition	Analysis

Table 4.2: Edward T. Hall's Knowledge Classification.

Knowledge transmission: Nonaka and Takeuchi's *Knowledge Spiral*

Innovation and Learning

For a more complete understanding, the interactions between the *innovator* and the *innovation* need to seen as *two-way*. Indeed, as we know from Newtonian physics, all interactions are two-way: *all actions have a reaction*. With innovation, the reaction is generally seen as the innovator 'learning' – which, in common parlance, is *acquiring knowledge from experience*: the innovator is gaining knowledge of how well the innovation is progressing towards fulfilling its intended purpose and/or how the innovation might better fulfil its intended purpose and/or how to more effectively interact with the innovation to enable it to fulfil its intended purpose.

Similarly, the innovator 'learns' from the interaction between the innovation and its user(s) – how it fulfills its intended purpose when it is in its 'user

environment'. This is all a very abstract way of saying that we *learn-by-doing*. But, by using this kind of description we can also describe the actions of the innovator as teaching and learning. After all, these interactions between the innovation, the innovator and the users are *relationships*, where all elements that interact with each other are changed by the interaction.

The foregoing has taken what is tacitly known by most people – and has made it explicit. As an inevitable consequence, it has made what was apparently simple into something that seems complicated. Although we can't undo *that* experience, we can make it understandable and believable by using an example of how it all might fit together. Two Japanese authors have provided a very useful example:

Ikujiro Nonaka and Hirotaka Takeuchi published a ground-breaking book in 1995 called the *Knowledge-Creating Company*[12]. The novel – or apparently novel – aspect of the book relates to its title – that groups, not just individuals, can be creative, as in Modes 7 and 8, above. The book describes how knowledge is developed and transmitted in the processes of invention and innovation in an organisation. The novel aspect of the book is the description of the 'knowledge spiral' – the process by which knowledge that begins with one person as *tacit knowledge* becomes *explicit knowledge* belonging to the group and ultimately enabling them to 'act' – *ie to produce a viable innovation*.

The essence of Nonaka and Takeuchi's model can be summarised thus:

1. ***An organisation is a system*****,** comprising sub-systems of people, down to the level of the individual (*the ontological dimension*).

2. ***Ideas start with individuals*** in the form of a statement of broad purpose or mode of action, which is essentially *tacit knowledge*.

3. ***Innovation occurs by the idea being transferred to successively larger groups*****,** with more 'knowledge' being added to it (*the epistemological dimension*).

4. ***The transference alternates between tacit and explicit*** as knowledge is articulated at one system level and then assimilated at the next level.

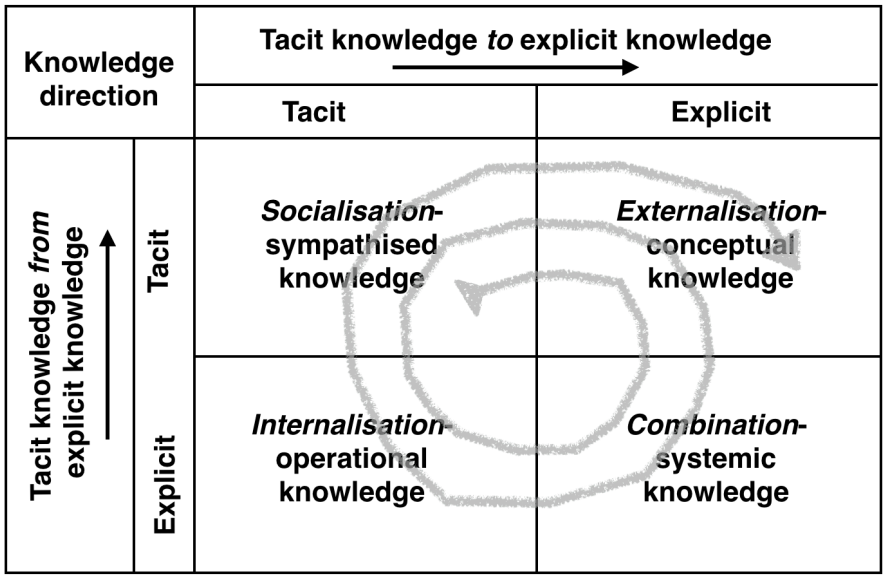


Fig. 4.6: Nonaka and Takeuchi's Knowledge Spiral.

The *knowledge spiral* is best-described using Nonaka and Takeuchi's diagram. *Fig. 3.7* depicts the four modes in two dimensions of knowledge transferring processes – from *tacit-to-explicit* (declarative) knowledge and from *explicit-to-tacit (procedural)* knowledge. Starting from an idea *in an individual*, *socialisation* (*tacit-to-tacit* – sharing a wide range of experiences) creates a common culture that enables the sharing of understanding or at least a shared perspective. This perspective is first made explicit (*externalisation- tacit-to-explicit*) in terms of broad images and metaphors that individuals can deconstruct and reconstruct (*combination – explicit-to-explicit*) in conventional analytical processes. These 'novel combinations' (Schumpeter's words) are then *internalised* (explicit to tacit) by participants gaining experience (*learning-by-doing*) using that knowledge. With successive iterations of this process, the knowledge 'spirals' both *inwardly*, ultimately to individual knowledge and *outwardly* through successively larger groups (ie from individual to team to organisation to inter-organisation). By this method, the original idea is 'innovated' – *ie transformed into something that works* by aligning the thoughts and actions of all the participants in the development process from inventor through prototype developers to production and marketing.

Conclusions

We have shown that learning can occur in a variety of ways in a variety of contexts – tacit, explicit, focal, subsidiary, creative or imitative, alone or interactive – and a number of these modes and contexts may occur at the same time, or in rapid sequence. As with many complex situations, we try to focus on what appears to be the dominant modes and contexts, although we may find later that what is being learnt and how it is being learnt is in fact different from what we intended. Such are the perils of analysis.

[1] http://en.wikipedia.org/wiki/Joseph_Joubert
[2] https://en.wikipedia.org/wiki/Hebbian_theory
[3] https://en.wikipedia.org/wiki/Mirror_neuron
[4] For an excellent account of mirror neuron theory and practice, see Rizzolatti, Giacomo, and Sinigaglia, Corrado, *Mirrors in the Brain: How Our Minds Share Actions, Emotions, and Experience* Frances Anderson (Translator), Oxford University Press, USA, 2008. For a summary article, see *Wikipedia,* http://en.wikipedia.org/wiki/Mirror_neurons.
[5] Ibid, Chapter 2
[6] https://en.wikipedia.org/wiki/Attention
[7] http://en.wikipedia.org/wiki/Behaviorism
[8] http://en.wikipedia.org/wiki/Classical_conditioning
[9] https://en.wikipedia.org/wiki/Pair_by_association
[10] David Brooks, *The Social Animal*, New York Times, September 11, 2008.
[11] Edward T. Hall, The Silent Language, 1959, Anchor Books Edition (1973), Doubleday, New York.
[12] Nonaka, Ikujiro and Takeuchi, Hirotaka, *The Knowledge-Creating Company – How Japanese Companies Create the Dynamics of Innovation*, New York, Oxford University Press, 1995.