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Mapping the tacit component: Getting away from knowledge conversion

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Mapping the Tacit Component: Getting Away From Knowledge Conversion

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Abstract

This paper argues for a radical new understanding of the topic generally referred to as Tacit Knowledge. On the basis of a new appraisal of the work of Michael Polanyi, we argue that mapping, assessing, fostering, developing, and improving the tacit component in all use of skill and knowledge is more important for management than converting 'tacit knowledge' into anything else. We also argue that attention to the tacit component is especially relevant to the diffusion of skills and knowledge related to new technologies, products, and processes. Finally we also argue that it should not be taken for granted that the tacit component actually existing in any activity is optimal. We suggest that the individual competency is the only level on which the presence or lack of the necessary tacit component can be mapped.

Keywords

HELMHOLTZ, POLANYI, REBER, NONAKA, GESTALT, TACIT KNOWLEDGE, TACIT COMPONENT, IMPLICIT LEARNING, HEURISTIC, ROUTINE, COMPETENCY.

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BACKGROUND

The work of Ikujiro Nonaka and his collaborators has established a paradigm within knowledge management and wider fields of management literature. This paradigm is based on the assumption of a fundamental opposition between the concepts of tacit knowledge and explicit knowledge. In this paper we will try to outline an alternative to this dichotomy. Before proceeding, we shall emphasise what elements of Nonaka's wider paradigm we share. We accept the basic assumption of the resource-based view of the firm, and the generally accepted corollary that knowledge is the least easily replicable resource.¹ Knowledge is therefore the core ingredient of competitive advantage, and of ability to survive at all in open markets where all other inputs are available to new entrants. We also accept the Schumpeterian model² which suggests that all quasi-rents will be eroded by the market, so that innovation is the only source of sustained growth. In the Schumpeterian model, innovation is the result of seeing the possibilities of new combinations of factors, including but not necessarily predominantly consisting of those new combinations made possible by new science and technology. Schumpeterian innovation draws on knowledge of the entire existing economy and technology, and uses this knowledge in a dynamic and transformatory way.

Creative destruction, meaning the obsolescence of entire infrastructures of transport, storage, repair, training, or marketing by the introduction of new technologies which require completely different systems, also has a tipping effect in the obsolescence and replacement of knowledge. Creative Destruction is also often Creative Obstruction, as investment in a new system of infrastructures may prevent the emergence of other new competing technologies which cannot reach the necessary critical mass to become competitive. Innovation thus becomes a race to establish new standards which validate the methods of the successful standard-setter and force competitors to re-tool and adapt to stay in the market.

We therefore also share Nonaka's assumption that firms must seek to achieve innovation in order to remain competitive, and that the generation of knowledge, the process which he dubs knowledge creation, is central to this. However, we will suggest that Nonaka has become too fixated on the boundary between what he calls tacit and explicit knowledge. We do not overlook the fact that he is aware that tacit

¹ The classic references for this field are Penrose 1959, Porter 1990, Drucker 1993 and now Baumol 2002.

² Schumpeter 1934, 1942.

and explicit are a scale rather than a dichotomy. But because he underplays the tacit and implicit elements in all use of explicit and codified knowledge, he actually sets up a distinction which can then easily be misunderstood as a polar opposition. We also consider that his emphasis on the boundaries between different knowledge types as the site of knowledge creation can divert from the task of mapping, evaluating, and improving the implicit and tacit component in all skills and knowledge.

Finally we suggest that the model of innovative knowledge as the sole source of competitive advantage must be nuanced by the recognition of the need for rapid diffusion of the knowledge and skill necessary to use new technologies and products. This follows from the need to not only sell products, but to achieve the role of standard-setter in markets. If achieved, this creates the possibility of a dynamic process of knowledge improvement by integration of feedback from the users of innovative products. Innovators cannot sit on their laurels but must engage in continuous incremental improvement. This is the area in which continuous monitoring of levels and effectiveness of the tacit component in all skills and knowledge can play an important role.

MICHAEL POLANYI

Michael Polanyi developed his theories of personal knowledge, tacit knowing, and indwelling through the 1940s, 50s and 60s in Britain. His works have been found as difficult to read as they were for him to write. A major reason for both of these problems has been that Polanyi wrote at a time and place where the major influences on his thought were unknown, being regarded as outdated (Hermann Helmholtz), having become discredited (the gestalt school) or never having penetrated (Wilhelm Dilthey). Polanyi was not a follower of any of these thinkers or schools, but developed his own versions of their ideas precisely because he considered that they had failed to do so adequately. Polanyi's contemporaries, and later commentators, have attempted to relate his thought to that of philosophers and methodologists of science who were active during the decades of his publication, but we have found that these confrontations are largely misleading and fruitless. The lack of knowledge of the questions and problems which Polanyi was trying to address means that most attempts to use his work have been superficial. This was true of our own attempts over several

past years which have only begun to lead to real understanding since we have been able to situate Polanyi in his proper context.

Polanyi began his philosophical work after three decades as a medical doctor, a crystallographer and a material scientist. The story of how he came to migrate through economic and social studies to philosophy has been told many times.³ One way of approaching the substance of his thought is through what he called the 'fiduciary programme'. He felt that both mainstream philosophy and the methodology of scientific practice had lost touch with the reasons why most people believe and think what they do and why they necessarily act on the basis of these beliefs. Philosophy has constructed a field of study called epistemology which attempts to define the conditions of justified true belief. During the prevalence of positivism and empiricism this discipline had evolved to the point where the only legitimate connection with reality was through the observations of scientific laboratory experiments, while all knowledge of the interconnection of things and processes was to be reconstructed through the logical and mathematical implications of the patterns of these observations. While valuing and participating in this scientific endeavour, Polanyi thought that this approach had lost touch with the ubiquity of belief which in these terms is non-justified or less-than-perfectly-justified, and also that scientists were fooling themselves when they assumed that these other kind of beliefs played no role in the progress of science itself. The 'fiduciary programme' was a list of the beliefs and assumptions which Polanyi believed needed to be explained and 'justified', not in the sense of epistemology, but by showing how they were articulations of experience which could be reproduced by entering into that same experience.

Gestalt theory is nowadays widely known through the frequent reproduction of some of the visual illusions which the gestaltists investigated. These are real phenomena, some of which were first discovered or scientifically described by the gestaltists. Their theory of how these illusions work is now almost completely unknown, because it was so completely discredited that it is no longer discussed. The gestaltists thought that Gestalten or configurations produced fields which actively worked on the nervous system to produce an image in the brain. In the words of a contemporary critic, Petermann, the gestaltists reverted to the *eidola* theory of Epicurus (c.341-271 BC), who suggested that objects project a material copy of themselves which enters the eye

³ Most authoritatively in the recent biography Scott & Moleski 2005.

and then the brain. The gestaltists were unable to produce any experimental evidence for the force fields they postulated, and so their theory was forgotten. Having lived through the heyday of the gestaltists, Polanyi accepted the demise of their theory, but remained impressed by the overwhelming force of images to produce an indelible and inescapable impression. To explain this he took up the theory of unconscious inference which had been proposed by the foremost physiologist of sight and hearing of the nineteenth century, Hermann von Helmholtz.

UNCONSCIOUS INFERENCE

Helmholtz had developed his theory of unconscious inference to explain the indelible and irreversible effect of visual illusions.⁴ The common assumption was that we receive visual data in the form of light particles, which give rise to electrical impulses in the nerves from which the brain constructs our inner visual field. Our visual and mental processes are instantaneous, but they seem to be conscious in the sense that we can learn to see things differently. Both in childhood and in the process of professional education or scientific investigation we can learn to see things differently, and we subsequently continue to see them in the new way. Visual illusions are intractable to this process: they do not go away even after we have measured the object producing the illusion and convinced ourselves that what we see cannot be right. This was the basis for Helmholtz to assume the existence of unconscious inferences, which can sometimes be misled by particular kinds of evidence, and which are impervious to conscious correction.

However, the point of the theory is not to explain visual illusions, rather, one must assume that unconscious inference is the underlying mechanism of all perception, and that the same mechanisms which produce normal vision most of the time produce visual illusions when they fail. Our contemporary understanding of vision suggests that perception is the sum of a variety of filters which are triggered by phenomena suggesting edges and planes, figures and grounds, approaching objects, animate as opposed to inanimate movement, and faces, among other things. Visual illusions arise when these mechanisms conflict. For instance, two lines of the same length appear to be of different length if they end in convex and concave angles respectively. This may arise because of a mechanism which looks for dynamic aspects and sees the endings

⁴ See Warren & Warren 1968, Hertz & Schlick 1977. There are also 19th-century translations of Helmholtz' popular lectures.

with arrow heads as more dynamic than those with arrow feathers (the Müller-Lyer illusion). Leaving the possible explanations of particular illusions, Helmholtz proposes the existence of a mechanism which would explain why all perceived phenomena are value-laden. Previous theories of perception had supposed that the raw data of the visual field were somehow suffused with meaning by the active conscious intellect. Particular parts of the visual field were identified as objects or entities of a particular kind and a practical or moral evaluation was added to them. The theory of unconscious inference allows layers of evaluation to be carried out pre-consciously. Polanyi does not accept Helmholtz's precise formulation of unconscious inference but he posits a similar mechanism underlying all perception and infusing all perception with meaning and value.

Helmholtz may also have contributed to another aspect of Polanyi's thought, namely his special concepts of *commitment* and *indwelling*. For Polanyi, *commitment* is the way in which we trust our environment to correspond to our expectations, nearly all of the time, and *indwelling* is the way in which we become entangled with those particular contexts which become *our* contexts. Both are results of our attuning ourselves to our surroundings. Helmholtz felt he had to explain why we assume that our perception is about reality, since it is inside our head and we have no way of getting outside our head to make sure that our perceptions are correct. He suggested that we turn phenomena such as patterns of light or sound into perceptions by relying on them as tokens of reality. Or rather he suggested that this is what primitive organisms with very minimal ability to be affected by light and sound and no ability to reflect on the matter did millions of years ago. We modern humans rely on our perception to be a map of reality because it has worked for us for millions of years. The rational intellect simply does not have any say in the matter. We can to some extent choose to indwell one way of life rather than another, but in whichever direction we choose to go we always encounter a meaningful and value-laden world. The scientist, the doctor, the connoisseur of art, the specialist of every kind, whether they pursue their specialism as a profession or as a hobby, enters into a world which initially consists of indistinct and confusing impressions, but which through indwelling falls into place in much the same way for all who persist in taking this path. As evidence that Polanyi may have been influenced by Helmholtz here are two passages, one from Polanyi, and one from a scientist who was certainly not familiar

with Polanyi's work but like him was educated under the sway of Helmholtz's reputation and tradition:

It presupposes that our sense impressions are not a permanent hallucination, but the indications of, or signals from, an external world which exists independently of us. Although these signals change and move in a most bewildering way, we are aware of / objects with invariant properties. The set of these invariants of our sense impressions is the physical reality which our mind constructs in a perfectly unconscious way. This chair here looks different with each movement of my head, each twinkle of my eye, yet I perceive it as the same chair. Science is nothing else than the endeavour to construct these invariants where they are not obvious. If you are not a trained scientist and look through a microscope you see nothing other than specks of light and colour, not objects; you have to apply the technique of biological science, consisting in altering conditions, observing correlations, etc., to learn that what you see is a tissue with cancer cells, or something like that. The words denoting things are applied to permanent features of observation or observational invariants. **Max Born 1964 pp.103-104.**

If explicit rules can operate only by virtue of a tacit coefficient, the ideal of exactitude has to be abandoned. What power of knowing can take its place? The power which we exercise in the act of perception. The capacity of scientists to perceive the presence of lasting shapes as tokens of reality in nature differs from the capacity of our ordinary perception only by the fact that it can integrate shapes presented to it in terms which the perception of ordinary people cannot readily handle. Scientific knowing consist in discerning Gestalten that are aspects of reality. I have here called this 'intuition'; in later writings I have described it as the tacit coefficient of a scientific theory, by which it bears on experience, as a token of reality. Thus it foresees yet indeterminate manifestations of the experience on which it bears. **Michael Polanyi 1964A p.10**

The scientific process, the 'endeavour to construct ... invariants where they are not obvious' or to 'discern... Gestalten that are aspects of reality' is seen as a development of the normal perception which 'which our mind constructs in a perfectly unconscious way' for Born as for Polanyi.

In 1959 Polanyi reaffirmed his debt to Wilhelm Dilthey and recommended the presentation of his thought in English by Hodges.⁵ Polanyi related his concept of *indwelling* to Dilthey's *reliving*, but criticised Dilthey for not realising (or allowing) that our relationship with nature is basically of the same value-laden kind. He considered that Dilthey was the major inspiration of the Gestalt school, but that they had failed because of following him in their acceptance of a rigid division between the natural and historical sciences.

⁵ Polanyi 1959 pp.101-102 and see Hodges 1944, particularly Dilthey on pp.121-124 and Hodges' explanation of this on pp.18-19.

PERSONAL KNOWLEDGE

This is the background out of which Polanyi developed his theories of *personal knowledge*, *tacit knowing*, *focal* and *subsidiary awareness*, *commitment*, *indwelling*, *probes*, *heuristics*, *breaking out* and *turning around*.⁶

The centrepiece of this array of concepts is the distinction of *focal* and *subsidiary awareness*. Human action is telic, goal-oriented. In any particular episode of a goal-driven process, we have in our focal awareness the current and the immediately following stages of progress towards our goal. Everything which is not part of the process fades into the background, unless it is an immediate danger, and sometimes not even then. Around the centre of focal awareness there are elements of subsidiary awareness which are more or less primed to become aware if called on: dangers inherent in the process, problems which often arise and which call for a particular response, ways in which the process may evolve so that our goal must itself be altered to take account of it, higher levels of goal which may become relevant if particular pathways emerge as necessary. Some processes are inherently more all-or-nothing whereas others can follow various branching pathways which each call forth new sets of opportunities, dangers, and methods. In the focal awareness there is an immediate unity of doing and knowing, of knowing how and knowing that, of judgement and decision.

The pattern of what is to be found in focal and in subsidiary awareness is inherently *personal*: no two individuals will have exactly the same pattern of past experience and of reaction to that experience which could create an identical pattern of response. Apprenticeship in a historically stable trade or profession, with a traditional repertoire of materials, tools, techniques, and products, can to some extent reduce the discrepancy between personal knowledge patterns to those which arise from the individual's personality and other life-experience. This way of life has now largely disappeared. Most practitioners now have a profile of experience which is likely to have arisen from exposure to a shifting and unrepresentative sample of contexts.

The balance between what must be focal and what can be subsidiary, or what can be focal and what must be subsidiary, is also not fixed. Superficially, through experience the novice becomes a practitioner and then an expert, becoming able to release more and more of the process into subsidiary awareness as both action and judgement

⁶ These concepts are best accessed through the detailed subject index to *Personal Knowledge* 1958; many of them are further developed in Polanyi 1959 pp.11-39, Polanyi 1966 pp.3-25, Polanyi 1969 pp.123-207, and Polanyi and Prosch 1975 pp.22-45.

become more automatic. But in some kinds of work this may be accompanied by an increased sensitisation to aspects which were initially not perceived at all, so that the burden on focal awareness remains the same although the content changes.

We could investigate these pathways in greater detail. But we must also realise that what makes this process possible at all is the faculty of maintaining a vast number of contexts distinct, and of situating each of these contexts on a branching system of pathways. The objectively same phenomena do not have the same value at different stages of any particular process. They may be symptoms of something good at one time and of danger or failure at another, and something to which no attention needs to be paid at yet another. The way in which we build up our knowledge of these facts may have explicit, tacit, and implicit elements. That is to say, we may be told things, we may experience things which we could put into words if necessary, or we may absorb data without even being aware of doing so. (And the three sources of knowledge may not agree, leading to discrepant behaviour based on which mechanisms are called on when we need to respond to the relevant phenomena).

But we could not build up any base of explicit, tacit or implicit knowledge if we did not have a way of tagging data and especially new data to particular contexts. This is at least part of the meaning of *indwelling*. In order for us to begin to build up a system of contexts such that over time we can evaluate a symptom differently in one context rather than another, we need to accept contexts as *our* contexts. This is the second sense in which knowledge is inherently *personal*: we cannot actively build up a system of knowledge from our experience unless we somehow 'know' which items of our past experience must be updated by which items of new experience, and which not, and unless we have a mechanism to sum data relevant to one context and keep this sum distinct from that for evaluating the same kind of data in a different context. These are processes which can take place on implicit, tacit, and explicit levels, and once again these different levels may give rise to different results if they use different filters to decide what new data to accept, or if they map our contexts differently.

Before moving on, it may be useful to reflect on Polanyi's prime example of the relationship of tacit and explicit knowledge. Drawing on his own experience, Polanyi describes how medical students learn to interpret pulmonary X-ray images. They begin by being introduced to three sources of knowledge: actual patients, X-rays, and the textbook terminology of symptoms and conditions. These are all equally meaningless. By moving backwards and forwards between wards, lectures, and

images, the students eventually begin to see figures emerging from the cloudy or web-like ground of the images, which they can associate with the professor's words or with a patient's symptoms. Polanyi is convinced that it is impossible to build up either an understanding of the terminology --- explicit or declarative knowledge --- or to distinguish the different forms --- a process which is largely implicit or tacit, based on habituation --- to any degree in isolation. It is the interaction of the two inputs which enable the student to fix the implicit recognition of similar forms by attaching them to a name, and the establishment of some classes of known forms which enables the student to ignore these and begin looking at the even vaguer and more hidden shadows which they at first do not even discern.

Probes are tools which provide us with data. The skilled user of a tool no longer feels the tool in the hand (unless it hurts) but interprets the pattern of pressure on the hand as data about the water at the end of the oar, the wood at the end of the screwdriver, or the nail at the end of the hammer. This is why it is normally not advisable to hammer nails in slowly: the chance of missing or hitting askew at each new approach is quite high, whereas the rapidly fading feedback from the first hit enables the user to improve the trajectory of the second hit. An important aspect of skill is that the tool user both has familiarity with the interpretation of the pattern of pressure transmitted by the tool, so that the tool is a better prosthesis for the skilled person than for a novice, and also that skill involves expectations about the quality of the medium and what to do in response to variations in the medium. We must both recognise the 'feel' of screwing into knotty wood and actually know what knotty wood is and implies for our purpose.

Polanyi believes that *heuristics are probes*. This is of fundamental importance for understanding the relevance of Polanyi's ideas to science, medicine, markets, management, navigational systems, diagnostic systems, and cyber space generally. In the same way that tools allow us to feel the medium in which they are working, the results of action based on heuristics allows us to feel and build up a picture of the medium in which our decisions are our tools. By indwelling a field of events and processes, we cannot avoid unconsciously integrating these particulars into a coherent scheme, an unconscious or implicit mental map (this may not entirely coincide with our verbal description of the same phenomena). When we make decisions which lead to unexpected outcomes, this can be felt like a chair collapsing under you, and in more mundane cases leads to an automatic updating of our valuation of the map we have

constructed, a wrenching feeling that things are not as they seem or should be, followed by an unconscious disintegration and reintegration of our scheme. Exposure to different patterns of information will necessarily lead to different patterns of integration of these particulars. This relates to the question of information overload pulling organisations in different directions as individuals and units construct different schema based on integrations of different selections of the information.

Polanyi considered that *breaking out* was a phenomenon common to science, mathematics, art and religion. This means that the integration of particulars, which we cannot avoid entering into when we indwell those particulars intensely, leads us to project continuations of the trends and tendencies which we consciously or unconsciously discern in them. In all these areas, *This endeavour must occasionally operate by demolishing a hitherto accepted structure, or parts of it, in order to establish an even more rigorous and comprehensive one in its place* (1958 p.196). These phenomena are the most developed expression of the fact that perception always points beyond itself. Helmholtz transmitted the idea that we can only investigate things which affect us in some way so that we become aware of them. Physics was initially developed so that we could predict eclipses, build bridges, fire cannon, and do other practical things. This ultimately led to the development of the theory of the atom, which we cannot see. You could say that we are not 'affected' by sub-atomic particles, and that therefore we have no reason to look for them except pure curiosity. But this curiosity is of a special kind. Those scientists who work at the frontier of science indwell their data and cannot help but build up heuristics and mental maps of their subject matter. For them minor discrepancies in existing theories are real issues which do affect them. This led them to postulate sub-atomic particles, the only 'evidence' for which was the fact that they cleared up discrepancies and contradictions in existing theories. This in turn led to the search for technologies which would actually reveal these entities. This is the paradigm of *turning around*, taking one set of ideas as the basis for developing a new one.

We can now return to the question of tacit knowledge, tacit knowing, and the tacit component or tacit component.

THE TACIT COMPONENT

From a bottom-up perspective, all of what is normally called knowledge consists of a system of correlations between internal states and external states. All such correlations remain implicit for entities which do not have a brain with an attentional centre, and remain tacit for all entities which do not have a language or sign system. We have both of these things, but how much of our system of correlations is accessible to the attentional centre, and how much of it is ever worked up into explicit statements and actually communicated to others? A vanishingly small proportion. Even when we use language, we interpret what we hear or read through implicit and tacit channels, assimilating vast amounts of information in the form of clues which we integrate unconsciously to add a massive amount of value and interpretation to the bare words of the message.

The use of language requires an enormous amount of shared cultural assumptions. When a job or task is described as unskilled, what is normally meant is that it requires only the vast amount of background knowledge and assumptions which can be expected to be shared by most adults of the culture in question. Within any particular profession or organisational context, explicit communication again takes for granted a wide range of special knowledge and familiarity. So most explicit communication really consists of triggers which cause the recipient to begin using one particular repertoire of actions rather than another. The amount of genuinely new information which is imparted by most explicit communication is very low.

Against this background, what can still be called tacit knowledge? It might seem that from an observer's point of view, it is knowledge which is not easily available in articulated form but which nevertheless constitutes the difference between the individual being able to do something or not being able to do it. There is a problem with this, namely that whether something is available in articulated form may be highly context-specific. The classical case of this is the inability of people to do formal arithmetic which exhibits exactly the same abstract structure as mathematical operations they conduct with ease in their personal or work life.⁷ This seems to show that these individuals do not recognise the problems as ones they know how to solve, but an alternative explanation would be that they simply do not activate the relevant processing circuits outside of the contexts where the individuals have gradually built

⁷ See Lave 1988.

up their actual expertise. This has obvious implications for retraining and other forms of transfer within work contexts. What seems to be an analogous situation or process to the observer may not reproduce the patterns of activation of tacit knowing which actually enable the individual to effortlessly call on them.

So, emerging from the tacitness related to the variability of articulation there is also a tacitness which is related to the variable levels of access to the processes themselves, which may be context or process-related. This would be explainable in Polanyi's terms by the goal-centred nature of focal awareness: every habituation to focal awareness on a particular object or process is associated with an activation pattern of subsidiary elements of tacit knowing, which will not necessarily be reproducible in different circumstances.

NONAKA AND CONVERSION

The statement made above to the effect that the paradigm of Nonaka and his collaborators *is based on the assumption of a fundamental opposition between the concepts of tacit knowledge and explicit knowledge* might seem unfair in view of some of the statements in Nonaka & Takeuchi 1995 which transmit a more nuanced understanding of the relationship between these elements. We must first of all acknowledge the importance of this work for beginning the widespread reception of Polanyi's ideas in management and knowledge management circles. The central importance of Michael Polanyi's theory of tacit knowledge for the processes of innovation and competitive advantage was already made clear by Nelson and Winter 1982, but gained wider attention after Nonaka took up the idea as a major element in explaining the relative success of the 'Japanese Model'. Nonaka and Takeuchi introduce the concept in the following way:

Polanyi contends that human beings create knowledge by involving themselves with objects, that is, through self-involvement and commitment, or what Polanyi calls "indwelling". To know something is to create its image or pattern by tacitly integrating particulars. In order to understand the pattern as a meaningful whole, it is necessary to integrate one's body with the particulars. Thus indwelling breaks the traditional dichotomies between mind and body, reason and emotion subject and object, and knower and known. Therefore, scientific objectivity is not a sole source of knowledge. Much of our

knowledge is the fruit of our purposeful endeavours in dealing with the world.

NT 1995 p.60.

This and the following paragraph pack in a good many of Polanyi's difficult concepts and display an understanding of the radical nature of Polanyi's project. The authors then present a diagram of the contrasting characteristics of two types of knowledge, tacit and explicit. In the text it is made clear that the qualities ascribed to the different kinds of knowledge are scalar rather than polar:

Features generally associated with the more tacit aspects of knowledge are listed on the left, while the corresponding qualities related to explicit knowledge are shown on the right. For example, knowledge of experience tends to be tacit, physical, and subjective, while knowledge of rationality tends to be explicit, metaphysical, and objective. NT 1995 p.60 (the table is on p.61)

The authors thus seem to be innocent of intending any dichotomy. But on the next page the introduction of their concept *Knowledge Conversion* actually does lead to this, even though their words express the intention of avoiding precisely this result:

While Westerners tend to emphasize explicit knowledge, the Japanese tend to stress tacit knowledge. In our view, however, tacit knowledge and explicit knowledge are not totally separate but mutually complementary entities. They interact with and interchange into each other in the creative activities of human beings. Our dynamic model of knowledge creation is anchored in the critical assumption that human knowledge is created and expanded through social interaction between tacit knowledge and explicit knowledge. NT 1995 p.61.

On page 62 they introduce their model of the four modes of knowledge conversion, from tacit to tacit through *socialization*, from tacit to explicit through *externalization*, from explicit to tacit through *internalization*, and from explicit to explicit through *combination*. At this point we are already forced to object. The discussion on these and the following pages seem to us to have one fundamental flaw, which is to overlook the irreducible tacit component in all use of explicit knowledge, in all acquisition of explicit knowledge, and indeed even in all holding of explicit knowledge. This seems to us to be at the root of the reintroduction of a dichotomy, which is not based on any explicit or intended differentiation of tacit and explicit

knowledge, but on the assumption that 'tacit' and 'explicit' knowledge are members of a species of 'knowledge'.⁸

Previous writers who have attempted to work with the concept of tacit knowledge have found it necessary to break away from the associations of the word 'knowledge'. Tsoukas and Gourlay taken up Michael Polanyi's more fundamental term 'tacit knowing'.⁹ Gourlay pointed out that Polanyi uses the term *tacit knowing* much more frequently than *tacit knowledge*.¹⁰ The use of the latter may derive from the greater familiarity of management writers with Polanyi's lectures contained in the short book *The Tacit Dimension*, rather than with the more challenging *Personal Knowledge*. Ambrosini and Bowman proposed using the term *tacit skills*, as was done by Ambrosini in her later book.¹¹ Our suggestion to be outlined below is to investigate Polanyi's use of the terms *tacit coefficient* and *tacit component*.¹² Before opening up this question we will return to the implications of Nonaka's scheme of the four modes of knowledge conversion.

Socialization is proposed as the mode of tacit to tacit conversion.¹³ Initially observation, imitation and practice are proposed as the basis of apprenticeship. However, two of the three examples given involve substantial verbal exchange.¹⁴ Our understanding of these examples is that over and above the explicit content of the exchanges, between colleagues and between workers and actual or potential clients of a firm, there is a degree of implicit learning by which the learners build up a pattern of expectations about how others will react in the future. This learning is implicit in the

⁸ The same problem arises with the later collaborative works von Krogh, Ichijo & Nonaka 2000 and Nonaka & Nishiguchi 2001, which continue the project of knowledge creation through converting or combining different types of knowledge.

⁹ Tsoukas 2003, cited here from 2005, pp.146-148, and Gourlay 2002 pp.8-11, and 2004b pp.90-93. Gourlay 2000 is a full-scale critique of Nonaka and Takeuchi which makes many of the same points as we are doing.

¹⁰ Gourlay 2004b p.90.

¹¹ Ambrosini & Bowman 2001 p.814. Ambrosini 2003 is an investigation of tacit routines in Nelson and Winter's sense.

¹² Very nearly half of the book *Personal Knowledge* (1958, 428pp) is made up of the section entitled *The Tacit Component* (pp.69-245 out of 405 pages of text). The 22 references to explicit discussion of the *tacit component* listed in the index include those for the *tacit coefficient*, which is not given a separate entry in the index but referred to *component*. In the passages where Polanyi uses the term *tacit coefficient* there is no obvious distinction intended between *coefficient* and *component*. In his subsequent books Polanyi increasingly uses the terms *tacit knowing*, *tacit powers*, and *tacit integration*. The book-length discussion of his thought by Prosch (1986) does not use term *tacit component* at all but discusses only *tacit knowing*. We consider this unfortunate both because it has led to the slide from *tacit knowing* to 'Tacit Knowledge', and also because it has caused the neglect of the aspect of variety and changeability in the mobilisation of different tacit resources. In our opinion Polanyi seems on balance to have intended the *tacit component* to be understood as made up of a wide variety of contributory inputs which would be activated in different patterns, while the *tacit coefficient* was probably intended to signify the sum total of these inputs. Since we have found that the use of the term *coefficient* either provokes simple rejection of the usage, or the expectation that a simple mathematical formula is intended, we will from hereon use *tacit component* throughout. Several of the quotations from Polanyi reproduced maintain his original usage however. It is our intention to find ways of mapping the tacit component, while remaining clear that this will be made up of a range of incomparable elements, so that any summative score of such a mapping would have only indicative meaning.

¹³ The individual development of tacit knowledge, by trial and error, or by trial-and-error combined with meditative reflection, as exhibited by Köhler's apes (Köhler 1927), is the only conceivable 'input' into the system of Nonaka and Takeuchi, which otherwise 'creates' new knowledge by its own interactions. This input may be purely historical, in the sense that all current trial-and-error is undertaken by individuals who have 'learnt' the technique of trial and error itself.

¹⁴ The other example is the contested bread-making project (Tsoukas 2003), which seems to us to be an *externalization* by the authors' own criteria.

technical sense because it is not the conscious aim of the process from the point of view of any of the direct participants, although it may be desired by management, and because the specific outcome is not the absorption of the other's explicit knowledge but of their habits and inclinations, based perhaps on their unconscious map of the world. We would largely accept this as valid, but we feel that there is already a problem with the authors' drive towards knowledge creation, which leads them to neglect apprenticeship and perhaps to overlook a mode of incremental growth of tacit knowledge as a viable alternative to knowledge 'creation'.

Externalization is treated next and is immediately linked with the concept of *Articulation*, the title of a section of Polanyi's main work *Personal Knowledge* on which he spent more time than on any other section.¹⁵ The examples given, however, are not examples of tacit knowledge being worked up into explicit knowledge by the process of articulation as understood by Polanyi. In fact the best example which could really illustrate this would be Tanaka's sudden insight that the twisting process made a difference to the bread, which the authors have treated in the previous section. Instead we are given examples in which the actors begin from conceptual thinking and dip down into the tacit realm through the use of metaphor. This is a valid procedure but it is misleading here because common understanding based on common metaphors is still not explicit knowledge from the point of view of persons who are not socialised into the context where the metaphors make sense. The authors' final paragraph leads into the aspect of *Sensemaking* as described by Weick: because most human contexts do not justify or could not bear being made fully explicit and mathematized, a small number of schematic heuristics is all that is necessary to make things function. This is part of the process of *articulation* as understood by Polanyi, but it is misleading to present it as the whole of the subject.

Combination is the most widely contested of the four areas of conversion proposed here. The idea is that bodies of explicit knowledge can be juxtaposed and their overlap or disjunction gives rise to new insights. This section displays a remarkable fracture between the two short definitional paragraphs, and the examples which seem to be talking about something else entirely. We surmise that this is because there is actually no way in which two bodies of explicit knowledge can ever be compared and contrasted without drawing on the vast background of tacit knowledge and tacit

¹⁵ See Grene 1977 p.168.

understanding which the users of the two bodies of explicit knowledge bring with them. This entire section exemplifies the basic problem of drifting into speaking of explicit knowledge as a separate realm from tacit knowing.

Internalization is described as *a process of embodying explicit knowledge into tacit knowledge*, and as *closely related to learning by doing*. Again we apparently start with a naked manifestation of explicit knowledge, but in the examples this fiction is abandoned and the processes actually described are hybrid methods of disseminating tacit knowledge within an organisation. There is a real process of moulding behaviour to parallel the processes described in highly abstract explicit sources, but on the one hand this requires another body of tacit knowledge, namely that of the systems used to encode and decode explicit forms of communication in language, mathematics, and diagrammatic forms, and on the other it is at the least an open question whether the knowledge eventually embodied in the skills and habits of the practitioners is the 'same' knowledge as that which they have used to condition themselves into these skills. The authors have previously referred to the ACT model developed by Singley and Anderson,¹⁶ which they saw as a one-sided model of conversion from declarative to procedural knowledge. It would have been useful if they had taken a real example from the ACT theory. The authors Matsushita example, of learning-by-doing what working 1800 hours a year would be like by working 150 hours in a trial month, is not an *embodiment* of any pre-existing explicit knowledge, and is merely a large-scale exercise in learning by trial and error.

The writings of Michael Polanyi are very difficult to absorb because they use terms in ways which are difficult to understand until one has grasped his entire system. In this sense they embody the very process of tacit integration which he is attempting to explain. It has taken us several years of gradual approach to reach the insight we believe we have achieved. We do not wish to denigrate the work of pioneers in uncovering the value of Polanyi's insights. We believe however that the lack of an understanding of the enormous tacit component in the use of all explicit knowledge has undermined the working out of the four conversion modes in this book. This problem is shown up acutely by the fact that most of the authors' examples could just as easily be fitted into one or more of the other of the four sections. Helping individuals and organizations to make their tacit assumptions explicit is a valid

¹⁶ Anderson 1983 and Singley and Anderson 1989 cited NT 1995 p.61.

procedure and has a place in management theory and many other areas of life. We feel that the emphasis on conversion between tacit and explicit knowledge has obscured the enormous importance and value of tacit knowing and the tacit component in all activity and skill. It has perhaps also led to an emphasis on the disjunction between tacit and explicit knowledge at the expense of insight into the variety, variable quality, and potential internal disjunctions within tacit knowledge. These are the areas which we now want to investigate.

MAPPING THE TACIT COMPONENT

Although not using the terminology of the tacit component, several previous writers have attempted to specify the levels and types of tacit knowing or tacit knowledge. The first was Boisot, who suggested in explicit contrast to Nonaka and Takeuchi that *tacit knowledge comes in three distinct variants*.¹⁷ These he considers to be (1) *Things that are not said because everybody understands them and takes them for granted ... Such knowledge could in principle be articulated, but it is not ...* This could be exemplified by describing a path to a stranger which local people never discuss as such. In Boisot's work it is highly relevant to the culture clash and cognitive dissonance which occurs when firms merge. (2) *Things that are not said because nobody fully understands them. This is the kind of knowledge that the philosopher Michael Polanyi deals with ...* This formulation is problematic because, perhaps driven by the rhetoric of contrast with the previous paragraph, Boisot apparently conflates understanding with explicit or declarative knowledge. This amalgamates the important aspect of the tacitness in use within the focal-subsidary relationship of knowledge which may otherwise be perfectly articulable, with the genuinely implicit nature of some elements of tacit knowledge. (3) *Things that are not said because while some people can understand them, they cannot costlessly articulate them.* Boisot sees this as being the kind of knowledge with which Nonaka and Takeuchi are actually concerned.

Boisot adds a very important point, namely that *codification and abstraction are devices for shedding data. Consequently, structuring data for the purpose of sharing it creates a fundamental asymmetry between senders and receivers ... Whether they*

¹⁷ Boisot 1998 p.56, the following citations are from p.57.

are aware of it or not, senders will always know more than they can say. Unfortunately, when Boisot states that *The passage from tacit to codified and abstract knowledge incurs a cost*, he introduces an ambiguity into his previous use of the phrase *costlessly articulate*, since we now do not know if he is referring to the resource cost of articulation or the 'cost' of losing some of the data. His trichotomy can be shown as a scale (reordered in accordance with the first criterion):

	Who has knowledge	Articulable	Resource cost	Information loss
2	No-one	No	NA / Very High	NA / Very High
3	Some people	Yes	High	High
1	Everyone	Yes	Low	Low

In most cases we can assume that resource cost and information loss are correlated, at least as Boisot has defined them, since gathering knowledge restricted to a few will divert them from their normal activities, while the information known to all will be easily collected and can be largely without a residue because of its inherent simplicity. But it would be useful to look for those special cases where this correlation breaks down. Where no-one fully understands a skill, 'articulation' of the skill would be impossible but modelling of the skill behaviourally would be a close but expensive substitute.

Ambrosini and Bowman suggested that causal mapping was the best way to approach mapping tacit skills, the term which they use for what is generally called tacit knowledge. Causal mapping would ask subjects *what they do that causes success* (2001 p.825). This method is therefore particularly useful for eliciting what are the critical competencies in any situation. Focussing the subjects on success also helps to elicit information which would otherwise be tacit. However, they stressed that the resource problems of mapping tacit skills were enormous. In her subsequent research, published in Amrosini 2003, Ambrosini felt that a more manageable approach, still using the causal mapping technique, was to concentrate on the routines rather than the individual skills of an organisation. Nelson and Winter (1982) had identified routines as special areas of competitive advantage because they are more difficult to replicate than individual skills. In investigating tacit routines Ambrosini attempted to develop a method for assessing which tacit routines contributed to the success of the firm. The difficulty of doing this research demonstrated that the criteria of success or of contribution to the wider success of the firm were very difficult to elicit and confirm.

Ambrosini and Bowman had begun by realising that *the definition of 'tacit' skills may encompass a range of different degrees of tacitness* (p.815), and they considered mapping the degrees of tacitness. However, their scale, based on how easily skills could be explained (p.816), was perhaps the wrong starting point, being situated in the discourse about knowledge conversion. In the text they mention an alternative approach, namely the degree to which skills *are tacit but have been acquired explicitly* (p.814). This prompts us to ask whether it would not be better to leave these questions, which are perhaps driven by research priorities, and to ask how much of a skill is tacit in use, or which parts of a skill are tacit in use, rather than taking ease of elicitation or the degree of articulation as the criteria.

Jimes and Lucardie formulate their approach as an attempt to escape the *tacit-explicit distinction* and return to Polanyi for insights on the possibility of *functional tacit knowledge management*. Their subject matter is knowledge management, and the aspect of particular interest to them is the matching of object-types. Concretely, for them this means that firms, banks, and government agencies need to have criteria for treating clients, cases or occurrences as the same (with a standard response) or anomalous. When skilled human beings look at a real situation, they immediately identify the goals, the primary goal, and what aspects of the situation are relevant to the primary goal and the necessary intermediate goals. For experts this judgement is usually tacit, which is to say it is usually immediately obvious. Perception and judgement are combined. For learners a degree of explicit reflection or consultation with sources of explicit knowledge may be necessary. Jimes and Lucardie are arguing that the organisation should reflect and facilitate these processes, but that a lack of clear formulation of the goals of the organisation or its parts leads to a proliferation of explicit knowledge which is often irrelevant to the practitioners' needs at any particular point in the process. By functional tacit knowledge management escaping the tacit-explicit distinction, they mean the development of a goal-driven total environment which supports and facilitates the use of human tacit knowledge in deciding anomalous cases, while making maximum use of standardisation wherever this is appropriate to functionally equivalent circumstances. This effectively means that instead of attempting to formalise tacit knowledge, their approach would direct the holders of tacit knowledge to their most useful areas of application of this knowledge in deciding on cases which were too complex for a formalised system to handle them.

This could be developed in terms of designing systems in ways which assist practitioners to develop the nested contexts and pathways we have discussed above. One contemporary of Polanyi whose works do have considerable relevance for the further development of his theories might be Piaget. Gourlay has drawn attention to Piaget's claim that the behaviourist

stimulus-response model must be modified by the interposition of *assimilation into a schema*.¹⁸

IMPLICIT LEARNING AND TACIT KNOWLEDGE

The term implicit learning was first used by Arthur Reber in 1967.¹⁹ Reber has acknowledged that Michael Polanyi's work was among the sources which inspired him to develop this approach. Implicit learning refers to the appearance of knowledge about our environment which we are not conscious of having. It is revealed when we are forced to choose between options in regard to which we have no conscious basis for any preference. Over the following decades Reber devised a series of experimental environments in which subjects of what is ostensibly a memory experiment are occupied with materials which are ostensibly strings of meaningless symbols. The symbols are indeed meaningless, but they are constructed according to rules which generate certain strings and exclude other strings. The attention of the subjects is not drawn to the structure of the strings, and as far as possible it is diverted from any conscious consideration by the demands of the ostensible task. It has been consistently found that subjects subsequently have some hidden knowledge of the 'grammar' of the strings, that is to say that they can judge whether novel strings are 'permissible' or 'impermissible' in agreement with the rules actually used to generate the initial sample of strings.

Reber's evidence has been challenged in recent years.²⁰ In some experiments it is alleged that the subjects have used the presence of recurring sub-sequences as an aid in the memory task, and therefore have applied some conscious attention to structural elements of the material, subverting the claim that learning has been implicit. More refined versions of the experiments have been developed which should remove this possible source of contamination. Another criticism may be an artefact of how Reber has interpreted and presented his material. He initially claimed that the product of implicit learning was an implicit representation, not available to the conscious mind, of the structure of the 'grammar'. This was often illustrated by a diagram of the pathways from one symbol to another which were permitted within a particular 'grammar', implying that two symbols which were not connected by a pathway could

¹⁸ Gourlay 2001 p.10 citing Piaget 1971 p.71.

¹⁹ See Reber 1993 for an overview of the subject.

²⁰ For the entire following discussion see Dienes and Perner 1999, an open review article with 38 comments and the authors' replies; and Shanks 2005, a literature review. Other important stages in the debate are Seger 1994, Stadler and Frensch 1998, and Reber, Allen, and Reber 1999.

not follow consecutively in the data samples presented to the subjects. Critics have alleged that experiments using different procedures seem to show that subjects do not have a unified abstract representation of the 'grammar' but only a number of discrete rules governing the construction of discrete 'chunks' of the data. This seems to be a distinction without a difference, or a confusion between using the 'grammar' and drawing a diagram of it. Presumably our 'grammars' of natural languages and of other rule-bound systems are normally available only in the form of 'chunks' of rules, which we can verbally or diagrammatically build up into a system, but which normally call on and use as discrete 'chunks'.

One important outcome of the improvement of the experimental conditions and their analysis which resulted from these disputes is that all participants appear to agree that subjects can 'codeswitch' between different 'grammars'. That is to say, subjects exposed on different occasions to two different 'grammars', both using the same repertoire of meaningless symbols, but with different rules for the possible combinations of these, can subsequently judge new strings as permissible or impermissible in terms of one or the other 'grammar', even though they do not have conscious access to the full system of rules for either 'grammar'.

This is of critical importance for the whole significance of Michael Polanyi's approach. We must suppose that in different situations there are different configurations of focal and subsidiary awareness, whereby different patterns of skill and knowledge are either activated or de-activated. We must further suppose that new input about the specific form of the task or problem is added to our data stores, updating the values of these in a way which is tagged to the specific situation or context and not necessarily altering the values of the same variables in so far as they are tagged to different contexts, or only in very attenuated way.

Thus the system which identifies different contexts, switches between them as necessary, and routes new data to the appropriate more-or-less insulated areas for summation with past experience, must be part of the most basic machinery of the brain which has been carried over to subserve the conscious and explicit functions of the brain.

At this point we can bring together all of the component strands of this paper. The economic theories we draw on suggest that the locus which the pressures of competition, the need for competitive advantage, and the need for incremental and

continuous innovation bear directly is the individual competency²¹ and the individual tacit routine. Wider systems of skill and knowledge also need to be continually updated and adapted to new circumstances, but the site of breakthrough innovations and improvements is at the level of the competency. Michael Polanyi's theories suggest that individual competencies will be the site of particular patterns of focal and subsidiary awareness, which will involve the active use of some particular skills and the activation of a specific penumbra of potentially relevant capacities for judgement and response to contingencies within the situation. It is this configuration which will be updated by experience generated within innovative developments. It is this configuration which will be continually further updated by further refinements of the processes involved. The processes by which these configurations are kept distinct is part of the most basic implicit operation of the brain. The processes by which the segregation of data and data-updating and summation processes is assured, and keyed to specific contexts, is also part of this implicit process. This is why, in Polanyi's terms, we must *indwell* our contexts in order to make them *our* contexts, because otherwise the data we absorb will be treated as generic and will not contribute to refining and developing the specificity of our responses to different contexts and situations.

This is also the value of 'metaphors', not for 'knowledge creation', but as part of the process of generating new vocabularies for describing new experience, giving us a structure for articulating the distinctions between areas of action and knowledge which are only beginning to diverge and become distinct as specific new contexts. The language of cyberspace, of the internet and of new markets is not merely a jargon or a cultural fashion but a necessary articulation of new phenomena. Other new developments will create other new languages.

A NEW APPROACH TO MAPPING THE TACIT COMPONENT

The foregoing presentation of the great scope of Polanyi's thought leads us to see a deep and complex problem in the concept of the diffusion of knowledge, particularly in the diffusion of new knowledge about new technologies, techniques, materials and products. The apparently simple alternatives of knowledge diffusion by explicit means or by induction can be seen to overlook or conceal a wide range of different processes

²¹ For a general introduction to the approach to competency and competency systems used here see Cullen, Jones & Miller 2001.

which are characterised by very different patterns of interrelationship between implicit learning, tacit learning, learning based on manuals and diagrams, and verbal explanation. These will be accompanied by different patterns of the generation of new integrations of the particulars to which individuals are exposed, and the dynamics of how this integration proceeds means that there will be different patterns of breaking out in Polanyi's sense, different conclusions drawn and projections made. This diversity will be further increased if there is an attempt to disseminate knowledge by a variety of media in order to appeal to a variety of cultural or personal preferences or educational attainments, since the selection of information will necessarily be different in each medium and the way in which information is received and used will differ for each medium.

The phrase *tacit knowledge* is the rubric under which Michael Polanyi's thinking has entered economics and management thinking. We have shown that this is the tip of an iceberg, underneath which there is a theory of knowledge and of scientific discovery and creative innovation, and more than that, a theory of how we rely on our senses to operate in the world. The debate about *tacit knowledge* has broken up an older and simpler dichotomy between knowledge and skills. Occupational classification systems and competency management systems retain this dichotomy in describing the requirements of work, the attributes of workers and the outcomes of training. Until recently these systems seemed to work quite well without *tacit knowledge*. Was this an illusion?

We suggest not. Until some decades ago most employment did not require knowledge apart from that which was *embodied* in skills. This was assured by systems and practices of formal and informal apprenticeship. Conversely professional qualifications, while in some classifications counting as knowledge, could also be assumed to imply the acquisition of the minimum skills which a professional required to be or become an effective practitioner. Under the blanket of an apparent distinction between hand and brain workers, there were actually systems which ensured that workers acquired the necessary repertoire of skills in judging the requirements, outcomes and pathways of all practical activities.

What has changed is the speed of change itself. Apprenticeship systems have declined because they could not keep up with the pace of change. Whereas perhaps fifty years ago management wanted to find out what workers really did, now often no-one knows what is really being done. Technological change means that the real content of work is

constantly changing. This is why we have felt for some years that the individual competency must be the basic unit of analysis of work. We cannot assume that work outcomes are the results of combining bodies of skill with bodies of knowledge. The skills of judgement, of discernment, of situating the present problem in its relation to a final goal, are skills which become increasingly contextual. Meanwhile contexts are themselves in flux due to organisational and market changes.

The consequence of this is that any mapping of the tacit component of a competency itself needs to be dynamic. One reason for this is contextual change, but another is that we cannot assume that the tacit component is optimal. What would it mean to regard the tacit component of a competency as a potentially adjustable variable?

Taking Polanyi seriously would mean attempting to identify the particular constellations of implicit or tacit knowledge, acquisition of which is critical to the diffusion of new knowledge in ways which are really effective. There is evidence that informal social contact with fellow practitioners within a stable team environment is highly effective in spreading knowledge about the knacks and tricks which really make a difference in achieving success (e.g. Edmondson et al. 2003).

There is no higher court of appeal for judging the new skills which arise in cutting edge innovation. As innovation becomes incremental the sites where new products, processes and materials are developed are the cutting edge. The only point of comparison with what is being developed in one site is what is being developed in another comparable site. This is the reason why there is knowledge diffusion cutting across competition to achieve competitive advantage: participants want to achieve secure advantage based on substantial achievements rather than on accidental quirks of development. For this reason there is a constant low-level exchange of information about the basics of using new methods and materials within healthy innovative sectors and clusters.

The neurological mapping of the activation patterns of implicit, tacit and explicit knowing and skills is something beyond present scientific and technological capacity. But even when it is achieved it will not tell us the specific content of the skills and knowledge involved. The dense description of what is done, combined with video, also only brings us part of the way. Induction is the normal way of transmitting skills,

but how does it apply when we are talking about comparison and calibration of two or more differently evolved competencies?²²

We have suggested that competitive advantage is essentially linked to the development of competencies which embody patterns of implicit, tacit and explicit skills and knowledge which are actually highly specific but which in the nature of things are very difficult to specify in ways which are comprehensible to outsiders. New languages are developed to assist in mapping the nuances of meaning which arise in novel situations. There are many sectors in which the potential loss of advantage from sharing knowledge is finely balanced with the gains of pooling knowledge. In particular, becoming a standard setter necessarily involves diffusing knowledge about the use of the products and systems which set the new standards.

As we have suggested elsewhere,²³ this approach leads to going beyond the concept of the knowledge firm to that of the knowledge-creating interface between the firm and its leading innovative customers. In changing and dynamic markets, firms must orientate themselves towards the needs of their most dynamic clients. This cannot be a one-way process, but must involve the exchange of information about needs arising from new technologies and equally from the new applications of existing technologies. In order to fully benefit from these processes, awareness of the tacit component must be involved both in the initial release of new technologies and products and in the phase of processing feedback from the first users. Initially, users must be assisted to gain the full benefit of new products by induction processes sensitive to the tacit component, and equally importantly there must be a feedback process which enables producers to become aware of the ways in which new

²² Part of the problem is that focal awareness and all patterns of the tacit component are driven by goal-directed action, yet at early stages of the development of new techniques and processes the precise nature of the goal may be under-defined or subject to revision. Optimising the repertoire of the tacit component may require fixation of the nature of the final goal. This is an analog, presently on a much more primitive level of conceptualisation, to the problem described by Jimes and Lucardie as reported above, of moulding the content and media of knowledge management to match the requirements of different stages of processes involving selection and discrimination according to different criteria and scales at different stages.

²³ Jones & Miller 2007, see chapters 5 and 6. The implications for the value and supply chain, with out-sourcing of 'innovation-resistant' processes, and new alliances and amalgamations determined by the mix of skills needed to develop new products and processes to meet client needs, are also developed here.

technologies and products are used innovatively and ways which were not necessarily envisaged by the developers. In another study,²⁴ we examined how commercial and non-commercial organisations were converging on a model of customization of solutions for clients presenting new needs and problems leading to the development of new product or service models and corresponding team structures within the organisation which would be available as paradigms if these areas of demand developed. This would require structures which serve to transmit the tacit component of new skills both to other teams within the organisation and to users or partners. The model of the knowledge firm generating knowledge internally is increasingly transformed into that of a knowledge-generating interface between clients generating new needs and providers supplying innovative and potentially more widely relevant solutions.

Without prejudging their potential and limits, we can say that there is a significant role for the development of methods of mapping the tacit component or component of skills and knowledge in a wide range of innovative activities. This would assist in the diffusion of new skills and knowledge, but would also provide a basis for comparison of parallel evolutions and for correcting and identifying deficiencies. We suggest that the natural unit for the investigation and diffusion of such knowledge is the individual competency. It is at this level that the components of individual knowledge and skill, training, and innovative development coincide.

²⁴ Failla, Jones & Miller 2007.

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