

British Academy of Management 2000
University of Edinburgh Management School
13-15 September

On some cracks in the “engine” of knowledge-creation: a conceptual critique of Nonaka & Takeuchi’s (1995) model

Stephen Gourlay
Kingston Business School
Kingston upon Thames
KT2 7LB
sngourlay@kingston.ac.uk

Refereed paper submitted to the Knowledge Management stream.

Abstract

The core of Nonaka and Takeuchi’s (1995) model of knowledge-creation is flawed because of ambiguities in the conceptualization of knowledge, and tacit knowledge, and their failure to specify clearly the nature of ‘explicit’ knowledge. It is argued that tacit knowledge must be viewed as irreducibly tacit, not specifiable in words, while ‘explicit knowledge’ is more accurately named ‘knowledge representations’. On this basis a new framework is proposed in which socialization, ‘externalization’ (renamed ‘representing’) and internalization are confirmed. Nonaka and Takeuchi’s discussion of these modes, however, fails to recognize the complex cognitive and social processes involved. ‘Combination’ is revealed as untenable, being either the iterative linking of representing and internalization, or an entirely separable process - information management. A new model is presented which indicates knowledge management has two important foci - managing cognitive processes, and managing information.

On some cracks in the “engine” of knowledge-creation: a conceptual critique of Nonaka & Takeuchi’s (1995) model

Abstract

The core of Nonaka and Takeuchi’s (1995) model of knowledge-creation is flawed because of ambiguities in the conceptualization of knowledge, and tacit knowledge, and their failure to specify clearly the nature of ‘explicit’ knowledge. It is argued that tacit knowledge must be viewed as irreducibly tacit, not specifiable in words, while ‘explicit knowledge’ is more accurately named ‘knowledge representations’. On this basis a new framework is proposed in which socialization, ‘externalization’ (renamed ‘representing’) and internalization are confirmed. Nonaka and Takeuchi’s discussion of these modes, however, fails to recognize the complex cognitive and social processes involved. ‘Combination’ is revealed as untenable, being either the iterative linking of representing and internalization, or an entirely separable process - information management. A new model is presented which indicates knowledge management has two important foci - managing cognitive processes, and managing information.

Introduction

Nonaka and his colleagues have argued that the creation of knowledge is a critical dimension of knowledge management that other writers in this field have overlooked. In order to remedy this they put forward a model of knowledge conversion as the “engine” (Nonaka & Takeuchi, 1995:57) of their model of organizational knowledge creation (Nonaka & Takeuchi, 1995; see also Nonaka, 1994; Nonaka et.al., 1996). This has been widely cited (265 citations of *The Knowledge-Creating Company*, alone in the Science and Social Science Citation indexes by March 2000) and forms the basis of an important study of tacit knowledge in organizations (Baumard, 1999).

The model rests on the distinction between tacit and explicit knowledge, attributed to Polanyi (Nonaka & Takeuchi, 1995: 8-11, 56, 59). These terms will be discussed in more detail below: for the present we can note that tacit knowledge is based on experience, and is not in words, while explicit knowledge is expressible in the form words, numbers or other common symbols. Their key assumption is that “knowledge is created through the interaction between tacit and explicit knowledge” (Nonaka & Takeuchi, 1995: 62). This allows them to postulate four “modes” of knowledge conversion - socialization, externalization, combination, and internalization (see Figure 1) - as the “engine” of knowledge creation (Nonaka & Takeuchi, 1995: 70-90).

Figure 1: Modes of knowledge conversion

	to tacit	to explicit
from tacit	Socialization	Externalization
from explicit	Internalization	Combination

adapted from Nonaka 1994:19

Knowledge conversion proceeds in a spiral, from socialization through externalization, combination, and internalization, and back to socialization again (Nonaka & Takeuchi, 1995: 70-73). Socialization is the process through which people share tacit knowledge. Tacit knowledge can then be made explicit through externalization, “a quintessential knowledge-creation process” whereby concepts are formed and shared. The next step in the knowledge creation spiral is combination - a “process of systematizing concepts into a knowledge system” through meetings, documentation, and so on. Finally, internalization is the process of embodying explicit knowledge into tacit knowledge, and is closely related to learning by doing (Nonaka & Takeuchi, 1995: 62-72). Their examples of these modes of knowledge conversion will be described and discussed in more detail later in this paper.

One difficulty with evaluating this model is the slightness of examples and empirical data to support it. The main presentation occupies no more than nine pages (Nonaka & Takeuchi, 1995: 61-70) although some details are given later in the book, and other papers (Nonaka, 1994; Nonaka et.al., 1996) cover similar ground. None of the ‘case studies’ covers more than a page or two, and there is little attempt to describe the actual processes of transfer or transformation. They claimed (Nonaka & Takeuchi, 1995: 91) that the four knowledge conversion modes were validated by a survey of managers (Nonaka et.al., 1994). While this report is suggestive, it is difficult to escape the conclusion that if you develop measures of four constructs and ask respondents to answer questions designed to measure these constructs, statistical analysis will reveal their presence.

Engeström (1999) has also drawn attention to the lack of empirical support for their model. He carried out detailed ethnographic studies of “innovative learning” (equivalent to knowledge creation) and evaluated their model on this basis. He notes their model takes as given the problem to be worked on. His studies, however, lead him to suggest that formulating a problem and analysing and systematically locating the problem are key innovation processes that Nonaka and Takeuchi’s model fails to identify or encompass (Engeström, 1999: 380, 388-90).

These are serious criticisms that anyone wishing to use Nonaka and Takeuchi’s model to understand the innovation and learning aspects of knowledge management must take into account. In this paper, however, my concerns are with more fundamental

issues. It is my contention that the core of their model is flawed. If the “engine” is cracked, then the validity of the rest of the model must also be called into question. At the heart of their model are the notions and distinctions of tacit and explicit knowledge. We will begin our critique by examining those concepts in some detail.

Tacit knowledge

In this section I first review Nonaka and Takeuchi’s account of tacit knowledge, based principally on *The Knowledge-Creating Company* (Nonaka & Takeuchi 1995). I then consider Polanyi’s views and finally draw attention to discussions of tacit knowledge and work that took place in Sweden in the 1980s. This provides the basis on which to evaluate Nonaka and Takeuchi’s account.

Nonaka and Takeuchi

They acknowledged Polanyi’s *The Tacit Dimension* (1966) as the source of their primary concepts, tacit and explicit knowledge but claimed to go beyond his formulation to develop the more practical side of the concept. They described tacit knowledge as highly personal and context specific, deeply rooted in individual experiences, ideas, values and emotions. Because of this it is hard to formalize, process systematically, or to communicate or share. Indeed, it is a form of knowledge that does not take linguistic or numerical shape (they did not specify the form more positively, but described it in contrast to explicit knowledge) but, they claimed, has to be converted into those forms in order to be communicated. Two forms of tacit knowledge were distinguished - technical, and cognitive. By technical, they meant crafts and skills or concrete ‘know-how’. Cognitive tacit knowledge, on the other hand, was described as being ingrained schema, beliefs and mental models that are taken for granted. Mental models giving rise to individuals’ ‘images’ of what is or what ought to be are central elements of the cognitive dimension (Nonaka & Takeuchi 1995: 8, 9, 59-60).

While this description of tacit knowledge is relatively straightforward, Nonaka and Takeuchi’s account of how it is created leaves room for confusion. On the one hand they emphasized that tacit knowledge is created by or through individual’s actions and direct experience in the ‘here and now’ (Nonaka & Takeuchi 1995: 8, 10, 60, 85). Thus tacit knowledge can be acquired through a master-apprentice relationship, or learning by doing, and does not require the use of language (Nonaka & Takeuchi 1995: 62-3, 70, 85; Nonaka et.al., 1994: 340). In this context they referred to Polanyi’s concept of “indwelling” that sought to capture how people create knowledge by involving themselves with objects, and knowing it by tacitly integrating objects’ particularities (Nonaka & Takeuchi 1995: 60).

On the other hand, they also described the transfer or acquisition of tacit knowledge by other quite different processes. Two of their three examples of “socialization” clearly involve talking despite their statement that the tacit is a non-linguistic form of knowledge (Nonaka & Takeuchi 1995: 9). They claimed that a team ‘brainstorming camp’ involving social activity and informal discussion of work problems was a particularly effective method for reorienting people’s mental models - the cognitive dimension of tacit knowledge (Nonaka & Takeuchi, 1995: 62-3). Elsewhere they asserted that tacit knowledge can be acquired through ‘internalization’ whereby an individual uses explicit knowledge in the form of documents and similar media to

generate tacit knowledge. In particular they claimed that the use of documentation (i.e. reading) also facilitates changing mental models (Nonaka & Takeuchi, 1995: 69).

There may be some order to their remarks in so far as they portray the technical form of tacit knowledge as being shaped and acquired through experience, and the cognitive form through talk and reading. However, they do not explicitly make this distinction and it is difficult to see why such an important difference could arise. Their account could be read as implying two forms of tacit knowledge, one not transmissible through words, and one through words. This would be difficult to sustain as knowledge in the form of words is explicit, not tacit. Another interpretation would imply two other forms of tacit knowledge: one not transmissible by linguistic or other symbolic means, and one that can easily be expressed in words, but currently is not, and therefore is tacit by default. Whatever the case, their account is confusing and ambiguous. (Discussion of the function words might perform in tacit to tacit knowledge transfer follows in a later section.)

Michael Polanyi

It is sometimes claimed that Polanyi introduced the concept of tacit knowledge (Prosch, 1973: 201; Barbiero 2000), although Wagner and Sternberg (1986) cite a definition from the *Oxford English Dictionary* of 1933. The philosopher of science Rom Harré (1977, 1982) said that Polanyi's concept was "profoundly important", but pointed out that Polanyi used the term ambiguously - a charge Polanyi's supporters deny (Scott, 1982).

Polanyi began with the proposition that there are two kinds of awareness - focal, and subsidiary (Greene, 1969: ix; Polanyi, 1969a, 128). Focal awareness could be termed "knowledge by attending to", and subsidiary awareness "knowledge by relying on" (Greene, 1969: ix). In terms of visual perception, the equivalent terms would be 'looking at' and 'seeing', but the terms focal, and subsidiary, are of wider application (Polanyi, 1969a: 128). He stressed that these are not two *degrees* but two *kinds* of awareness (Polanyi, 1969a:128). They are present in every kind perceptual situation (visual, haptic, auditory, and so on).

The significance of his distinction was made clear in a series of examples, framed around discussion of the problem of how we perceive 'wholes' or entities through perceiving many particulars; and how we identify particulars by virtue of their being perceived as parts of a whole. Thus aerial photographs reveal archaeological remains clearly, while on the ground what were previously just bumps and hollows are revealed as the 'particulars' of an archaeological site. Similarly, medical diagnosis proceeds through an interplay between attending to particulars, integrating them into wholes, and attending back to the particulars again (Polanyi, 1969a: 123-8). In general, he concluded, recognition of a whole depends on seeing and integrating the parts, but if they themselves are focused on, this process itself prevents you from recognizing the whole of which they are part. This semantic dimension of tacit knowing (Greene, 1969: xiv; Polanyi, 1966: 12-13) directs attention from particulars to the whole they signify. Thus Polanyi claimed that "all knowledge is fundamentally tacit, as ... it rests on our subsidiary awareness of particulars in terms of a comprehensive entity" (Polanyi, 1969a:133), and elsewhere: "*All knowledge falls into one of these two classes: it is either tacit or rooted in tacit knowledge*" (Polanyi, 1969c: 195).

Polanyi's aphorism "*we can know more than we can tell*" (e.g. Polanyi, 1966: 4) is often cited in discussion of tacit knowledge, but the meaning he intended it to convey is seldom remarked upon. It is, however, central to his concept of tacit knowledge or tacit knowing. In one article he strongly implied that a cyclist turning a corner maintains his or her balance by tacitly knowing the formula relating angle of imbalance, radius of curve, and velocity (Polanyi, 1969b: 144). In *The Tacit Dimension* (1966) he provided two commentaries that develop this idea. First, he described psychological experiments in which subjects were shown nonsense syllables, and given an electric shock after some of them. Subjects later showed detectable signs of anticipating a shock when the key syllables appeared but although they were aware of anticipating a shock, they could not say why they were aware (Polanyi, 1966: 7-8). These reports were of early investigations of subception, subsequently called implicit learning (Polanyi, 1969b: 144-45; Reber, 1993: 17, 68-9).

The second example is also a crucial illustration for Polanyi (1966: 21-3). Here he discussed 'seeing a problem' in the context of scientific research - and his discussion could be applied to business problem formulation as well. A problem is by definition hidden, and he claimed that seeing a problem is "to have an intimation of the coherence of hitherto not comprehended particulars" (Polanyi, 1966:21). If this 'intimation' is a good one, i.e. is "true" then we have a good problem. Polanyi noted this situation is identical with the classical philosophical problem (Meno's paradox) of the impossibility of searching for the solution to a problem since a search implies knowledge of what is being sought. He concluded that we can recognize a statement (i.e. a problem) as true by appreciating the wealth of its as yet undisclosed consequences "if we admit that we can have a tacit foreknowledge of yet undiscovered things." (Polanyi, 1966:23).

He justified this argument by claiming that human beings have a "competence for comprehending unspecifiable entities, which will yet reveal themselves in the future" (Polanyi, 1969a: 133). As a practical illustration of his intention he referred to the connection between Copernicus and Newton in the following way: "The true meaning of the heliocentric system was discovered by Newton, but it was anticipated 140 years earlier by Copernicus." (Polanyi, 1969a:133). What Polanyi claimed here was that if someone (e.g. Copernicus) had an idea that was later shown by someone else (e.g. Newton) to have implied more than had previously been considered or explicitly realised, then the first person had 'known more than he could tell', due to his competence for 'comprehending entities that would reveal themselves in the future'.

For Polanyi, then, tacit knowledge referred to several things. First, it referred to the particulars of a focal entity; second, it was the base of knowledge if not itself all knowledge; third, tacit knowledge is hidden from the knowing person; and finally, it is "foreknowledge". The latter sense perhaps reflects the religious elements of his thought that he retained as he grew older (Tiles, 1992: 9). Baumard (1999: 60) discusses foreknowledge in organizations, but though lacking detail, his example seems to be of one where a group or individual is *concealing* what they know from others, for some reason or purpose. This kind of "foreknowledge" is not the same as that which Polanyi referred to which is more akin to knowing the future.

While the issue of tacit foreknowledge may be difficult to accept, and it is certainly not easy to see its relevance to knowledge management, there is a more fundamental problem with Polanyi's argument. He granted that we can have specified (i.e. explicit)

knowledge of a focal entity or whole. This entity will have particulars which will remain tacit, so long as the entity itself is the focus of attention. We can however shift our attention to a particular of our original entity. This particular would then become our focal whole, and in turn it will have tacitly known particulars. They too can be attended to in turn, and so on. After pursuing each of the original entity's particulars it can be 'reconstructed', and, as Polanyi said, this "recovery" will change and may even improve on the original meaning (Polanyi, 1966: 18-19; see also Polanyi 1969a). Furthermore, given that our original focal entity is a particular of a yet larger entity, 'sister' entities can also be identified, and so perhaps, ultimately, can other larger entities. Thus in all 'directions' from our original focal entity lie 'things' that are alternately focal or subsidiary, and explicitly or tacitly known at any one moment in time.

Granted then that any focal entity is 'surrounded' by tacitly known particulars of yet 'larger' tacitly known entities, and is itself composed of tacitly known particulars, tacit knowledge *is* always present 'in' and 'around' the focal entity, as Polanyi claimed. If, however, for any given focal entity at a particular time and place you know that you have explicit knowledge of all the other associated entities (i.e. the particulars *of* that entity, and the sister entities that are particulars of another whole), then for practical purposes you could quite reasonably claim that *all* knowledge about the situation *was known explicitly*, although it might not necessarily all be held 'in mind' at the same instant in time. His model thus seems to contain a contradiction that is fatal to his insistence on the pervasiveness of tacit (i.e. wholly unspecified) knowledge, or at least it could be read as meaning that the 'problem' of managing tacit knowledge is far less difficult than the above account would suggest.

Throughout his writing on tacit knowledge Polanyi was especially concerned with this problem of integrating particulars into a whole, and argued that this process itself was only known tacitly. This could be taken as an argument then, that although the model might not preclude complete explicit knowledge (for a particular time and place) of an entity, yet there still remains a tacit aspect. But this tacit element would refer to the process of knowing, not the knowledge itself, and surely it is not necessary to know how you know in order to claim explicit knowledge of something? Even if this point were conceded the knowing process itself could presumably be treated as a focal entity. There is no *a priori* case why it should not be known, unless you accept that Polanyi's claim about intrinsically mysterious human powers precludes enquiry into the knowing process.

It seems, therefore, that Polanyi's concept is really one of tacit knowledge 'in the long run'. In so far as he was concerned to argue against the claim that 'science' could produce objective knowledge, in the sense of absolute, value-free and timeless knowledge (Polanyi, 1962, *passim*) then he only needed to show that there is 'always' a tacit element. But when we confine our attention to particular places and particular times, it seems wholly consistent with his model to claim that we can have explicit knowledge about a focal entity, its 'environment', and its inner parts to such a degree that this state of affairs is indistinguishable from a claim to know completely and explicitly.

Tacit knowledge in work and AI: a Wittgensteinian contribution

Discussion of tacit knowledge in work inspired by Wittgenstein's later philosophy identified several distinct types of knowledge as tacit, and concluded that tacit knowledge is fundamentally non-explicable. This research and debate took place in Sweden in the late 1980s in the context of research into skilled work and discussion about the scope and implications of artificial intelligence. These studies distinguished three types or forms of knowledge. The first was theoretical or propositional knowledge which is identical with explicit knowledge and will be discussed below. The other two types of knowledge they called variously knowledge by experience, knowledge by acquisition or knowledge of familiarity, and practical knowledge or know-how (Josefson et al., 1982:69; Göranson, 1988: 16-17; Janik, 1988). These two types are all related to tacit knowledge.

Janik and Göranson differed in their description of knowledge of familiarity, the former saw it as resulting from "sensuous experience" (Janik, 1988: 56), the latter described it as "knowledge that we acquire from learning in practice by examining the examples of tradition" (Göranson, 1988:16). Göranson also emphasised the importance of collectivity and interaction with others in the formation of knowledge of familiarity. Josefson (1988) and Gullers (1988), writing about nursing, and manufacturing respectively, argued that knowledge of familiarity, and practical knowledge, are interdependent, arising both from reflecting on experience, and interaction between more and less experienced workers in a manner reminiscent of what was later called "situated learning" (Lave & Wenger, 1991). Since the term tacit knowledge is now used generally to refer to all kinds of experiential knowledge (von Krogh & Roos, 1996:39-40), and Janik (1988) also regarded knowledge of familiarity as a form of tacit knowledge, it seems useful to regard tacit knowledge as comprising several distinct forms, or having several names that actually all refer to the same thing.

Janik (1988) argued that the term tacit knowledge is used in two senses: first, to refer to knowledge that could be made explicit, but which has not yet been so rendered; and second, to those "aspects of human experience which are *wholly* knowable self-reflectively ... but by their very nature are incapable of *precise* articulation" (Janik, 1988: 54). The second sense he called the strict sense of knowing tacitly (Janik, 1988: 56) which originates in two distinct types of experience or activity, sensual experience, and rule-following. In elaborating on these Janik drew on Wittgenstein's later philosophical ideas, particularly those concerning rule-following, and the role of practice.

A purely sensuous experience is one such as smelling coffee, or identifying a musical instrument from the sound it makes. Following Wittgenstein, Janik claimed that such knowledge is impossible to put into words, or to convey to someone else, except by subjecting them to the same experience. As regards the “open-textured character of rule-following behaviour” (Janik, 1988: 56) all human behaviour can be described as rule-following, but rules can never be so precise or detailed that they suffice to guide our actions fully. We have in fact to learn how to accomplish something before we know how to follow the rules for accomplishing the same goal. The rules themselves are always insufficient because we would require rules for following the rules, the logic of which results in an infinite regress. Wittgenstein’s solution to this problem is to say that ultimately rule-following always rests with actual doing, practice, or activity (Janik, 1988: 57-8). Knowledge of how to follow the rules, whether tacitly known, or explicit as in the form of propositional knowledge, can only come from doing, following good examples, training, and interaction with other preferably more experienced practitioners (Göranzon, 1988: 15; Josefson, 1988; see also Lave & Wenger, 1991). Tacit knowledge, therefore, is the primary form of all knowing in the sense that all knowledge is tacit in origin, and there is always an irreducibly tacit element to all knowing (Janik, 1988: 56; Gullers, 1988: 36).

Tacit knowledge - a conclusion

We should note that there is a long history of controversy among philosophers as to the status and significance of ‘tacit knowledge’ and its synonyms, and its relationship with ‘explicit knowledge’ (see Baumard, 1999: 30, 54-64, 104 for lists of several other apparent synonyms). Dewey (1938/1986: 145-6) argued that “immediate knowledge” (equivalent to tacit knowledge) is better called “apprehension” and as such clearly distinguished from ‘knowledge’ defined as “warranted assertion”. Russell, in *Problems of Philosophy* (1912) contrasted “knowledge by acquaintance” and “knowledge by description” while William James (1895, 1911) also used the terms knowledge of acquaintance and immediate knowledge (equivalent to tacit knowledge) and knowledge-about (i.e. explicit knowledge). Grote (1865, 1900) wrote at length on these distinctions, and the debate and discussion can be traced back even further (Prosch, 1973).

Of course all these philosophers could have been mistaken, and Polanyi was perhaps the first philosopher to make the link between tacit knowledge, and psychological observations of learning experiments which identified subception or implicit learning. While the concept of implicit learning is still contested many accept it as a genuine facet of human behaviour (Buchner and Wippich, 1998; Frensch, 1998). There is also a considerable amount of research evidence to support the notion of non-conscious acquisition of information that probably also has a bearing on the issue of tacit knowledge (see Lewicki et.al, 1998). We must therefore accept the idea that some form of ‘knowledge’ that cannot be made explicit (at least for the present) needs taking seriously into account.

Polanyi’s discussion of tacit knowledge is, however, contradictory and confusing, for reasons additional to those Harré (1977) noted. Thus while he claimed that *all* knowledge is either tacit, or based on tacit knowledge, his construct of focal/subsidiary relations through which he elaborated and justified the term can also be used to justify a claim to having, for all practical purposes, complete and explicit knowledge. It has been suggested that Wittgenstein’s position on tacit knowledge was

substantially the same as that of Polanyi (Gill, 1974). Wittgenstein, however, produced good arguments, subsequently supported by studies of work and attempts to automate skilled work (i.e. reduce knowledge to explicit rules), to substantiate a claim that there is an irreducibly tacit aspect to all our knowing.

Nonaka and Takeuchi actually appear to have made little use of Polanyi beyond borrowing the term 'tacit knowledge'. They believed that tacit knowledge can be made explicit and indeed not only argued that it must be made explicit if it is to be of any use to an organization but claimed that Japanese companies do make it explicit (Nonaka & Takeuchi 1995: 11). They recognized that articulating tacit knowledge might not be easy but in so arguing, they ignored (or failed to recognize) that some tacit knowledge is irreducibly tacit. Polanyi and Wittgenstein also agreed that practice is the source of tacit knowledge. Nonaka and his colleagues appear to accept this as regards skill, but also to see tacit knowledge as being learned by talking, and by 'internalizing' explicit knowledge. If by this they meant that all relevant tacit knowledge was put into words then their views are at odds with Polanyi's and Wittgenstein's conception of tacit knowledge as being irreducibly inarticulable. The implications of their ambiguities for the knowledge creation 'engine' will be considered below.

In the rest of this paper I use the phrase 'tacit knowledge' to mean knowledge that is irreducibly tacit, and will distinguish this from a 'weak' tacit knowledge, meaning that which is merely currently tacit, but which can be made explicit without much effort or cost (see Baumard, 1999, 78-87 for discussion of these aspects).

Explicit knowledge

Explicit knowledge is knowledge that is in the form of words, spoken or recorded, or in other intersubjectively understood symbolic form. Explicit knowledge is what we commonly refer to when speaking of 'knowledge'. It is also known by a number of other names such as theoretical, propositional, thematized, migratory, articulated knowledge (von Krogh & Roos, 1996: 39), declarative and codified knowledge (Nonaka & Takeuchi, 1995: 59,61). Since it is expressed in commonly understood symbols it is generally in a communicable form and as such can easily be separated from the context in which it arose. It consists of generally applicable rules and is usually privileged over tacit knowledge as being scientific, verifiable, and objective (Josefson et.al., 1982, Josefson, 1988; Göranzon, 1988; Gullers, 1988).

Nonaka & Takeuchi

Explicit knowledge and tacit knowledge were generally contrasted such that each was defined in terms of the other. Explicit or declarative knowledge is codified knowledge that can take a number of forms - words, numbers, scientific formulae, rules, and computer code within which it takes the 'shape' of metaphors, analogies, and concepts (Nonaka & Takeuchi, 1995: 8, 59-61, 64). Being in a systematic formal language it is easily communicated, shared, and transmitted among people and by electronic means. Furthermore, it is objective, concerned with rationality and the 'there and then', and is theory oriented. Explicit knowledge corresponds to the traditional Western view of knowledge as being universal and objective. Documents, meetings, telephone conversations and computerized communications networks are typical media through which explicit knowledge is exchanged and combined in

organizations (Nonaka & Takeuchi, 1995: 8, 11, 59, 61, 67).

Polanyi

Polanyi appears to have made little use of the term 'explicit knowledge' in his writing on tacit knowledge. He defined it in a passing comment as knowledge that is "capable of being clearly stated" (Polanyi, 1966: 22) and implicitly identified it with "theoretical knowledge", "mathematical theory", and with the "strictly detached objective knowledge" associated with "exact science" (Polanyi, 1966: 20-21). Elsewhere he referred to explicit knowledge as spoken words, formulae, maps and graphs (Polanyi, 1969c:195). By way of an implicit contrast with tacit knowledge, explicit knowledge could be defined as that 'knowledge that we can tell' where 'tell' means to put into intersubjectively meaningful symbols. Grene similarly talked of explicit knowledge as being crystallized in words, pictures, formulae and "other articulate devices" (Grene, 1969: xv), and referred to explicit knowing as being the mastery of an intellectual discipline (Grene, 1969: x).

In *Personal Knowledge*, Polanyi gave much consideration to the concept of articulation that has an important bearing on this issue (Polanyi, 1962: Chapter 5). Language, he claimed, is an instrument for articulation, and it is language use that serves to separate humans with their "formalized intelligence" from animals which only have "inarticulate intelligence" (Polanyi, 1962: 69-70, 77). Animals and humans engage in three modes of learning - invention, observation, and interpretation. For humans, however, the 'articulate forms' of learning are manifested in patents, the subjects of engineering and technology, and the natural sciences (corresponding to the three modes of learning). The highest of the articulate forms is mathematical knowledge (Polanyi, 1962: 76). There is thus "a sequence of increasing formalization" from the descriptive to the exact, and then to the deductive sciences (Polanyi, 1962: 86). In his account there is a clear correspondence between that which has been articulated, and the notion of explicit knowledge. Consistently with his later emphasis on tacit knowledge, throughout his discussion of articulation Polanyi repeatedly returns to the theme that humans' use of symbols "ultimately" rests on unformalized intelligence (Polanyi, 1962: 82), and that all descriptions of experience rely on a "tacit coefficient" to resolve indeterminateness (Polanyi, 1962: 86-7, 95).

A question of names

Before turning to evaluate the knowledge-creation matrix we need to consider the appropriateness our key terms, tacit knowledge, and explicit knowledge. Use of these two terms implies that we are concerned with two forms of the same thing, knowledge. We have already seen Dewey's (1938/1986) proposal that they should be distinguished as being different things, and need to consider whether this should be followed up, and if so, what names might we use.

Nonaka and Takeuchi (1995: 58) said that the traditional western definition of knowledge is "justified true belief". This definition has, however, been criticized since at least the time of Plato because it raises the question of 'justifiers', and how their justification can itself be justified, a situation of infinite regress (Brown, 1994). Moreover, although Nonaka and Takeuchi claimed to have adopted this definition, with some changes of emphasis, in the same section they also defined knowledge as "*a ... process of justifying personal belief toward the "truth".*" (Nonaka & Takeuchi,

1995:58). Here then is another ambiguity in their account: knowledge is apparently both a kind of belief, and a process of justifying a belief.

Dewey (1938/1986: 15) also pointed out that ‘belief’ and ‘knowledge’ are ambiguous words since belief can either name what is believed, or refer to a personal matter or position, a mental state while ‘knowledge’ can refer to the terminus of inquiry, or something that has meaning of its own apart from inquiry. Neither ‘belief’ or ‘knowledge’ (in an unqualified sense) are useful words to use when we are trying to gain some precision of understanding on just how ‘knowledge’ is created so that we might seek to manage the process. One solution would be to adopt Dewey’s definition of knowledge as warranted assertion, giving us ‘tacit warranted assertion’, and ‘explicit warranted assertion’. It is however difficult to conceive of a tacit assertion, let alone one that is warranted, since both words imply some degree of explicitness that is ruled out by the very term tacit knowledge. It may have been thinking along these lines that made Dewey suggest they are not two kinds of ‘knowledge’, but two different things related to knowing, or understanding. Thus we might adopt his view, and replace ‘tacit knowledge’ by ‘apprehension’, and call explicit knowledge ‘warranted assertion’.

While this would provide some conceptual clarity it has the drawback of eliminating the term ‘tacit knowledge’ which is much in vogue. Moreover, Dewey himself later abandoned his attempt to define knowledge precisely, and wrote that ‘knowledge’ is “No. 1 on a list of “vague words”” (Dewey and Bentley, 1949:48). A different solution to the question of names can be drawn from writing on situated cognition and in particular the work of Clancey, an expert in AI and expert systems design.

Clancey defined knowledge as the “capacity to interact, to reflect, to innovate.” (1995 :12); “to coordinate and sequence behavior” (1997:3); the “capacity to engage in an activity” (1997:19). As befitting a capacity, knowledge is conceptualized in dynamic terms: the appropriate metaphor is not of something that can be possessed, but rather “energy” (Clancey, 1995:2;, 1997:6). From this perspective he argued that knowledge is “*dynamically constructed* as we conceive of what is happening to us, speak, and move” (Clancey, 1997:7). Knowing occurs in the process of acting (Sierhuis & Clancey, 1997), and knowledge “corresponds to conceptualizing and other representing processes in the brain” (Clancey, 1997: 26). As a process in the brain, knowledge is simultaneously “inherently “neural” in form.” and “inherently social in content” (Clancey, 1997: 14, fn 5) because it develops with respect to activities, which are themselves socially constructed (Clancey, 1997:3). This perspective is consistent with other contemporary views on knowledge and knowing that emphasise knowledge as ‘embodied’ (e.g. Varela et.al., 1991; Lakoff and Johnson, 1999).

Clancey argued that artefacts such as books, maps, instructions, goal statements, and so on, that we typically refer to as ‘knowledge’ are better called *representations* of knowledge (Clancey, 1995: 2-4). Representations of knowledge, and knowledge, are distinct, not equivalent or interchangeable, and not different types of a common entity. Knowledge representations are tools for inquiry that lie, speaking figuratively, ‘between’ performances – the past performance that is reflected on, and the future performance toward which end ‘knowing’ is directed (Clancey, 1997: 11-12; see also the discussion by Keller and Keller, 1993). From this perspective, knowledge itself, in so far as it is a ‘thing’, is ‘in’ the performances, as has been indicated in the

preceding paragraph.

There are two types of knowledge representation, internal, and external (Clancey, 1997: 11, 14, fn. 4). Internal representations are internal to an individual's brain, and take two forms – conscious representations, and unconscious representations. Conscious representations are those we use in “imagined experiences” (Clancey, 1997: 28) when we think through something, consciously representing it to ourselves. Subconscious representing occurs during conceptualization, the neural process at the heart of knowing (Clancey, 1997: 14, fn. 4). Clancey argues that internal representing is “*coupled* such that perception, movement, and conceptualization are changing with respect to each other moment-by-moment” (Clancey, 1997: 12). External representations on the other hand are things such as books, computer files, and so on - those things we commonly refer to as ‘knowledge’.

This suggests that the term ‘explicit knowledge’ could be abandoned, and replaced by a more accurate descriptor: knowledge representation, referring in particular to external representations. This name also points to another potentially interesting source of research and theorizing, namely, work on representing and representations (see e.g. Stufflebeam, 1998; Billman, 1998). The name ‘tacit knowledge’ can be retained to mean knowledge that *cannot* (at the present time and place) be made explicit. Polanyi’s notion of ‘foreknowledge’ will be excluded from consideration as too imprecise, and conjuring up notions of mysterious powers of mind. The ‘weak’ version of tacit knowledge is of no particular concern since its conversion to knowledge representations is taken care of by the representing process.

Knowledge conversion – a critical review

We can finally turn to subjecting the knowledge conversion matrix to critical scrutiny, having clarified the meaning of tacit knowledge to refer to knowledge that is irreducibly tacit, and replaced the term ‘explicit knowledge’ with ‘knowledge representations’.

Socialization - tacit to tacit knowledge conversion

Knowledge conversion begins with socialization, a process of sharing experiences, whereby, for example, one person or group shares their tacit knowledge with others, thereby creating common tacit knowledge (Nonaka & Takeuchi, 1995:62). Nonaka and Takeuchi gave three illustrative examples. The first concerned the “brainstorming camp” which has already been discussed which they claimed was a particularly effective type of activity for sharing and reorienting “mental models” (Nonaka & Takeuchi, 1995: 11-12, 63). The second example illustrated how a tacit skill could be transferred: a team attempting to design a home baking machine only learned how to make good bread by apprenticing themselves to a master baker, after which they succeeded in developing automated technology. Here, tacit knowledge was transferred through “observation, imitation, and practice” (Nonaka & Takeuchi, 1995: 63-4, 103-9). Finally, they suggested that interaction between producers and customers enables the producers to improve products through sharing experiences with the users (Nonaka & Takeuchi, 1995: 64).

One problem with these examples, as was noted before, is the lack of detail which makes them difficult to evaluate. It is clear, however, that the first and third examples

involve talking, with the implication that tacit knowledge was transmitted through the talk. If, however, tacit knowledge is by definition not expressible in words, these cannot be examples of the acquisition of tacit knowledge. Talk can play a role in the transfer of tacit knowledge, provided we make explicit the idea that language functions on more levels than that of representing knowledge.

Shotter (1990: 120-21) argued that in fact we do not use language primarily to represent the world. Instead, our “ways of speaking” help us coordinate our diverse activities with each other. Thus we speak in order to create, maintain, reproduce and transform social relationships rather than to represent facts. From this perspective it would be perfectly permissible to envisage the transfer of tacit knowledge through speech since that knowledge would be ‘in’ the speaking; but the talk could not be *about* what was known tacitly. (Talk could perhaps be used explicitly to convey tacit knowledge by a skilled rhetorician, but this would be a special case). Perhaps this is what Nonaka and Takeuchi meant to say through these examples, and in claiming that this kind of interaction is particularly effective for ‘cognitive’ tacit knowledge exchange, but they do not actually make this point, and we can only evaluate what they have written. In any case, the talk in their examples took place off the job, not on it, and it may therefore only have had a rhetorical function with regard to socializing, not to designing since it was divorced from the latter practice.

Is ‘transfer’ of ‘knowledge’ that is fully tacit, and remains so in the transfer process, possible? A study of classroom teaching and learning (Edwards and Mercer, 1987) suggested that it is. This showed that children learn two kinds of implicit rule of how to behave in the classroom, and how to construct knowledge from the lessons they receive. These rules were rarely if ever made explicit by the teacher, and Edwards and Mercer commented that it is likely the teachers themselves were not aware of what they are doing in this respect (1987:59-60). Indeed, a particularly striking aspect of this study was that the teachers intended *not* to inculcate any such rules of conduct. Edwards and Mercer concluded that tacit or implicit knowledge is thus intrinsically social, and cultural, and constructed through joint activity and discourse (1987: 160-3), the latter term reflecting the rhetorical aspect of language use noted above. Lave and Wenger’s (1991) concepts of “situated learning” and a “situated curriculum” whereby people learn through experience and reflection, but not necessarily direct instruction, also helps indicate how tacit to tacit knowledge transmission occurs, as does the concept of implicit learning (Buchner and Wippich, 1998; Frensch, 1998).

So far as the transfer of tacit knowledge without language is concerned, only the bakery case seems to qualify as a genuine example of tacit to tacit knowledge transfer. Here we are told that the people observing or participating in the bread making process noticed a “twisting” action of the master chef that they concluded made all the difference to the final product (Nonaka & Takeuchi 1995: 64). The precise nature of this technique apparently remained unarticulated even when incorporated into the automatic process. This example might actually be a more apt case of tacit to tacit knowledge transfer (or simply an example of a fortuitous accident) than Nonaka and his colleagues realise. The flavour of hand-made bread has nothing to do with any special “twisting” process but is due to the fermentation process and time (David, 1977: 110). Assuming the team did replicate the flavour of the chef-made bread, this was probably because in experimenting with designs, they altered the nature of the fermentation process.

The emphasis in the transfer or exchange of tacit knowledge must therefore be on the non-verbal dimensions of such learning, on subception (Polanyi, 1969b: 142-3) or implicit learning (Buchner and Wippich, 1998; Frensch, 1998) in which words have, at best, 'only' a rhetorical function. On the basis of the examples discussed here, there may be at least two ways in which this occurs. First, as evidenced by the classroom study, there is a repeated transaction over time involving people in a particular institutional setting (that must also be defined to include other others not present in the particular situation observed, such as the classroom). Tacit knowledge is transferred / learned as an intrinsic part of this transaction but without the necessity of any conscious intention by the learners (or 'teachers') to learn or impart what is actually learned. For the children, classroom behaviour in its widest sense (i.e. including how to construct knowledge from the teaching process) is something they learn without conscious intent. Here, transfer depends on participation in a shared activity that itself was not explicitly concerned with transferring that particular tacit knowledge, but with something else (such as learning lessons).

The second way in which tacit knowledge may be transferred is when one individual observes another, imitates their actions in an attempt to replicate the results, and develops an understanding of how to do something through reflecting on their experience as they do it, or in subsequent recollection (e.g. Perby, 1988). This happens, for example, when novices imitate experts in an apprenticeship-like situation. The novice presumably consciously intends to seek through imitation and practice to identify for herself that elusive 'something' that the expert is aware of. The expert in turn may be trying consciously to direct her pupil's attention towards something she cannot express in words, or that requires more than words (i.e., practice) to fully understand. Confirmation /disconfirmation of having achieved that identification is made, and can only be made, in practice, and by interacting with the expert - a process of trial and error.

From tacit knowledge to knowledge representations - "externalization"

The next step after socialization in the process of knowledge creation is the transformation of tacit into explicit knowledge through the process of "externalization". Externalization, claimed Nonaka and Takeuchi, is "a quintessential knowledge-creation process" that is the key to knowledge creation, because it is here that new concepts are created although despite this status it is rather a neglected concept (Nonaka & Takeuchi, 1995: 62, 64-6). Their exemplars of conceptual knowledge all relate to novel commercial "concepts" - a new model of car, and a photocopier. Externalization is seen as a process of working from metaphors through analogies to new models. The idea for a new sports car was derived from seeking to operationalize the car maker's corporate slogan; the metaphor of "evolution" led other car designers to develop the "tall car"; and an empty beer can inspired a photocopier designer team to develop a radical new product with a disposable ink cartridge (Nonaka & Takeuchi, 1995: 64-7).

One difficulty with this account is that the notion of transforming tacit knowledge into knowledge representations implies, first, that this tacit knowledge is 'weak' tacit knowledge, and second, that it is clearly known, though not yet articulated. Ryle (1963: 214-7) provides an interesting example of how a claim to knowledge that could not be made explicit could be tested - by getting the claimant to do something that would illustrate and substantiate their claim to knowledge. In these instances,

however, we appear to be dealing with situations in which a group constructs a new idea through interaction, practice, and talking and something new by definition did not exist before. Unless Nonaka and Takeuchi wished to invoke Polanyi's notion of "foreknowledge" we are forced to question whether these are examples of the process of representing hitherto tacit knowledge. Indeed, it would be simpler to view them as examples of 'creative' teamworking through which new product and design ideas are constructed by complex social transactions. While those ideas might be called 'concepts', it is questionable whether they are of the same type as concepts in the sense of knowledge that emerges from the processes of systematic investigation. This is an issue that requires further investigation and clarification.

Nonaka and Takeuchi also used the term "externalization" to refer to the setting down of tacit experiential knowledge (1995: 69). This is certainly more in keeping with the idea of making representations of hitherto tacit knowledge. Unfortunately they do not provide us with any examples. Besides, we have already seen that if tacit knowledge can be made explicit it can only have been 'weak' tacit knowledge. Their examples of customer-producer interaction, and the brainstorming camp (on the basis of what they tell us about those processes) probably constitute examples of tacit knowledge representing processes rather than of tacit to tacit knowledge transfer.

What might be taking place when (if) tacit knowledge is successfully 'converted' into knowledge representations, or perhaps more accurately, when a knowledge representation is created of a portion of tacit knowledge? It is interesting to note that in an early version of the matrix, Nonaka (1990, cited in Baumard, 1999:24) had called this cell of the matrix 'articulation'. This might have been a better name, reflecting, for example, Polanyi's term, and thus linking the process with a wider literature. It is not clear why he later substituted "externalization". If we assume that the creation of internal (Clancey, 1997: 11, 14) or mental (Ramsey, 1992) representations is the first step from tacit knowledge to external representation, then as Ramsey (1992) and others (Stufflebeam, 1998; Clark, 1997) show, this is a complex set of processes, both cognitive and social, the precise nature of which is highly contentious. There is not space here to enter into further discussion, but suffice it to say that a more accurate descriptor than "externalization" would be 'representing'.

"Combination" - the 'joining' of knowledge representations

Combination, follows "externalization" (or, representing) and is "a process of systemizing concepts into a knowledge system" (Nonaka & Takeuchi, 1995: 67, 72). According to Nonaka and Takeuchi combination occurs when individuals meet and exchange and combine explicit knowledge through various media, such as documents, meetings, and conversations. They also asserted that new knowledge can arise from the sorting, combining and categorizing of explicit knowledge, and claimed that this is the primary mode of knowledge development in formal education. Combination can also occur within computer systems when data is sorted and combined in databases.

Given the argument that 'explicit knowledge' should be replaced by 'knowledge representations', the concept of 'combination' poses considerable difficulties. Knowledge representations are symbols, or collections of symbols, and it is of course possible to combine symbols themselves, by means of other symbols. Computer databases are created in this way but the critical symbols are those initially specified

by people to ensure that the computers perform humanly meaningful tasks. 'Combination' might therefore perhaps make sense in the limited and special case of entirely automated combination processes within computers, even though these cannot be understood without the human dimension. Human beings on the other hand are not equipped to process knowledge representations (and there is even debate as to whether there are such things as internal representations - see Clark 1997). Moreover, it is a caricature of educational systems to suggest that people become educated simply by 'processing' knowledge representations.

Human beings can in fact only combine knowledge representations first by 'internalizing', then by 'externalizing' or making further new representations, to use Nonaka and Takeuchi's terms. Formal education involves among many other processes reading books and writing summaries or notes, perhaps linking ideas in one book with those from another. Thus in human beings and probably in organizations, 'combination' does not seem to be a distinct process, but is an iterative linking of internalization and representing. Since the matrix is intended to indicate four distinct modes of knowledge conversion it is not possible to maintain combination as a distinct mode when it simply encompasses two other modes.

Combination, meaning the joining together (in some sense) of knowledge representations can only occur with a meaningful outcome if the process is carried on under human instruction, whether direct, or indirect (e.g. as through a computer program). In this way the bringing together of disparate sets of symbols to create a new and potentially more useful set is possible, and commonplace. Everyday examples are the creation of databases, and the development and maintenance of libraries. From this perspective, 'combination' should more accurately if less glamorously be called 'information management', the methods and processes of managing knowledge representations (Burke and Horton, 1988; Orna, 1990).

"Internalization" - from knowledge representations to tacit knowledge

The final step in the knowledge conversion spiral is internalization, the process of "embodying explicit knowledge into tacit knowledge" which is "closely related to "learning by doing." (Nonaka & Takeuchi, 1995: 69). They claimed that internalization is facilitated "if knowledge is verbalized or diagrammed into documents, manuals, or oral stories". Documents seem in their account to perform a double function, of "enriching tacit knowledge" and facilitating "the transfer of explicit knowledge". It is not clear whether the production, or consumption (or both) of documents is what helps these processes. Reading or listening to stories, however, was suggested as an important method of internalization facilitating changes in tacit mental models because it helps people to "feel the realism and essence of ... the experience" of others in such a way that in reading, people may change their mental models without having actually to have the experiences themselves (Nonaka & Takeuchi, 1995: 69-70).

It seems clear from their examples that by 'internalization' Nonaka and Takeuchi intended to focus attention on 'learning'. There seem to be two distinct processes in their account and examples of 'internalization'. First is 'learning by doing' which is relatively straightforward. Nonaka and Takeuchi described how people developed an understanding of what a reduced working year would be like by working for one month at the new annual rate (an example that makes sense for people working

annualized rather than daily, weekly or monthly hours (Nonaka & Takeuchi 1995: 70)).

The second process is learning through reading and the use of other kinds of knowledge representation. Once again, there are some difficulties with this concept in terms of their own model. If, as they sometimes emphasised, tacit knowledge is created by action and experience learning by doing makes sense but learning by reading does not. Indeed, the very idea of ‘turning’ knowledge representations directly into tacit knowledge is highly questionable. If tacit knowledge is a ‘product’ of (or better, integral to) practice then it must arise in practice, and cannot be reduced to anything else. Indeed the ‘consumption’ of knowledge representations is itself a practice and so the only tacit knowledge that can be generated by ‘internalization’ is that relating to the consumption of knowledge representations. The tacit knowledge integral to practices that the knowledge representations are intended to represent cannot simply be ‘transferred’ by working with or on the representations. You only need to consider the gap between what is learned from reading instructions and what you actually need to know in order to do something to accept this point.

One way of making sense of this notion is to see it as the process of making use of knowledge representations prior to engaging, literally, in some practice. Keller and Keller (1993) provide an account of craft iron-working that illustrates this. Preparing to make a something ‘in the spirit’ of a 19th century kitchen implement involved examining historical examples, reviewing knowledge representations about the tools (historical records, studies of previous making of similar tools), and evaluating materials, skills, and production constraints (Keller and Keller, 1993:130-35). In this way “an umbrella plan, an internal representation of goal and procedure” (Keller and Keller, 1993: 135) could be formed which was subsequently modified in the course of the manufacturing process during which “reorganizations of knowledge and action take place” (Keller & Keller, 1993: 135). These external and internal knowledge representations enabled them “to conceptualize an orientation toward a goal: to provide a combinatorial arrangement of previous knowledge in the service of a new, and therefore partially unknown, production” (Keller and Keller, 1993: 141). The tacit knowledge aspects of actually working iron were only re-awakened in the practice itself, and it was only after having completed this task, or had this experience, that the full extent of required knowledge was apparent: “what one needs to know ... becomes a product of behaving” (Keller & Keller, 1993: 141). Interaction with the implement-in-the-making, tacit-to-tacit knowledge transfer across time (within the same individual) and internal representing, shaped the next act on a ‘moment-by-moment basis’.

This account suggests that external representations facilitate a form of remembering, and the creation of an ‘internal’ ‘picture’ or account of what might happen. As Marx wrote, “The architect will construct in his imagination that which he will ultimately erect in reality. At the end of every labour process, we get that which existed in the consciousness of the labourer at its commencement” (Marx, 1974, cited in Cooley, 1980: 27). This internal representation, in whatever form it occurs, is clearly quite different in origin, and most likely also different in nature, from the tacit knowledge acquired by actually engaging in a practice. The process of ‘internalization’ thus also appears far more complex than Nonaka and Takeuchi give credit for, as does the question of how knowledge representations are (if at all) related ‘back’ to the practices from which they arose in the first place.

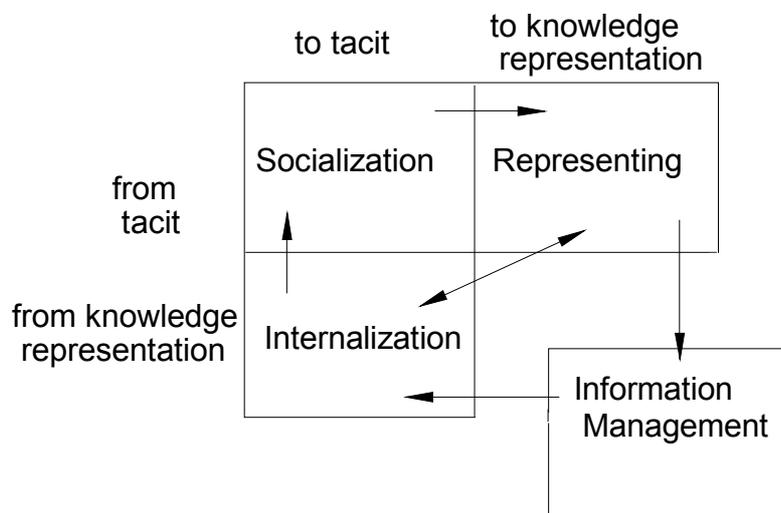
‘Consuming’ knowledge representations in preparation for an activity or practice involves complex processes of remembering and reminding; of metaphorical experiencing (i.e. in practices not previously experienced, reminding cannot happen, but metaphors might be a powerful way of creating a ‘virtual reality’ world in which the desired practice can be envisaged on the basis of other implicitly similar experiences). It might also involve creating ‘internal’ representations for an activity-being-planned. If this account is a better representation (!) of what ‘internalization’ might refer to, then it is again apparent that it indicates a more complex set of psycho-social processes than Nonaka and Takeuchi’s account suggested.

Conclusion

Nonaka and Takeuchi’s knowledge-conversion matrix has provided a focus for enquiry debate and thought, but it is ultimately flawed in its present form. Their conceptualization of tacit knowledge is ambiguous and lacks clarity, as does their concept of knowledge. It is widely agreed that tacit knowledge is by definition not expressible in words and is an irreducible aspect of all knowing. This means that tacit to tacit knowledge transfer cannot use words to convey the knowledge itself. Words might play a part in such transfers but only as rhetoric, not as representing. The neo-Taylorist vision of making tacit knowledge explicit (Nonaka & Takeuchi 1995: 11; Myers 1996) thus freeing the organization of its troublesome employees must remain a dream. Their definition of explicit knowledge is less problematic but it was suggested that a better term would be ‘knowledge representation’.

The consequences of this re-conceptualization for the knowledge conversion matrix are shown in Figure 2:

Figure 2: Modes of knowledge conversion (2)



Nonaka and Takeuchi only provide one firm example of tacit to tacit knowledge conversion and it appears that was a more tacit transfer process than they realised. Other examples provided in this paper, and the link made with implicit learning, show that it is a well documented process although the precise nature is subject to much debate. The name socialization was retained for tacit to tacit knowledge transfer since it seems quite appropriate, and links this aspect with similarly named social processes (see e.g. van Maanen and Schein 1979; Bauer et.al. 1998).

Their discussion of the making of knowledge representations from tacit knowledge also lacks clarity. Here a key issue is the question of the similarity of new product “concepts” with what is more usually thought of as a concept in the context of knowledge. Some of their examples of tacit to tacit knowledge conversion are more appropriate to this mode of knowledge conversion. Even so, the link made to research on representing suggests they have understated the complexity of social and psychological processes involved in making representations of tacit knowledge. It was suggested that this cell be renamed ‘representing’ in order to draw attention to the link with this wider literature.

Since knowledge representations cannot interact meaningfully with each other (and still cannot without human intervention) the cell labelled ‘combination’ has to be radically reconceptualized. Two possibilities were indicated: first that it is a name for the iterative linking of ‘representing’ and ‘internalizing’, and second, that it should be treated as an entirely separate process, information management. It cannot remain a cell of a matrix where it actually encompasses two other cells of the same matrix. ‘Combination’ has thus been renamed information management, and is depicted as a separate process, linked to representing (from where its objects come) and internalization (where representations are used). ‘Combination’ as an interative linking of representing and internalization bypassing information management is indicated by the double-headed arrow.

Finally, internalization seems to stand in for ‘learning’, but the term Nonaka and Takeuchi used has been retained for the present. It is important here though to recognize again that internalization involves more complex psychological and social processes than their account would indicate. Moreover, it is difficult if not impossible to see internalization as providing a direct means of tacit knowledge acquisition. It is rather the process of ‘consuming’ in some sense knowledge representations.

The implications of this revised model for knowledge management are that we now have two clear processes and foci of action. On the one hand we have the three processes socialization, representing, and internalization, that are all centred on people, their interactions with each other, and with their work. Tacit knowledge, in particular, can only be managed through managing people and their relations in the organization. On the other hand we have information management, concerned with storing, manipulating, and managing knowledge representations. Knowledge management activities seem, by and large, to have concentrated on the latter. Perhaps it is time to look more to the former in order to complete the ‘circle’ of managing knowledge creation processes.

References

Barbiero, D., n.d., ‘Tacit knowledge’, *Dictionary of Philosophy of Mind*, (<http://artsci.wustl.edu/~philos/MindDict/> accessed 4 Jan 2000)

Baumard, P. 1999 *Tacit knowledge in organizations*, London & Thousand Oaks: Sage

Bauer, T. N., Morrison, E. W., and Callister, R. R. (1998) ‘Organizational socialization: a review and directions for future research’, *Research in Personnel and Human Resources Management*, Vol. 16, pp. 149-214

- Billman, D. 1998, 'Representations', chapter 51 in Bechtel, W. and Graham, G., (eds) *A companion to cognitive science*, Oxford: Blackwell, 649-659
- Brown, H. I. 1994, 'Judgement and reason: responses to Healey and Reiner and beyond', *Electronic journal of analytic philosophy*, May (<http://tarski.phil.indiana.edu/ejap/1994.May/brown.htm>)
- Buchner, A. and Wippich, W. 1998 'Differences and commonalities between implicit learning and implicit memory', Chapter 1 in Stadler, M. A., and Frensch, P. A., (eds) *Handbook of implicit learning*, Thousand Oaks and London: Sage, 3-46
- Burke, C.F., and Horton, F.W., 1988, *InfoMap: a complete guide to discovering corporate information resources*, Englewood Cliffs, NJ: Prentice Hall
- Clancey, W. J., 1995, 'Practice cannot be reduced to theory: knowledge, representations, and change in the workplace', in S. Bagnara, C. Zuccermaglio, S. Stucky, (eds), *Organizational learning and technological change*, Berlin: Springer-Verlag, 16-46 (Page references here refer to the copy at the Cogprints Archive, <http://cogprints.soton.ac.uk>)
- Clancey, W. J., 1997, 'The conceptual nature of knowledge, situations and activity', in P. Feltovich, R., Hoffman, K. Ford (eds), *Human and machine expertise in context*, Menlo Park: AAAI Press, 247-91 (Page references here refer to the copy at the Cogprints Archive, <http://cogprints.soton.ac.uk>)
- Clark, A. 1997 *Being there. Putting brain, body and world together again*, Cambridge, Mass. and London: MIT Press
- Cooley, M. 1980, *Architect or bee? The human/technology relationship*, Slough: Hand and Brain
- David, E. 1977, *English bread and yeast cookery*, London: Penguin
- Dewey J. and Bentley, A. F. 1949, *Knowing and the known*, Boston: Beacon Press
- Dewey, J. 1938/1986, *Logic: the theory of inquiry*, Carbondale: Southern Illinois University Press (*The Later Works of John Dewey 1925-1953*, vol. 12)
- Edwards, D. and Mercer, N. 1987 *Common knowledge. The development of understanding in the classroom*, London & New York: Methuen
- Engeström, Y. 1999, 'Innovative learning in work teams: analyzing cycles of knowledge creation in practice', Chapter 23 in Engeström, Y., Miettinen, R., and Punamäki, R-L., *Perspectives on activity theory*, Cambridge: Cambridge University Press, 377-404
- Frensch, P. A. 1998 'One concept, multiple meanings: on how to define the concept of implicit learning', Chapter 2 in Stadler, M. A., and Frensch, P. A., (eds) *Handbook of implicit learning*, Thousand Oaks and London: Sage, 47-104
- Gill, J. H. 1974, 'Saying and showing: radical themes in Wittgenstein's *On Certainty*', *Religious Studies*, 10, 279-290

Göranzon, B. 1988, 'The practice of the use of computers. A paradoxical encounter between different traditions of knowledge', Chapter 2, Göranzon, B., and Josefson, I. (eds) *Knowledge, skill and artificial intelligence*, London, Berlin: Springer-Verlag, 9-18

Grene, M. 1969, 'Introduction', Polanyi, M., *Knowing and Being. Essays by Michael Polanyi*, London: Routledge & Kegan Paul, ix-xvii

Grote, J. 1865, 1900 *Exploratio philosophica*, (Cambridge: The University Press), vol. I (1865, reissued 1900); vol. II (1900)

Gullers, P. 1988 'Automation - skill - apprenticeship', Chapter 4, Göranzon, B., and Josefson, I. (eds) *Knowledge, skill and artificial intelligence*, London, Berlin: Springer-Verlag, 31-38

Harré, R. 1977, 'The structure of tacit knowledge', *Journal of the British Society for Phenomenology*, 8 (3), 172-177

Harré, R. 1982, "'Attending from clues": an essential ambiguity in Polanyi's account of science', *Journal of the British Society for Phenomenology*, 13 (3), 302-3

James, W. 1895 'The knowing of things together', *The Psychological Review*, II (2), 105-124

James, W. 1911 *The meaning of truth*, (New York: Longman Green & Co) (text at: <http://paradigm.soci.brocku.ca/~lward/James>)

Janik, A. 1988 'Tacit knowledge, working life, and scientific method', Chapter 6, Göranzon, B., and Josefson, I. (eds) *Knowledge, skill and artificial intelligence*, London, Berlin: Springer-Verlag, 53-66

Josefson, I. 1988 'The nurse as engineer - the theory of knowledge in research in the care sector', Chapter 3, Göranzon, B., and Josefson, I. (eds) *Knowledge, skill and artificial intelligence*, London, Berlin: Springer-Verlag, 19-30

Josefson, I., Göranzon, B., Nordenstam, T., 1982 'The case study', in Göranzon, B. et.al. *Job design and automation in Sweden*, Stockholm: Center for Working Life

Keller, C., and Keller, J. D. 1993 'Thinking and acting in iron', in S. Chaiklin and J. Lave, (eds) *Understanding practice. Perspectives on activity and context*, Cambridge: Cambridge University Press, pp. 125-43.

Lakoff, G. and Johnson, M. 1999, *Philosophy in the flesh. The embodied mind and its challenge to Western thought*, New York: Basic Books

Lave, J. and Wenger, E. 1991 *Situated learning, Legitimate peripheral participation*, Cambridge: Cambridge University Press

Lewicki, P., Hill, T. and Czyzewska, M. 1998, 'Nonconscious acquisition of information', (<http://cogprints.soton.ac.uk/archives>, accessed 18/9/99)

Marx, K. 1974, *Capital*, vol. 1, London: Lawrence and Wishart

- Myers, P. S. 1996 *Knowledge management and organizational design*, Boston, Oxford: Butterworth-Heinemann.
- Nonaka, I. 1990 'Managing innovation as a knowledge creation process', Presentation at New York University, Stern School of Business, International Business Colloquium (cited in Baumard 1999)
- Nonaka, I., 1994, 'A dynamic theory of organizational knowledge creation', *Organization Science*, 5 (1), 14-37
- Nonaka, I., and Takeuchi, H., 1995, *The knowledge-creating company*, Oxford: Oxford University Press
- Nonaka, I., Byosiere, P., Corucki, C. C., and Konno, N., 1994, 'Organizational knowledge creation theory: a first comprehensive test', *International Business Review*, 3 (4), 337-351
- Nonaka, I., Umemoto, K., and Senoo, D. 1996 'From information processing to knowledge creation: a paradigm shift in business management', *Technology in society*, 18(2) 203-18.
- Orna, E., 1990, *Practical information policies. How to manage information flow in organizations*, Aldershot: Gower
- Perby, M-L. 1988, 'Computerization and skill in local weather forecasting', Chapter 5 in Göranson, B. and Josefson, I. (eds), *Knowledge, skill and artificial intelligence*, London and Berlin: Springer-Verlag
- Polanyi, M., 1962, *Personal knowledge. Towards a post-critical philosophy*, Chicago: University of Chicago Press (originally published 1958; corrected edition published 1962)
- Polanyi, M., 1966, *The tacit dimension*, London: Routledge & Kegan Paul
- Polanyi, M., 1969a, 'Knowing and being', chapter 9 in *Knowing and Being. Essays by Michael Polanyi*, London: Routledge & Kegan Paul, pp. 123-137 (originally published in *Mind*, 1961, vol. 70 pp. 458-470)
- Polanyi, M., 1969b, 'The logic of tacit inference', Chapter 10 in *Knowing and Being. Essays by Michael Polanyi*, London: Routledge & Kegan Paul, pp. 138-158 (originally published in *Philosophy*, 1966, vol. 40 pp. 369-386)
- Polanyi, M., 1969c, 'Sense-giving and sense-reading', chapter 12 in *Knowing and Being. Essays by Michael Polanyi*, London: Routledge & Kegan Paul, pp. 181-207 (originally published in *Philosophy*, 1967, vol. 42 pp. 301-325)
- Prosch, H. 1973, 'Polanyi's tacit knowing in the 'classic' philosophers', *Journal of the British Society for Phenomenology*, 4 (3), 201-216
- Ramsey, W. 1992 'Connectionism and the philosophy of mental representation', Chapter 8 in Davis, S. *Connectionism: theory and practice*, New York, Oxford: Oxford University Press, 247-76

Reber, A. S. 1993, *Implicit learning and tacit knowledge*, New York, Oxford: Oxford University Press

Russell, B. *Problems of Philosophy* (1912) (text at: <http://www.ditext.com/russell>)

Ryle, G., 1963, *The concept of mind*, Harmondsworth: Penguin (originally published 1949)

Scott, W. T. 1982, 'On Harré on the structure of tacit knowledge', *Journal of the British Society for Phenomenology*, 13 (3), 300-301

Shotton, J. 1990, 'The social construction of remembering and forgetting', Chapter 7 in Middleton, D., and Edwards, D. (eds), *Collective remembering*, London and Thousand Oaks: Sage, 120-138

Sierhuis, M., and Clancey, W. J., 1997, 'Knowledge, practice, activities and people', *Proceedings of the AAAI Spring Symposium on Artificial Intelligence in Knowledge Management*, Stanford University, CA, 142-148 (<http://ksi.cpsc.ualgary.ca/AIKM97/sierhuis/sierhuis.html>)

Stufflebeam, R. S. 1998, 'Representation and computation', chapter 50 in Bechtel, W. and Graham, G., (eds) *A companion to cognitive science*, Oxford: Blackwell, 636-648

Tiles, J. E. 1992, 'On deafness in the mind's ear: John Dewey and Michael Polanyi', *Tradition and discovery*, 18 (3), 9-16

van Maanen, J., and Schein, E. (1979) 'Toward a theory of organizational socialization', *Research in Organizational Behavior*, Vol. 1, 209-64

Varela, F. J., Thompson, E. and Rosch, E., 1991, *The embodied mind. Cognitive science and human experience*, Cambridge, Mass.: MIT Press

von Krogh, G., and Roos, J. 1996 'Imitation of knowledge: a sociology of knowledge perspective', Chapter 2 in von Krogh, G., and Roos, J., (eds), *Managing knowledge. Perspectives on cooperation and competition*, London & Thousand Oaks: Sage

Wagner, R. K. and Sternberg, R. J. 1986, 'Tacit knowledge and intelligence in the everyday world', chapter 4 in Sternberg, R. J., and Wagner, R. K., *Practical intelligence. Nature and origins of competence in the everyday world*, Cambridge: Cambridge University Press, 51-83