**Draft:**

# *Concepts in Innovation and Change*

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## Chapter 3: Knowledge, Learning and Innovation

### Introduction

Discussions about innovation rarely progress far before the word 'knowledge' is invoked. Google reveals more than 300 million results for 'knowledge and innovation' – about twice as many results as for 'innovation definition'! Commentators who talk about 'the knowledge economy', 'knowledge-based industries', 'knowledge-intensive goods and services', 'knowledge workers' and 'knowledge management' often couple these phrases with the word 'innovation' *e.g*., 'innovation is the key to the knowledge economy', 'knowledge-based industries are innovation-intensive', 'knowledge workers are innovators', 'knowledge management enables innovation', and so on.

It all sounds impressive, with connotations of commercial competitiveness through cleverness and complexity – but what does it mean? What are the actual connections between 'knowledge' and 'innovation'? And further, is it useful or important for us to understand it?

The notion of 'knowledge' is talked about quite differently by philosophers, psychologists and managers. While our objective is to provide practical management outcomes, we will also touch on some philosophical and some cognitive ideas along the way.

We find that there are two main types of knowledge – *declarative* and *procedural* – and that their acquisition and application are quite different and that understanding this is crucial to our ability to innovate. There are also two main ways of displaying or communicating knowledge – *explicit* (or *codified*) and *tacit*.

In this section we will build on our definitions of *systems* and *innovation* with a consistent description of the concept of *knowledge.* A pictorial model is also presented, using a systems model similar to that used in Chapter 2. Before establishing this model, we will quickly review the basic – and generally accepted – principles and definitions of *knowledge*.

### Knowledge and Knowing

Like the definitions of innovation, the many definitions of knowledge vary widely. A useful *starting point* is the definition given by Wikipedia, which is very similar to many definitions:

- *(Wikipedia):* ***Knowledge*** *is a familiarity, awareness or understanding of someone or something, such as facts, information, descriptions, or skills,*

*which is acquired through experience or education by perceiving, discovering* or learning.

Following our principle – established in Chapter 1 – of avoiding the *five fallacies*, we can improve on this definition by making it more concise:

- 'familiarity, awareness or understanding' can replaced by the word 'possession', as this covers these three modalities and allows for others.

- 'facts, information and descriptions' is tautological, as these three words are similar and can be replaced by the one – 'information'.

- 'skills', as we shall discuss, is fine.

- The rest of the definition can be eliminated, as the mode of acquisition of knowledge does not necessarily have any bearing on being knowledgeable and further, it is not complete, as knowledge may also be *innate* or received by *revelation* or some other means.

So we can now make a viable, concise definition:

- **Definition:** ***Knowledge is the possession of information or skills.***

As with our definition of innovation, we relegate all the explanation and examples of the key-words 'possession', 'information' and 'skills' to the discussion, rather than trying to make the definition an 'extensional elephant' (as discussed in Chapter 1.), by including some, but possibly not all, of its attributes.

**Two types of knowledge**

Our concise definition, above, indicates that there are two different kinds of knowledge – *information* and *skills*. We call 'information-knowledge', *declarative* knowledge and 'skills-knowledge', *procedural* knowledge. We will look at each kind separately and then see how that they can be connected.

**Declarative knowledge**

- **Definition:** ***Declarative knowledge is information that we can display by declaring it – that is, by verbally uttering it or by writing it.***

This information can take different forms:

- Data;
- Facts;
- Information;
- Descriptions; and
- Prescriptions

We will deal with them in turn, below, after establishing a system-like image to use in our descriptions.

Essentially, someone who possesses knowledge – a *knower* – can claim to either 'know-that' or to 'know-how'. 'Know-that' is *factual* or *historic* or *contemporary* knowledge (it includes 'know when', 'know what' and 'know who' from *Table 3.1*). 'Know-how' can be *declarative*, if it is the information relating to *how* an action is, has been, or should be performed, or it can be *procedural*, as described below. By definition, facts are statements about things that *are* or *were*. Something cannot be a fact until it has come into being or come to pass – we cannot say, for example, that 'it is a fact that the sun will rise tomorrow' – we may *believe* that it will, but, by definition, that belief isn't justified.

| **Knowledge Type** | **Example** |
|---|---|
| *Know-what* | Roses are flowers |
| *Know-how* | Recipes: 'add flour, milk, eggs and beat for 2 minutes' |
| *Know-who* | 'The sparrow killed Cock-Robin' |
| *Know-when* | 'World War II ended in 1945' |
| *Know-why* | 'The dog was itchy because it had fleas' |
| *Know-that* | 'George Washington was the first president of the USA' |

**Table 3.1** Six types of common (factual) knowledge

**Procedural Knowledge**

*Procedural knowledge*, or 'skills', practical knowledge or *know-how-to*, is expressed by undertaking an intentional action. It can be defined as:

- **Definition: *Procedural knowledge is the capacity to act.***

What do we mean by *the capacity to act*? Essentially, it is *the capacity or capability to perform some action deliberately, intentionally or purposefully*.

- **Example:** I might claim that I know how to bake a cake, but by itself, this is only an assertion (or declaration) about a possible future event. I can also describe (declare) to you the steps that I would take to bake a cake. My claim that 'I baked the cake that is on the table while you were away' might be true, but it only by inference that you might believe my claim (who else could have baked it?). My recipe might be plausible, but only by watching me *actually* bake the cake will you really have *justified true belief* that I know how to bake a cake.

Procedural knowledge can be expressed wordlessly, or it can be accompanied by declarative knowledge of the know-how-to kind. Examples of this modality are sports coaches and celebrity chefs on TV.

By *capacity*, or *capability to act* I mean that, based on my previous displays of intentional action, you might assume, or believe, that I can repeat those particular actions if called upon to do so – that I am ready, willing and able to act. Of course, your assumptions or beliefs might be unfounded – I may no longer

have that ability – as is often the case as we grow old – but it is often the case at *any* time when we simply forget. Or my performance, which gave rise to your belief, was just a lucky combination of actions (like hitting a hole-in-one in golf). We will deal with forgetting in a later chapter and assume for the time being that if I have displayed an ability to act, that there is a fair chance that I can more-or-less reproduce those actions.

Procedural knowledge is often supplemented by *conditional declarative knowledge* ie, *if/when-then.* For example, part of the recipe/procedure for baking a cake could be '*if* the mixture is too thick, *then* stir in more milk until the mixture slides off the spoon…' and so on.

**Procedural knowledge and innovation**

Actions change, or transform things and procedural knowledge is *intentional action*, that is, action with a purpose. Therefore, while we usually need to absorb declarative knowledge to be able to know what to do when we are innovating. The act of innovating is essentially the expression of our procedural knowledge – the *transformation of ideas into something that works*.

**What about 'wisdom'? The *DIKW Pyramid***

Many discussions of knowledge present a spectrum, hierarchy, or pyramid, known as that DIKW Pyramid[1], in which *data* leads to *information* which in turn leads to *knowledge* and eventually *wisdom. (Diagram)* There are many and varied descriptions of these four notions, which can broadly be defined as:

- **Data:** Simple facts with no organisation
- **Information:** Structured data, with relationships providing context and meaning;
- **Knowledge:** The ability to use information strategically to achieve objectives; and
- **Wisdom:** The capacity to choose objectives consistent with values and social context.

We will not enter into discussion of the DIKW pyramid at this stage, other than to say that it is essentially presents a *nested system* of knowledge, with facts as the basic element, leading to successive systems and super-systems containing increasingly related fact-elements. As to how these systems develop will be discussed below.(More?)

**The Knower as a System or 'Container'**

Our definition, above, describes knowledge as a *possession*. We often talk of our *having knowledge, possessing knowledge* or *being knowledgeable. Having knowledge* has the connotation that one *has* a collection of things (data, facts, information) in a container, or that one *is* a container with that collection of things in it somewhere. The use of words like *capacity* or *capability* leads us to think of knowledge as something that is separate from us, but may be contained within us, like so many coins in our pocket or sandwiches in our lunchbox or tools in our toolbox. The extension of this approach is that knowledge can be

broken down into data, facts, information, descriptions, prescriptions, etc. that can be put in the container. These different approaches to knowledge are rather like the psychoanalyst Erich Fromm's distinction between 'having' and 'being'[2]. 'Having' is a *possessive* concept; 'being' is a *doing* concept. In what follows we will see that it is useful to think of a person as *being knowledgeable* as well as *having knowledge*.

While we often focus on the *individual* as the container, or system- boundary, we can also see knowledge that is either:

- **dis-embodied** into information storage systems, including books, pictures and electronic data storage systems (computers); or
- **embodied** in groups, organisations, businesses or larger groups up to nations.

**The starting point of knowledge**

As we describe below, much of the discussion about knowledge revolves around the relationships between entities. The 'atoms' (ie indivisible quantities), or elements, of language and ideas are *individual named objects* – things that we can point at and name, without further elaboration or comment. For example we can point at a chair, a dog, a computer, a building or a mountain and give it a name. Knowing names of things constitutes knowledge, by definition, but it is only when we form relationships between things that knowledge starts to become interesting. Some names imply relationships, others don't. For example, naming the dog 'Fido' does not necessarily mean that Fido belongs to the species *canis familiaris.* Calling a chair a 'chair', generally means that is an object that satisfies the definition of what we call a chair – it belongs to the class of objects called 'chair'.

**Facts**

First, we will look at the basic element of knowledge and its relationship to an individual.

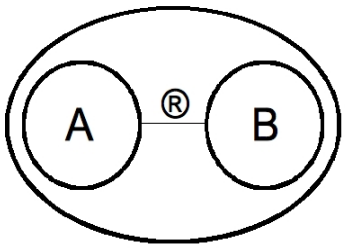


**Fig 3.1:** System depiction of a *fact*: 'A *relates to* B'.

When we say someone *has* knowledge we are usually saying that they have *the capability to tell us about something* – that they have *data, facts, information, descriptions and prescriptions* stored *within* themselves and that they can retrieve that stored knowledge and communicate it through speech or writing. This *container-view* of knowledge is similar to our *systems-view*, described in

Chapter 2, where the system is an abstract container for a collection of related elements. Knowledge is similar in that it can be seen to have relationships between its constituent parts. To say that something is a *fact* is to say that there is a relationship between at least two entities – or in our language – *elements* in a system. Fig 3.1 is a systems depiction of a simple fact: (element)A *relates to* (®) (element) B.

- Example: When I say that '*A* is the president of France', I am saying that there is a person (element) called *A* and there is another element called France (B) and that there is a *relationship* (®) between them in that the *element A* performs those actions on *element France* which are the interactions that a French president would normally perform on France. Further, other elements, called *the people of France* have interacted with each other and element *A* and have conferred the name 'president' on the relationship between *A* and France.

At the heart of this is a *justified* statement about the relationship between some elements that is either historic (if we were talking about a past president) or is now happening (the present president). So *factual* knowledge can be of the form of *know-who, know-what, know-when*, etc. *In each and all of these cases the knowledge can be boiled down to a statement about elements in a system and the relationships between them.* Examples are given in Table 3.1

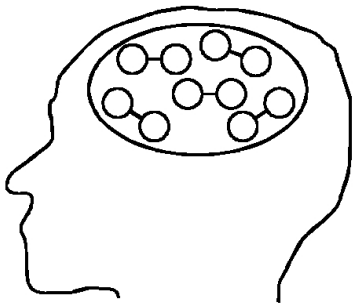

**Fig 3.2:** Knowledge is typically viewed as a collection of facts in a container called our mind or brain.

We should note that although each quantum of knowledge (data, fact, etc) that is known by the knower comprises elements and relationships, not all of these quanta are related to each other, as illustrated in *Fig 3.2*. In other words, much knowledge resides in the knower as stand-alone items or in piecemeal, unconnected collections, rather like an encyclopedia.

**Invention and knowledge**

The process of *invention* involves the connection of previously unconnected units of knowledge into – as Schumpeter called them – 'novel combinations'[3]. As to

what is *actually* happening at the physiological level is not entirely clear, but we do know that thoughts and ideas are correlated with particular collections of connected neurons. Although each neuron is connected to many others, it is physically impossible for all of them to be connected to each other. 'Novel combinations' occur by new connections between neurons and their associated ideas or knowledge. Although *how* these new connections are made is outside the scope of this book, we do know that 'neurons that fire together wire together'. This notion will be dealt with in greater depth in the next chapter on *Knowledge and Learning*.

**Facts and procedural knowledge**

While 'facts' are the knowledge of *having*, the knowledge of *being* is somewhat different. *Being knowledgeable* refers to *the ability to use knowledge*. *Being* connotes *action* – it refers to an ability to *do things* – that is, the ability to *undertake actions*.

- **Examples:** This kind of knowledge is usually referred to in terms such as 'she is a good organiser – she *knows how to* organise an effective meeting', or 'he is a brilliant mathematician- he *knows how to* solve simultaneous non-linear differential equations'.

Thus, *being* is *the state of having the capacity to do something*. It is the knowledge of 'know-how-to'- which we often called 'capability'. In everyday terms, we think of someone as 'capable' when they are able to actually perform some intentional action. (We exclude spontaneous random action). The *intention* is some form of pre-meditation or envisioning of an outcome or system-state that is then actualised by their capability to perform the required actions or *procedures*. Therefore, we call this kind of knowledge 'procedural knowledge'. As we will see below, the definition of this kind of knowledge is 'the capacity to act'.

- **Definition: *Procedural knowledge ≡ the capacity to act***

Where ≡ means 'the same as'.

Quite where *know-how-to* resides in the knower is also a matter of significant debate and research[4] in the field of cognitive psychology. Clearly, the *intentions* are related to conscious activity in the brain, but it seems that the actual *capabilities* to carry out these intentions are distributed between the conscious and non-conscious brain, the body's nervous system and the muscles and, arguably in the environment that the knower is related to. (diagram) Disconnected facts may form part of this capacity to act, but not exclusively, and not necessarily consciously. We shall return to these matters later (XXX).

Whether the knowledge is in the form of 'having' or 'being', the knowledge is seen as somehow *residing* in the knower – the knower is the container or system that knows facts, or knows how to do deliberate things. Although, in different situations, the knowledge is in different forms and located in different places in the knower, we are reasonably comfortable with the idea that we can point to a finite something or somebody that knows something – *the knower*. As this

bounded-ness is system-like, for the time being, we shall think of the knower as a container-system, as depicted in *Fig 3.1*. A discomfort with this notion arises in the case of *complex adaptive systems*, which are outside the scope of this book.

**Purpose and knowledge**

We need to look again, more deeply at 'purpose'. Purpose is an anticipated outcome that is intended, or that guides your planned actions. The purpose of a system is its intended use. An 'outcome' is 'something' – a system, or an element for a system, or a new relationship between elements in a system. When we act purposefully, we perform deliberate actions on an existing system, or the elements that will comprise a system, with the intention of making a (new) system that has a purpose. That is, we *relate to* that system or its elements.

- Example: A caveman chips at a rock to make an axe-head, a welder joins sheets of steel to make a drum; a painter daubs acrylics on a canvas to make a portrait of the president; etc. The axe-head becomes a hunting tool; the drum holds water for the village; the painting will be a permanent record of the president.

Thus we can see that purposeful systems make (new) purposeful systems or elements for (new) purposeful systems and so on. We can see now how systems become 'nested' or relate to each other.

**The Conventional Definition of Knowledge revisited – *Justified True Belief***

Plato[5] described knowledge as 'justified true belief', which has been used and/or argued over by philosophers ever since. It is worth examining it briefly in the light of the declarative/procedural approach that we take in this book.

Plato's approach starts with the idea of *belief*: If I *believe* that I *know* something, it remains simply as a thought (internal) or an assertion (external – declared) unless I can demonstrate or *justify* to others that I actually *do* know that particular something. A demonstration could be by speaking, writing, or doing what I claim I know. As in the above example, I might assert that I believe that I know who is the president of France, or I believe that I know the size of the hard disk drive on my computer. I can justify that assertion by actually saying or writing the name of the president of France or writing down the actual size of my computer's hard drive. But this is not sufficient. I could say or write something, but it may not be *true*. By 'true' we mean that the statement is the same statement that others would make, or could be revealed by asking the President of France to state his name, or by looking at the specification label on the hard drive.

Thus, *justification* and *truth* have become the foundation of the modern empirical approach to knowledge – unless it can be *shown* and *shared*, it is not 'public' knowledge – ie scientific, as Ziman[6] has succinctly described it.

**Is this book declarative or procedural?**

Paradoxically, although this book is *about* innovation – ie, *ideas in action* – it is, at one level, only *about* innovation – it is a collection of written utterances – words

and symbols- not *action itself* – other than the action of writing utterances. This book is, essentially, *declarative-how-to knowledge* – a set of directions and prescriptions of how to understand and manage innovation. Unless it is read, remembered and translated into actions, it is no more than a series of written utterances. At another level, it *is* knowledge-in-action, as the *production* of this book has been the process of transforming the *idea* of a book on innovation into an *actual* book on innovation. While a myriad of technical and self-help manuals would lead us to believe that declarative knowledge *can* be transformed into a capacity to act, we need to look closer and in more detail at the notion of knowledge if we are to be more effective at innovating.

Essentially, in *our* definition of innovation – the 'process of transformation' is carried out by the *application* or use of knowledge (whatever it is) to create new elements and/or to bring together existing elements to make the system envisaged by our 'idea'. *It is knowledge that enables innovation* – the dynamic process of transforming an idea into something that works.

## Two Modes of Knowledge- *Explicit* and *Tacit*

### Explicit Knowledge

The two different types of knowledge – *facts* and *actions*- can be expressed in two different ways: We can know *of* or *about* 'something', or know 'something' *directly*. We can know *of* something by hearing or reading about it. This is what we call *declarative* knowledge – because someone claims to know something by declaring that knowledge in speech or writing (or maybe hand-signs). As we have said above, declarative knowledge*,* or the *knowledge of utterances,* is know-what, know-how, know-why, know-that, know-if-then, know-when etc. Essentially, it is *explicit statements* – strings of words and/or symbols or *declarations* or utterances about things – that may be spoken, written or otherwise *codified*. By 'explicit' and 'codified' we mean that we can *perceive*, ie, see, hear, taste, touch or smell – and therefore examine – all of that particular knowledge. And because it is accessible – visible, audible, tangible *etc*. – to everyone in much the same way, it may be possible to form a common, or shared pool of knowledge – although actually reaching agreement on its meaning may be difficult. This is the basis of modern science. ***Table 3.1*** gives some examples of each of these forms of declarative knowledge.

- **Definition: *Explicit knowledge is declarative knowledge that can be transmitted completely in a code, such as speech or writing.***

Declarative knowledge may be directly associated with action/procedural knowledge, or it may exist independent of action – ie as 'something interesting' that can be declared to others, but is not immediately or obviously associated with 'a capacity to act'. This is 'knowledge for knowledge's sake'[7]. Despite its apparent lack of immediate usefulness, all cultures continue to accumulate declarative knowledge, at least partly on the justification that some of it demonstrates its usefulness in unpredictable ways and at unpredictable times. *One of the important processes of innovation is to connect facts to make procedural*

*knowledge.* This is one of the main justifications for public spending on 'basic research' – activities that produce new declarative knowledge that is not immediately connected to commercially-oriented procedures.

**Tacit Knowledge**

We can also demonstrate our knowledge of *how-to* without any declarations – by actually *doing* what we claim we know how to do. We can usually describe our actions to some extent – this is the declarative/procedural knowledge that is often associated with action. But, despite our ability to completely and successfully perform the action, we may not be able to completely describe how to do it. The extent of the undeclared action/procedural knowledge is *tacit knowledge*. It may be undeclared because we choose to not declare it, or because we don't have the capability to say the words, or because we simply don't know how we actually successfully perform the actions. A classic case of the last two alternatives is the sports champion who is a poor coach – he may excel in the performance of his expertise, but he hasn't the ability to explain his technique to others.

- **Definition: *The part of one's capacity to act (procedural knowledge) that is not described and is not obvious is tacit knowledge.***

**A philosophical view of explicit and tacit knowledge**

One does not have to utter to be able to act, and in some philosophies utterance and knowledge are considered incompatible. This is far from a new idea. For example, the legendary Lao Tsu, in the *Tao Te Ching* said:

> Those who know do not speak.
> Those who speak do not know…..
>
> Thus, the True Person acts without striving
> and teaches without words.[8]

In Buddhism, *right mind* will lead to *right action*. Right mind can only occur when the internal chattering ceases.

**Polanyi and tacit knowledge**

In Western philosophy, the idea of tacit knowledge was first expounded in detail by Michael Polanyi, who called it *personal knowledge*[9]. As summarised in Wikipedia:

> *… [Polanyi] argued that all knowing is personal, and as such relies upon fallible commitments. Our skills, biases, and passions are not flaws but play an important and necessary role in discovery and validation. Observers cannot remove themselves from their observations and judgements, nor should they[10].*

According to Polanyi, unlike factual knowledge, the capacity to act – ie *procedural knowledge* – cannot be separated from the actor. While recorded utterances, or facts, may be considered as knowledge, separate from any

particular knower, actions are *embodied in* the knower. Therefore, action-knowledge must always be referred to in the context of a knower and must always be, at least partly, tacit. In Polanyi's view, *all* knowledge is ultimately tacit:

> *We may conclude quite generally that no science can predict observed facts except by relying with confidence upon an art: the art of establishing by the trained delicacy of the eye, ear and touch a correspondence between the explicit predictions of science and the actual experience of our senses to which the predictions shall apply*[11].

In essence, Polanyi is saying that as *all knowledge is empirically based*, it ultimately relies on the senses, which are fundamentally subjective and therefore tacit – ie cannot be described at a deeper level of objectivity. Modern neuropsychology is possibly contesting this assertion by identifying the physiological, chemical and electrical processes that attend thought.

So when we say that the knowledge in a system is tacit, we are saying that we observe that the system has the capacity to act purposefully, but we cannot articulate or describe how it does so in sufficient detail for another system to completely emulate its actions based on those (limited) descriptions to achieve the same purpose.

- *Dissecting a lark's larynx will not necessarily enable us to sing as sweetly.*

Anderson[12] summarises the explicit/tacit distinction:

- *The theory of declarative memory gives a natural account of the explicit–implicit distinction. Explicit memories refer to specific declarative chunks that can be retrieved and inspected. Implicit memory effects reflect the sub-symbolic activation processes that govern the availability of these memories.*

Although the above discussion ventures into the realm of philosophy, it is difficult, if not impossible – and ultimately inadvisable – to try to separate what appears to be objective from what appears to be subjective. The processes of innovation and change rely on both.

**Combining the Modes and Types of Knowledge**

We have briefly discussed two *types* of knowledge- *procedural* and *factual* and two *modes* of knowledge- *explicit* (or *declarative*) and *tacit*. In practice, these types and modes can be combined in the following ways:

1. *Procedural/explicit*: This is *know-how* and is in the form of written, spoken or otherwise codified prescriptions, recipes and other logic and reason-driven procedures (eg, if-then).

2. *Factual/explicit*: This is *know-what, know-who, know-when* and any other

kind of data or facts that may be in the form of written, spoken or otherwise codified lists, catalogues or encyclopedias.

3. *Procedural/tacit*: This is *know-how-to* and is only observed and validated in the performance of the claim to knowledge.

4. *Factual/tacit*: This is not tautological, but comprises one's memories, beliefs, dreams or other conscious 'inner voices or images' that may provide a basis for any of the other three combinations.

| **Knowledge Types** | | |
|---|---|---|
| **Knowledge Type/Mode** | **Declarative or Explicit** | **Tacit** |
| **Procedural** | Know-how | Know-how-to |
| **Factual or Propositional** | Know-what, know-who, know-that, etc | Beliefs |

**Table 3.2:** Knowledge types.

It is possible to operate simultaneously in the combinations of *procedural/tacit* and *procedural/explicit*: One can describe one's actions while performing those actions – which is typical of teaching or coaching.

(Summary?)

**Tacit and Explicit Knowledge and Systems**

With the foregoing, we can now proceed to depict explicit and tacit knowledge in a *systems context*. As we have discussed, the *elements* of a particular system-of-interest are usually *sub-systems* – that is, they *also* comprise elements that are related. Sub-systems, by our definition, also have a purpose – which is to serve a function within the system-of-interest. But we may, or may not, know anything about the internal workings of the sub-system.

In our system-of-interest, we can represent the tacit knowledge of elements as shaded circles (Elements B and D in *Fig. 3.5*)- we *may* know their relationships to other elements within the system-of-interest, and we *may* know their purpose with regards to the system-of-interest, but we do not know how to describe their inner workings – they are *terra incognita* – *unknown* in the sense of *declarative know-how*. We say that we *may* know their relationships to other elements, but in some cases we may not, or may only partly know. We know that they *seem* to interact with other elements, but we cannot describe those interaction or relationships in any detail. In these cases, we denote the relationships by a dotted line (relationships A-E and A-C in *Fig. 3.5*).

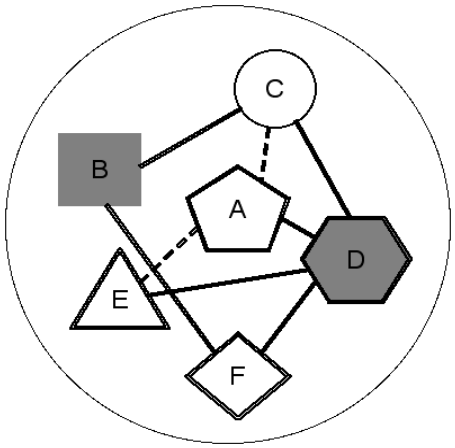


***Fig. 3.5:*** Some elements (shaded B and D) or relationships (dashed) in a system may be functionally or intrinsically tacit.

It is the task of the *cognitivists*- that is, analysts and scientists – to transform these dark elements and dotted lines into *terra cognita* – ie, *declarative know-how*. Holistic thinkers – the autopoieticists and Zen Buddhists and hands-off managers – may chose to leave the inner landscape of such an element unexplored, and remain concerned only with what *emerges* from the system or sub-system. This book, of course, is an example of the cognitivist approach – describing the inner workings of the system called 'know-how-to-innovate', by describing the elements and relationships of the sub-systems that comprise the body of knowledge related to innovation.

**Box- Golf as Codified and Tacit Knowledge**

The game of golf is a good example of how codified and tacit knowledge are linked. At the simplest level, golf is a *system* comprising the basic *elements* of: the golfer, golf course, weather, golf ball and golf sticks. The *purpose* of golf is to strike the golf ball as few times as possible from tee to hole. The codified rules of golf are many and complex and describe some of the *relationships* between the basic elements. What the rules do not describe is *how* to strike the ball (other than that the ball must be stationary when struck): this is left to the golfer to discover for himself or herself. A visit to bookstores and websites will reveal many books, magazines and videos on all aspects of the game – how to use each stick, how to stand and swing it and how to correct problems such as hooking, slicing and topping. The continuing popularity of this codified knowledge would suggest that it is useful – the golfer can translate these written words into bodily action. Nonetheless, the continued purchase of books and magazines or viewing of videos by many golfers would suggest that something seems to be missing from this declarative knowledge: what is missing is something that only the golfer can do – assimilate the knowledge into *their own* actions.

To continue our golfing example, we can easily describe the major steps to hitting the ball 65 metres eg, estimate distance, estimate wind speed and direction, select club, take appropriate stance, swing club, etc. But this leaves a lot up to the golfer – how do they estimate the distance, wind speed and

direction and how hard to strike the ball for a 'half shot'? How do they know what is the appropriate club? What is the appropriate stance given the wind speed and the slope of the ground, etc. All of these questions could, in principle, be answered explicitly, but in practice, *my* 'experience' tells them what to do: having played this shot many hundreds of times, almost everything is *automatic* – ie *subconscious* – they have *tacit knowledge*. Table xx is an example of how this situation might be broken into explicit, functionally tacit and intrinsically tacit components.)

Another source of knowledge is the coach - generally a professional golfer – a 'pro'. Pros often amaze amateur golfers by their ability to deconstruct in great detail the actions that take place in the several seconds that it takes to swing a stick back and strike it at the ball. To the pro, the sub-system of the golfer has many sub-sub-systems with relationships between them: there is grip position, wrist action, left- and right- arm movement, shoulders, posture, feet movement *etc.* – and the combination of any and all of these movements to result in a successful or unsatisfactory result. (This ability to deconstruct is a *skill* - that is, to observe the whole real system and sense variations from the ideal system. In this case tacit knowledge in the golfer is transformed into codified knowledge in the pro). The pro guides the golfer in a number of ways, ranging from demonstrating to advising. Ultimately, the hopeful golfer must 'internalise' this codified knowledge to become his or her own tacit knowledge – *their* 'capacity to act'. A frequent problem is that the golfer endeavours to consciously command himself while executing his swing: e.g., *backswing slowly, shorten back-swing, cock wrists now, pivot hips now*, etc. If there is more than one or two 'corrections' to be made to the golfer's 'known' swing, there is too much codified knowledge to be translated into action in the fraction of a second available – the human mind and body cannot 'compute' quickly enough. The result is often worse than before the lesson. Most pros will advise you to stay on the practice range and hit a thousand balls while any change that you have made becomes part of your 'muscle memory'. Only then can you step up to the ball and hit it successfully without directing your actions with conscious (codified) commands - in other words, you have *tacit knowledge- a capacity to act that is beyond codified description*.

**Functional and intrinsic tacit-ness of Procedural Knowledge**

Another way to look at procedural knowledge is the capacity to *deliberately (purposefully) relate* to another system or other systems. A systems picture helps: As we have discussed above, elements of a system are usually sub-systems – that is, they are also divisible into elements that are related. Like systems, sub-systems, by definition, have a purpose – which is to perform a function within the system of interest that is directed towards the purpose of the system. But we may – or may not –know anything about the internal workings of the sub-system. Polanyi's approach is that tacit knowledge is unuttered and is, essentially, *not amenable* to being uttered, or codified. However, for *our* purposes, it may be more useful to consider tacit knowledge as

- **Definition:** ***Tacit knowledge is procedural knowledge that enables one to act, which has not been codified.***

(We have to confess that in this case we have transgressed one of the 'five fallacies' of definition' discussed in Chapter 1- we have defined something in a negative tone, ie as what it is not. However, we justify this exception because codified knowledge is more apparent and can be used as a clear basis for discussion.)

In turn, we can consider this *non-codified knowledge* in five categories:

1. *Knowledge that may, in fact, be codified, but we don't have (and maybe don't see the need to have) access to that code.* For example, we use computers to send emails and analyse databases and we can drive cars quite successfully without knowing anything about electronics or mechanics.

2. *Knowledge that may, in fact, be codified, but we are unaware of the existence of the code.* For example, the knowledge may be written in another language, or not widely distributed ('arcane'), or we have simply overlooked the possibility that the knowledge exists and have blithely proceeded to 're-invent the wheel'.

3. *Knowledge that we believe that we can readily codify now, but haven't codified for some reason.* For example, we know how to sequence genomes, but the gene sequence of many organisms hasn't been done because of lack of resources and/or immediate interest.

4. *Knowledge that has been previously codified, but has merged into tacit knowledge and the code can no longer be fully understood.* This happens in systems at all levels*, e.g.,* we have successful coaching on improving our golf swing, but later have forgotten the details, even if the swing is still effective; companies implement new specific plans of action and, several generations of staff later, the reasons for that action have been lost or forgotten, although the action is still being carried out.

5. *Knowledge that we can't readily codify now (and maybe will never be able to).* For example, we have a limited understanding of how the brain/mind works – this knowledge is increasing, but is recognised as elementary relative to the brain's complexity. Advances in psychology and psychiatry and human resource management still cannot provide complete and accurate descriptions and predictions of people's behaviour in organisations, or elsewhere for that matter. Nonetheless, we are able to get many of these systems to fulfil their purpose quite well, despite our ignorance of their inner workings.

So, in summary – knowledge may be tacit because we simply do not know how to usefully deconstruct (analyse) the particular system, or simply because we have not applied the necessary analytical effort necessary to understand it. In the first

four cases above, the knowledge is *functionally* tacit, because, as far as we are concerned, we don't (explicitly) know that knowledge, although it may be known or knowable. In the last case, it is *intrinsically* tacit because the knowledge is beyond our (present) reach to codify it.

So our system-of-interest might be depicted by a collection of related elements, with some of the elements depicted in solid colour, and/or some of the relationships between elements depicted as dotted lines, as the explicit (ie declarative procedural knowledge) is not at hand. Nonetheless, as the *system-as-a-whole* has demonstrated its capacity to act to produce an intended result, we assume that *it* 'knows-how-to'. In all these examples, the required actions, or outcomes, consistently follow from the commands that are given to the system-of-interest, so it is not necessary to 'know-how' its sub-systems work – ie what the elements and relationships are within that sub-system – to 'know-how-to'. In all five cases, whatever the reason, we will denote the tacit knowledge as a filled-in (shaded) element or dotted relationship. (Fig. 3.5). This depiction is useful for our purposes of investigating the processes of innovation as we can now visually distinguish between the known and the unknown and the unknowable. (Perhaps different colour-coding of the different types would be helpful).

As we shall see, this systems-depiction can be a useful analytical tool by being able to map the 'players' – ie elements of a system-of-interest in a way that enables us to more accurately pin-point issues that need attention.

**The value of explicit knowledge**

*Declarative/procedural knowledge is not a necessary pre-condition for knowing-how-to*: Although a major goal of the Western intellectual tradition is to codify tacit knowledge, wherever possible, we can live quite successfully despite our ignorance of the detailed inner workings of many things.

- **Example:** Consider the statement:
    - *'they know how to run a successful company'*.

  The 'they' comprises operating staff, managers, a CEO and a board of directors, who need to justify their knowledge to the shareholders by producing an acceptable return on their investment. Although, collectively, much of the 'know-how-to' of the company is explicit, it is *functionally* tacit to most of the staff: The CEO considers the accountant 'knowledgeable', at least with respect to accountancy, as she has demonstrated that she can analyse the company's financial information and provide him with useful financial reports for himself and for the directors to see. She has 'knowledge of accounting' – ie, she has the 'capacity to act', with respect to accounting. The CEO, who trained as an engineer, does not know all the rules, regulations and accounting standards that are the accountant's stock-in-trade. However, *he* knows that *she* knows them, as the company's auditors have consistently verified her work. Of course, he does know how to read and interpret a balance

sheet and a cash-flow statement for the purposes of keeping the company profitable. In turn, the board of directors believe that he is a good manager – that is, he has demonstrated the capacity to act as a manager, even though they do not know exactly how he produces the financial statements for the monthly board meeting, or how he motivates the staff in the factory to make computers that sell well. And the directors are considered by the shareholders to be knowledgeable about directing a company, as the dividend cheques arrive each quarter, the value of the stock continues to increase and the corporations' regulators have not received any complaints about the company's governance. In summary, the 'system', from the computer components, through the shop floor, back office, manager, board and share market, is considered to be performing its purpose – to make a legal profit for the company's shareholders. Things get done – who knows how? – and the desired outcome occurs. There is codified or explicit knowledge in many of the sub-systems, but much of it not known to other subsystems – just that the subsystem has the capacity to act – ie, it 'works' as it is intended to work.

Often, it is only when the system does not function as intended that we want to turn those solid-coloured elements into explicitly described sub-systems and join the dots on the unknown relationships, on the assumption that this 'know-how' will enable the system to 'know-how-to' or why it *didn't* know-how-to when it was believed by the shareholders that it did. In this case, deconstruction, analysis, or making-the-tacit-explicit is the role of the auditors and/or government corporate regulators. Trust is often a substitute for the need for explicit (codified) knowledge. (See Chapter xxx on 'Trust')

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[1] *https://en.wikipedia.org/wiki/DIKW_Pyramid*

[2] Fromm, Erich, *To Have or to Be*, Continuum International Publishing Group; Revised edition (September 23, 2005)

[3] Schumpeter, J.A. (1934): *The Theory of Economic Development: an inquiry into profits, capital, credit, interest, and the business cycle*, Cambridge: Harvard University Press.

[4] See, for example, Anderson, John R et al, *An Integrated Theory of the Mind,* Psychological Review, 2004, Vol. 111, No. 4, 1036 –1060

[5] Plato's *Theaetetus*

[6] Ziman, John M, *Public Knowledge: An Essay Concerning the Social Dimension of Science*, Cambridge UP, 1968.

[7] http://www.timeshighereducation.co.uk/news/v-c-knowledge-for-knowledges-sake-is-piffle/2003445.article

[8] Tao Te Ching, http://spoerlein.iwarp.com/tao1.html (accessed 18/6/2004)

[9] Polanyi wrote a number of treatises on tacit knowledge. One of the most concise is Polanyi, Michael and Prosch, Harry, *Meaning*, Chapter 2, The University of Chicago Press, 1975.

[10] http://en.wikipedia.org/wiki/Michael_Polanyi

[11]

[12] See Anderson, Ref 4