THE DYNAMICS OF TACIT LEARNING IN ORGANISATIONS: A SYSTEM VIEW

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August 2011

The dynamics of tacit learning in organisations: a system view

Inaugural lecture delivered August 2011

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ABOUT THE AUTHOR

Prof John Powell is the Director of the University of Stellenbosch Business School. John started his studies in engineering at Cambridge University and received his PhD at Cranfield Royal Military College of Science. At both institutions he received various awards for excellence. He started his working career in the Royal Navy and then joined British Aerospace (BAe) as a systems engineer. After being awarded a fellowship, John decided to pursue an academic career. He gained lectureships at Cranfield and Bath University and, in due course, assumed the chair of strategic analysis. He subsequently held similar posts at Southampton and Cardiff Universities. John's research programme is highly applied in nature and can be divided into three main streams, namely the use of scenario methods for the identification of corporate strategy; systems-based methods for strategic management; and semi-formal and formal approaches to knowledge strategy. John has published his research in numerous academic articles and in books, and has applied it in consultancy contracts with various high-profile organisations.

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ABSTRACT

A decade of scholarly and practitioner work in knowledge management has shown that the tacit dimension of knowing is critically important. It is important, firstly, because tacit knowledge demonstrably exists – ignoring it would create a fatal gap in the management of the resources of the organisation. Secondly, tacit knowledge possesses interesting and useful strategic properties; because it is less accessible to persons outside the organisation it is more difficult to detach the tacit knowledge from its owner(s).

There are well-known frameworks for explaining the behaviour of tacit and explicit knowledge but they possess one major and one minor gap. The less significant lacuna is the general absence of consideration of that component of knowing which is not merely inexpressible (thus tacit), but is unknown, i.e. the knower is unaware of her/his knowing. More significantly, work deriving from intelligence systems stresses the importance of that knowing which is of a systemic nature, as opposed to knowing of a localised, or 'point', nature. An extensive body of work now exists which takes this system view of knowledge into account, but little exists in terms of frameworks for understanding how this systemic knowledge behaves dynamically.

Some practical experiences are described in the form of mini-cases, which collectively give indications of the conditions under which tacit knowledge (of both forms) is likely to be co-created in the organisation. These are brought together in an informal structure for guiding managers in creating the conditions for that co-creation.

WHY IS TACIT KNOWLEDGE IMPORTANT TO ORGANISATIONS?

All knowledge is important to an organisation. While it is not (contrary to a wide body of opinion [Anand and Khanna, 2000; Brusoni and Prencipe, 2001; Grant and Baden-Fuller, 2004]) the only asset worthy of consideration in the strategy of an organisation, it holds a unique place in that register of assets in so far as without knowledge, the complex trading of a company, by which value is added by the firm to a set of input factors, becomes reduced to such purely mechanistic value-adding processes as translation (to a place where the input factor is more highly valued) or storage (to await more favourable selling conditions) [Cowan and David, 2000; Ford, 1997, 1998; Swart and Henneberg, 2007; Swart and Kinnie, 2003, 2010]. Such limited business is rarely all that is desired by an organisation.

Tacit knowledge (by which is meant all knowledge which cannot be codified, or made explicit – explicated [Polanyi, 1966; Swart, 2006), specifically, holds a particularly important place in the asset base for a number of reasons. Firstly, it is itself a form of knowledge (or of knowing, if preferred) and as such contributes, potentially, to the ability of an organisation to deliver its valued outputs [Kinnie, Swart and Purcell, 2004]. Secondly, it has certain attributes, primarily because of the way in which it is created in an organisation, which make it more difficult to identify, and even detect, from the outside, and so (as is shown later in this paper) it presents a natural contributor to the desirable 'causal ambiguity' by which strategic advantage is protected from predation and decay [Grant and Baden-Fuller, 2004; Tsoukas, 1996].

Tacit knowledge, then, is of fundamental concern in the knowledge management and strategy of an organisation and it is hardly an exaggeration to observe that, with a certain flexibility of definition, the strategic aim of an organisation is to ensure that, at any time, the requisite knowledge is available in order for value to be added to the input factors

MODELS OF KNOWING

Ensuring the availability of tacit knowledge within the firm in practice, however, is an affair charged with difficulties because of the essential nature of tacit knowledge: we can talk about it, but we cannot describe how we know it [Bowman and Swart, 2007]. Some authorities claim that the most effective way of describing how we know it is to attempt the capturing of that knowledge into the explicit domain, where it is easier to manage the transfer of knowledge, since, by definition, explicit knowledge can be transferred explicitly.

The model is as follows.

We conceive of a person as having repositories of both tacit and explicit knowledge.

Knowledge, it is asserted, can be brought from the tacit to the explicit level by a process of explication [Baumard, 1999].
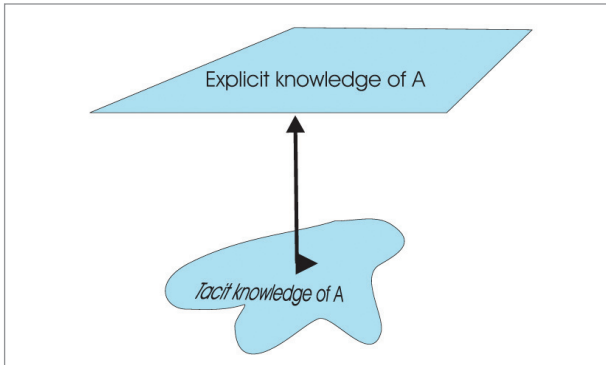

Figure 1: Explicit and tacit knowing are linked by explication

There is some variety in the views on what this process constitutes but, in essence, it is generally seen as a proceduralisation of the tacit knowing, so that the steps of the process and the components of sense-making can be stated explicitly and hence defined for use by others [Nonaka and Takeuchi, 1995]. The model assumes that tacit knowledge cannot be transferred directly from one person's tacit knowing into another's. After all, how could we possibly transfer to another something that we cannot explain? It has to pass up and over, using the explication process as the medium of transfer.
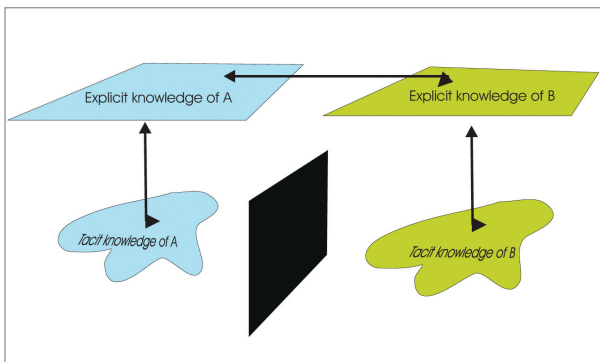

Figure 2: Tacit knowing is transferred only through the layer of explicit knowing

There are difficulties with this approach, however.

First, even in a narrow interpretation of knowledge management as constituting the capturing of knowledge in explicit form, two issues of strategic practice come to light, namely

- the extent to which we should apply the scarce resources of the firm, and apply them to the particular

activity of knowledge capture rather than to other worthy causes, such as physical and human resource building, brand management, organisational development and others [Grant, 1998; Purcell et al., 2004], *and*

- the extent to which, as we make knowledge explicit ('capture' it), we make it available to others to exploit [Swart and Henneberg, 2007].

Figure 3 shows how, in terms of the explication of knowledge, the efficiency of capture becomes less as we proceed to explicate knowledge more and more. We express this through a concept of *resistivity*, i.e. the amount of resource required to capture a given amount of knowledge. Little argument needs be applied to indicate the broad shape of the efficiency curve. Asking an expert, say a gardener, what she knows about horticulture will produce massive availability of basic knowledge rather quickly. One simple question will elicit a flood of what is known about which flowers grow well in certain conditions, what the feeding and watering regime should be, how photosynthesis works and so on. Soon, however, the questions become more difficult to phrase and the answers less certain. 'How do you design a flower bed, then?' will elicit both a long pause before the phrasing of an answer and considerable mental effort in clarifying the deep tacit knowledge immanent in the skill of garden design. While the question is well-defined, the informant will have to work hard to explicate the aesthetic rules of design.
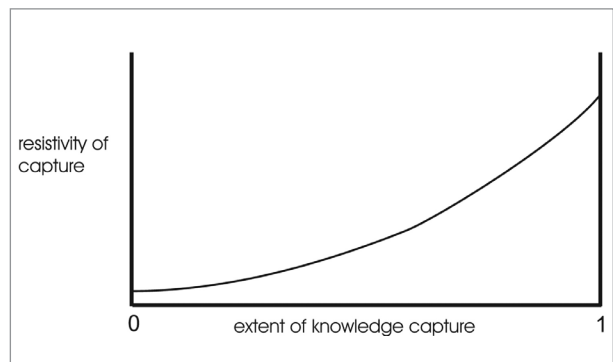

Figure 3: As we capture knowledge it becomes more difficult to capture the remainder

Figure 3 represents one of the main accepted views of knowledge management, where, by the application of more and more resources, we can eventually capture as much of the knowledge resident in an organisation as we wish. Even with this simple view of knowledge management, there are resource application issues. Simply, the firm must decide how much knowledge risk

[Kahaner, 1996] it wishes to take. By knowledge risk (KR), following Kahaner's conception, we mean the likelihood that, under a given future circumstance, the knowledge available in the firm to meet the needs of that circumstance will prove insufficient. For example, one can imagine the decision to engage in a research project to meet a predicted demand for functionality in consumer goods, or a decision to invest in knowledge capture to reduce the loss of available knowledge should, say, skilled sales staff be poached by a competitor.

Clearly, as investment is made in making knowledge available (capturing it), the KR will reduce (see Figure 4).
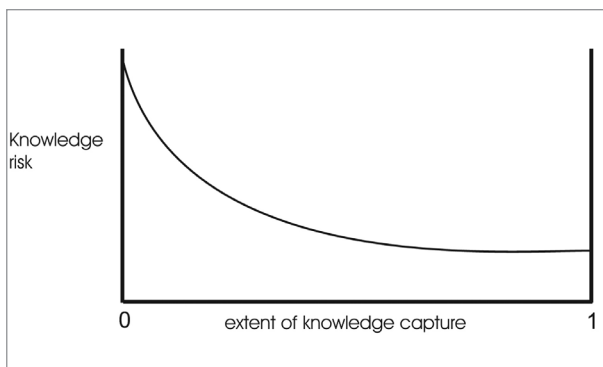

Figure 4: Knowledge risk reduces as more knowledge is made available to the firm

There is, however, another issue, which is that if we make knowledge available (in the strict sense of capturing and explicating it), we will increase the competitive intelligence risk (CIR) [Powell and Bradford, 2000], which captures the idea that explicated knowledge is more easily available for acquisition by competitors. Figure 5 shows that, as the knowledge available increases, the CIR increases, and there will be an optimum level of explication that balances the KR and the CIR. In other words, it does not make sense for the firm to attempt a complete explication, not only because of the scarcity of resources but also because of considerations of the competitive risks inherent in explication. What is written down is vulnerable.
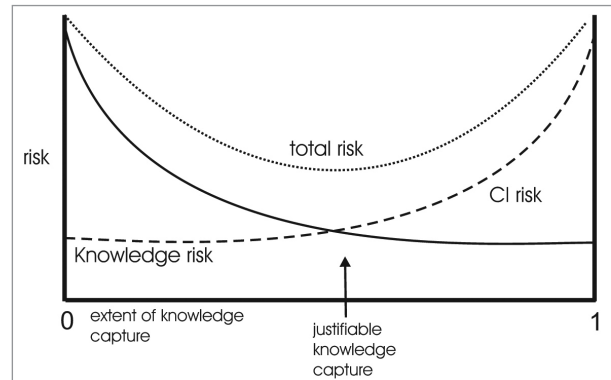

Figure 5: Accommodation between KR and CIR leads to an appropriate level of capture

This view of knowledge availability as a matter of capture is unnecessarily and unhelpfully narrow, however.

First, the idea that making knowledge available to the firm for business use is simply a matter of capturing the tacit, of explication of the tacit into the explicit, is untenable. It is not only desirable, but demonstrably possible, to transfer tacit knowledge directly from a tacit to a tacit domain; indeed, it is the main purpose of this paper to uncover those characteristics of an organisation that would facilitate tacit-to-tacit transfer. Thus, the idea of knowledge capture is replaced by the associated idea of knowledge availability. The view that knowledge availability results merely from capture and explication implies that only knowledge made explicit is available. Here it is argued that, to the extent that a) tacit knowledge can be transferred without explication and b) knowledge can be co-created in an organisation, the available knowledge is greater than that which has been explicated.

Second, the interaction of KR and CIR is such that, when the unexplicated tacit knowledge is included in the available knowledge set of the firm, the KR profile can be improved (see Figure 6).
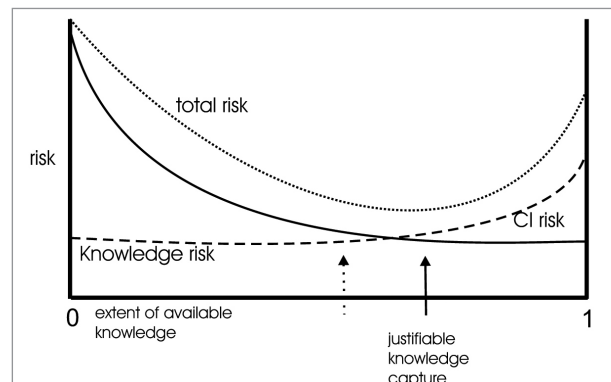

Figure 6: If unexplicated tacit knowledge is included, the available knowledge can be increased

Because the available knowledge is not merely that which is explicated, the CIR curve rises less sharply as the available knowledge is increased. Only that part of the available knowledge deriving from the explication process is vulnerable directly; that portion of the knowledge made available by tacit-tacit transfer and co-creation is not directly vulnerable. Hence the optimum point of knowledge 'capture' (which now includes that transferred by tacit-tacit means) is greater. Clearly the issue of the opportunity cost of resource expenditure remains, and that can only be addressed within the financial specifics of the firm, but from a pure KM perspective it is now safer to make more knowledge available and, as a result, the firm will be better prepared to meet an uncertain future.

There are, then, significant business advantages to be gained should we be able to make available knowledge that is relevant to the future business problem other than that deriving from the tacit-explicit-explicit-tacit (t-e-e-t) process [Kinnie, Swart and Purcell, 2005].

We therefore seek a direct transfer of knowledge (if such a thing were possible) from one person's tacit knowing to another's. We refer to the supporting context and processes of this tacit-tacit diffusion as the tacit learning environment (TLE), in contrast with the explicit learning environment, which underlies much of the 'explication school' of organisational learning.
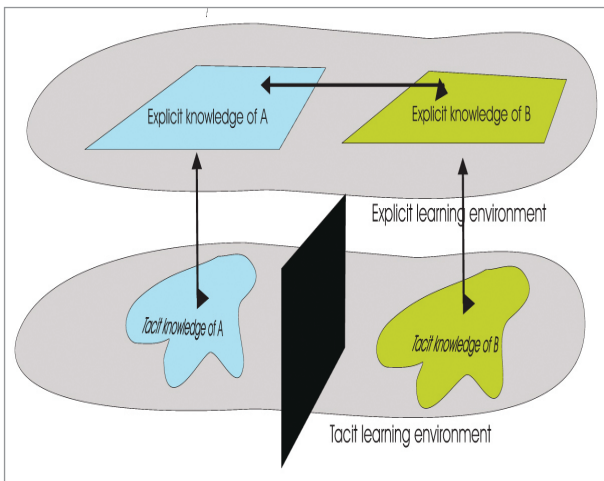

Figure 7: *We seek a direct tacit-tacit transfer through an appropriate learning environment*

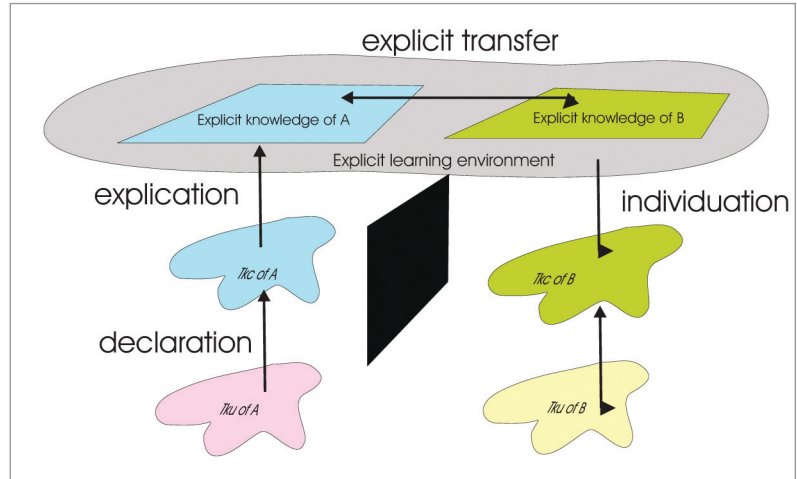Figure 8 defines some terms needed in the subsequent discussion.

Figure 8: *Terms used in the TLE discussion*

- *Declaration* we define as the process by which un-known (i.e. unrecognised tacit knowledge (TKu) is brought into the awareness of the knower and is brought from the domain of what is not known but is nevertheless enacted into the domain of con-scious tacit knowledge (TKc).

- *Explication* is the process by which known tacit knowledge (TKc) is codified and captured into the explicit domain.

- *Explicit transfer* is the diffusion of explicit knowledge within the explicit domain from one participant to another (we include groups as well as individuals).

- *Individuation* is the internalisation of explicit knowledge into the tacit domain of the recipient.

The objectives of the TLE are threefold:

a) To engender tacit-to-tacit knowledge transfer and, by implication, the co-creation of knowledge.

b) To assist in the individuation of knowledge (its expression back into the tacit knowledge of the recipient under the t-e-e-t architecture).

c) To assist in the declaration of TKu.

'STRUCTURALISATION' OF KNOWLEDGE – THE SYSTEMS DIMENSION
Localised versus systemic knowing

While the distinction between EK, TKc and TKu is critical to our understanding of how knowledge is co-created and disseminated within the organisation, there is another consideration which, we shall see later, bears strongly on the practical organisation of that

management of knowledge. This consideration is the span of concern of the material that is claimed to be known. We can claim to know small things and great things in system terms:[1] In the system in which we operate, some of our knowing is localised; I know that cumulus clouds often bring rain. Such 'point knowledge' [Powell and Bradford, 2000] is valuable, but, it is argued, not as valuable as a more systemic knowledge of why these particular atmospheric features generate rain. In our opinion, in the latter case our understanding, being based on the causal mechanism of precipitation (in this instance), allows better prediction, deeper understanding and enhanced prospects for development and extrapolation [Leonard and Strauss, 1998; Nonaka, 1995; Powell and Bradford, 2000; Swart and Powell, 2005].

The extent to which the known attaches itself to the system as a whole as opposed to some localised material fact is referred to here as the degree of structuralisation. A high degree of system understanding (knowing how convection currents, airflow dynamics, thermal gradients, etc. work together to create rainfall in a cumulus cloud) has a high structuralisation, whereas the simple, almost childlike knowing that cumulus clouds bring rain is nevertheless valid, but of low structuralisation. We shall see later that the degree of structuralisation of knowledge in an organisation is important in terms of its relevance and usefulness to an organisation, but also determines to a great extent how we should manage the dissemination and creation of knowledge in a firm.

Structuralisation in tacit and explicit knowing

An extended example might serve to illustrate how structuralisation and the tacit-explicit distinction serve together to categorise knowledge.

The knowledge domain that we will use to illustrate this connection is that of seamanship and navigation. We have chosen this for particular reasons. Firstly, it is an area of human endeavour familiar to the writer, who has observed it at close quarters for many decades. Secondly, it is sufficiently accessible to most readers. Thirdly, and most importantly, it is an area of activity

where EK, TKc and TKu are strongly evidenced and, moreover, where systemic knowing is of demonstrable validity and importance. Our subject is an individual rather than an organisational group. He has some 40 years of experience and is both an experienced seaman (having accumulated some 10 000 nautical miles of journeying in sailboats) and an RYA[2] instructor of sailing and seamanship. We shall examine the way in which this person's knowing can be categorised according to the two characteristics, structuralisation and the tacit-explicit distinction.

Table 1 shows the framework.

We see in Table 1 that explicit knowledge is authen-

Degree of structuralisation					
	Point data	Connective knowledge	System knowledge	Authen-ticator	Basis
Explicit				public	declared knowledge
Tacit TKc				self	self-knowing
TKu				third party observer	action of observed

Table 1: *Framework for categorisation of knowledge*

ticated by explication, by the declaration and public availability of the codified knowledge, whereas tacit knowledge is authenticated not by declaration, but by observation. The authentication of TKc and TKu, however, is very different. The former is authenticated directly by the self-knowledge of the knower, whereas TKu is authenticated only through observation of the actions that imply the existence of unconscious knowledge on the part of the actor.

We now proceed to populate the shaded area of

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1. One is reminded of the timeless fable of the fox who knows many small things and the hedgehog who knows but one great thing. The hedgehog is an effective 'point-knower', but the fox is a 'system-knower', albeit not a very powerful one.

2. The Royal Yachting Association certificates sailing and navigation instruction worldwide. It is based in the UK.

Table 1 with examples of the knowledge of our informant (see Table 2).

Sailing a boat is a multi-dimensional experience demanding a huge spread of point, connective and systemic knowledge. An experienced sailor, attuned to the feeling of the boat, will wake not only when the noise of the boat against the water alters (Table 2 – bottom left corner), but will do so without knowing why. Experienced sailors will utilise more complex (systemic) knowledge, altering sails, for example, without really being aware that they do so. As the bottom row of Table 2 we show examples of more complex, systemic knowledge exhibited by a third party.

Much of the knowledge exhibited by our informant is TKc. For example, he can tell us when the tide has turned without being able to see the obvious clues, such as which way boats in the immediate area are facing.[3] He also knows exactly when to reduce the amount of sail carried by a boat, taking into account a huge variety of factors. When asked how he does this, he answers, "I don't really know, but I can tell you that if you don't take [the wave shape] into account you could well get it wrong". This is, without question, TKc of a highly systemic nature.

Explicated knowledge is very common in sailing and navigation and forms the basis of most training. Our respondent is an expert teacher and trainer and has no difficulty (where it is possible) in expressing his tacit knowledge. When pressed, for example, he explains in great detail how he knows that when the tidal flow is strong (so-called 'spring tides'), a heavy sea declines more quickly compared with when the tidal flows are weak (top centre box of Table 2). Nevertheless, there is much in what he knows that cannot be explicated.

The contention of this paper, supported by Powell and Bradford [2000], is that systemic knowledge is more valuable for the firm in the sense that knowledge which is applicable to a wider system is inherently more useful than knowledge which is localised in its scope. This is apparently not always the case. One can think of examples where a piece of point data (the price at which a competitor will enter a commodity market, for example) is of great use, but a moment's thought will show that even in this extreme case, the point data is important only when mobilised within the system understanding of the effects of such a price entry upon the market dynamics. Generally speaking then, and

Degree of structuralisation			
	Point data	Connective knowledge	System knowledge
Explicit	'Note that when the tide turns, the water flows the other way in the river.'	'If the tide runs strongly, more wave energy is lost in the disturbed motion of the water, so the sea dies down more quickly.'	'I have a full hydrodynamic and aerodynamic model of the boat, its environment and how they interact to cause motion and movement of the hull. Here it is.'
Tacit — **TKc**	'The stream has turned' (but I don't know why I know)	'The sea dies down more quickly after a storm if the tide is running strong' (but I can't explain why)	'I know when to reduce sail by taking into account the strength of the crew, the weather, the position, the sea state, the balance of the boat. All these work together.' (but I can't explain how they work together.)
Tacit — **TKu**	'The skipper wakes up when the noise of the boat alters.' (but he doesn't realise he does so)	'I notice that Jeremy makes the boat turn into the wind whenever there's a gust.'	'Fred fiddles with the sails all the time according to the strength of wind, the sea state and the speed of the boat.' (but he doesn't realise he does so)

Table 2: Examples of types of knowledge drawn from navigation and seamanship

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3. Readers from Mediterranean countries will need to know that, as the tide turns, streams reverse, causing boats to swing on their moorings.

subject to the resources needed, our learning environment will add value to the firm if it can expand knowledge in the direction of the right-hand side of Figure 9, towards system understanding rather than point data.

The same clean position cannot, however, be adopted in respect of the degree of explication (the vertical axis of Figure 9). There is no assumption here that explicit system knowledge is better than tacit system knowledge and, indeed, arguments surrounding the CI risk illuminated earlier in this paper show that a mix of tacit and explicit knowledge is likely to be a desirable output of the learning environment.
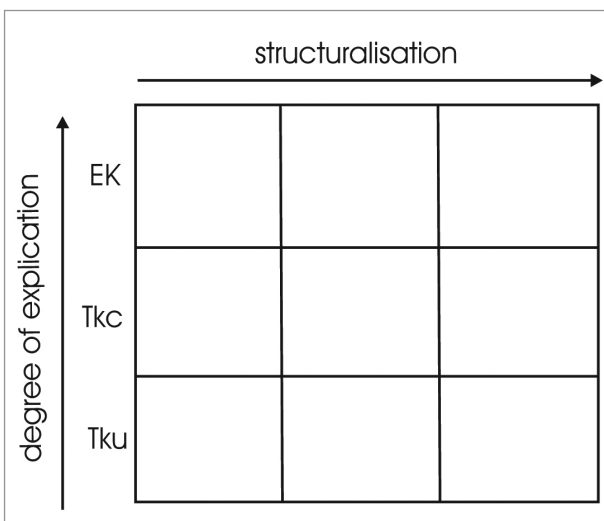

Figure 9: *Schema for characterising the learning environment*

SOME OBSERVATIONS FROM PRACTICE

Sharing knowledge, be it explicit or tacit, is a common feature of cooperative endeavour; indeed, one can almost characterise cooperation in terms of knowledge sharing and co-creation alone. Unless the protagonists are prepared to share a common understanding (or at least to aspire to such sharing), there is little point in conversing.

The examples which follow are drawn from a field of cooperation which is well-documented, namely the cooperation of professional, high-technology workers in projects. It happens that our examples derive from the defence industry, but they stand as typical of professional cooperative endeavours. Three situations are described, illustrating some common themes in the way in which knowledge was or was not effectively co-created during its trajectory The transfer of knowledge

and the co-creation of knowledge when specialists from different companies and resident experts from the civil service come together in project teams, often for substantial periods of time, form a common thread through these examples.

The 4.5" Mk8 Mod 1 Naval gun

The standard naval gun for the Royal Navy for many years has been the 4.5" Mk8, designed and manufactured by Royal Ordnance plc (RO). A requirement for a replacement gun system, the 4.5" Mk 8 Mod 1, emerged and the project was put out to tender by the UK government, it being that government's policy not to grant sole-tender contracts.

There was, however, a problem common to many projects deriving from a country's strategic defence industrial base, namely that, because of the high investments required to maintain a world position in technology in this specialised area, only one entity (RO) was in a position to design the new gun system. It was decided to run a competition solely for the manufacture of the gun. There was an aspiration that subsequently this would have the potential to engender increased competition, in that were a bidder other than RO to win the competition for the manufacturing, design knowledge would be transferred as dialogue took place between RO and the new bidder. In our terms there was an expectation that knowledge would be transferred, both *explicit* (in the form of design books) and *tacit* (in the sense of design know-how), from the design authority to the winner of the manufacturing competition. When that knowledge was transferred, it would be possible, in the future, to satisfy government competition policy by running both a design and a manufacture competition for subsequent projects in this area. Such governmental endeavours are common throughout the world of defence procurement [Sandler and Hartley, 1995].

The competition was run and, as was discreetly hoped, a bidder other than RO indeed won. This company, Devonport Management Limited (DML), was skilled in the fitting and maintenance of such naval guns and, at first, it was hoped that not only would design know-how migrate from RO to DML, but even that the DML knowledge of the guns' performance in service would enhance the design capabilities of RO. All looked well for the co-creation of knowledge between the two contenders.

But then RO looked at its costs. Maintaining an expensive design team with a dramatically reduced

expectation of attracting lucrative manufacturing work under the new competitive regime no longer made sense to RO. Essentially, because of the stringent governmental competitive policy, DML was able to take a rent on RO's investment in design know-how. RO decided to shut down its naval gun design team, deploying some to related land systems, but losing the integrity of the design team in the process.

The effect was catastrophic for the UK government's competition policy in this somewhat specialised area. Co-creation of knowledge simply ceased. Not only was the knowledge transfer from RO to DML now limited to explicit, contracted design material, but any co-creation of knowledge by the back-transfer of DML's in-service knowledge to RO ceased before it had started.

The Astute nuclear submarine joint team

Another, more successful attempt to transfer professional knowledge between and among designers and other specialists occurred in the UK submarine industry in the period between 1993 and 2003. The Astute project was a complicated one, aimed at providing a replacement for the Trafalgar class nuclear attack submarine. It went through a number of phases, some of which ran out of funds in attempting to advocate wholly new designs, but in essence it was the embodiment of a government competition policy aimed at improving the competitive dynamics of the nuclear submarine industry, while at the same time procuring a much-needed new build of enhanced nuclear fleet (attack) submarines.

Essentially there was only one supplier at the beginning, namely Vickers Ship Engineering Ltd (VSEL), based in north-western England. This was viewed as inadequate in two respects. Firstly, as a matter of competition policy it was deemed desirable to have more than one contender for submarine design and manufacture and, while the French submarine industry provided a ready theoretical source of competitive pressure, it was recognised that in-country competition would be less problematic in terms of the security issues surrounding nuclear design matters. A group of four companies (Rolls Royce, VSEL, British Aerospace and GEC) were brought together to develop an initial design and subsequently to bid for more detailed design and manufacture.

These four companies provided specialists with backgrounds in submarine matters together with their own specialist expertise. For example, the GEC company brought ex-naval submariners who had developed digital system expertise in torpedo launch and sonar detection systems, while the Rolls Royce (RR) contingent was able to talk with authority about the placement of the nuclear steam plant in the hull of the submarine. The two teams had a common language of submarine operation and could work together to create, for example, knowledge about how to design so that the noise originating in the nuclear plant would not unduly affect the ability of the submarine sonar systems to detect other vessels. There was a clear combination of common knowledge from the design environment as well as the bringing in of specialist expertise.

Things went well; an effective design team was formed and made progress with a design, motivated by a clearly agreed memorandum of understanding between all four companies. The team spent many months working and playing together. There were competitions to design rafts to race on the English Lakes at weekends, as well as serious, committed, late-night design reviews. Important project positions were shared between the companies, so that the four firms' employees formed an impression of a joint endeavour. While VSEL were the titular head of the group, there was no doubt about the importance and contribution of the other companies' experts.

There was also a fifth body of experts, namely the Specialist Professional Engineers (SPEs) of the UK scientific civil service. Prior to the initiatives underlying the setting up of the four-company group, design authority had been vested in these SPEs, in that responsibility for the performance of the design remained with the Crown. The SPEs were important people but, with the arrival of the four-company design team (which held clear design authority under contractual conditions of liability), they were relegated to the role of advisors. Moreover, their advice was, in essence, unwanted or at best unusable, since their ability to understand the commercial context of the risk judgements being made in the design team was limited because of their dedication to a career only in the public service. Their advice was aimed at minimising risk rather than optimising it – a crucial difference.

Relations between the SPEs and the design team deteriorated. There was an initial expectation that both sides would work together to co-create knowledge about the design deriving from (on the part of the SPEs) the operational requirement and context, 'how we did things before' and deep specialised technical knowledge, and (on the part of the four companies' designers) how experience in other, adjacent domains and an integrated

approach to system design could assist in producing a better submarine. The reality proved very different. The SPEs' inputs were minimised. The industrial designers avoided meetings with the SPEs. There was little or no social contact. The SPEs exacerbated the situation by appealing to contractual conditions which served only to amplify the perceived differences in position between the contractor and the contract authority. It became a 'them' and 'us' situation and both parties lost thereby.

Stealth projects in the European aerospace industry

The final example is set in the late 1980s, when stealth technology, and in particular radar cross-section reduction, became a critical design issue in the world aerospace industry. Two teams, concentrating separately on Electromagnetics and on Aerodynamics, were set up in British Aerospace to develop the precursor to the Typhoon (Eurofighter). Radar cross-section reduction, while not a central feature of the design, nevertheless was a material issue. This was a very highly classified aspect of the design and the team in aerodynamics, dealing with the general aerodynamic arrangement of the aircraft, was not allowed to talk to the electromagnetics team, which was responsible for the detectability of the design by threat radar systems and the system effect on the electronic warfare suite of the aircraft. Both teams understood the requirements and the operational context extremely well, and there was a high degree of motivation to share the useful differences in underlying expertise between members of the two teams.

Two things seemed to prevent the co-creation of knowledge, however. First was the obvious constraint of the security environment. Initially, discussing such highly confidential design aspects across the boundary of the Electromagnetics Department was a disciplinary affair – you could literally lose your job. Secondly, there was little or no professional motivation so to do. There was little understanding on the part of the electromagnetics people of the dramatic effect of (what they saw as) minor changes to trailing edge design on aeroelastic and aerodynamic performance, while the aerodynamics specialists had no appreciation for the equally dramatic effects on warfare capability of radar cross-section reduction. There was, for example, blank amazement about and distrust of the results of a study by the electromagnetics staff presented at one of the few formalised design reviews, where it was shown that a modest radar cross-section reduction was equivalent

in its contribution to medium-range air combat capability of a weight reduction of 30%, an unthinkably ambitious achievement by conventional means.

Soon reason dawned and the security fence was widened to include both teams, who soon reverted to their natural state of mutual trust and socialisation under the common endeavours of enhancing their own professional knowledge and their commitment to the design of the aircraft that would secure their futures. They talked freely and without formality, and the stealth design progressed impressively fast.

SYSTEM CONSIDERATIONS: CHARACTERISTICS OF THE TRANSFER

We can draw some clear messages from these vicarious experiences in respect of the conditioning factors which lead to the co-creation (or otherwise) of knowledge.

Existence

When, as was the case in the 4.5" gun example, one of the parties ceases to exist, it is self-evident that co-creation of knowledge will also cease.

Capacity of channel

To the extent that knowledge is transferred between parties (rather than being created anew in the recipient's mind), all three examples lead us to consider whether there is a straightforward issue of the capacity of the channel between the parties being adequate to support the transfer of knowledge and whatever underlies the transfer of knowledge. Below, we discuss the way in which, for example, the absence of a common experience in the Astute submarine example was a negative conditioning factor in respect of the ability of the SPEs to form common cause with the designers. Conversely, within the four-company group there was substantial homogeneity of experience, which provided a basis for common understanding. Similarly, in the extreme example of the stealth project, the security environment was not only coercive in and of itself, but by legislating the very timing and scope of discussion it clearly constrained the available channel capacity for knowledge transfer.

Content of transfer

While the potential of the channel to support knowledge transfer may be high, there is no guarantee that knowledge transfer will take place. In the case of

the Astute programme and the SPEs, for example, there were many topics even in that area of joint interest in which the two parties (the SPEs on one hand and the four companies' designers on the other) held similar knowledge. What then is the motivation to expend effort merely to check common understanding, when more effective participation in the co-creation of knowledge can be achieved with a different partner? In the case of the stealth project, the co-creation mechanism bounded ahead as soon as the security constraints were lifted, since, with the large channel capacity created by the high degree of homogeneity of knowledge (the common knowledge of the firm, structures, technology and context), the heterogeneity of the electromagnetic and aerodynamics experts provided ideal circumstances for the interlinking of new sets of concepts that comprehended by the Swart-Powell entropy-based model of knowledge expressed elsewhere [Powell and Swart, 2008; Swart and Powell, 2005].

Availability function (enthalpy)

Just as the total energy of a system in thermodynamic systems is not always available for work (the concept of enthalpy), so not all the knowledge is available for transfer in knowledge systems. Some of it is not available to the knower because it is tacit and unknown, but even that which is known (tacit or explicit) is subject to discretionary application. There is a huge body of literature that addresses this, usually in terms of trust between participants [Granovetter, 1973; Lee and Cole, 2003; Lin, 1999; Swart and Kinnie, 2003], and the SPE case illustrates this issue of trust and mutuality dramatically. Where there was perceived mutuality of endeavour, knowledge was made available by the participants in order to further the declared joint aims of their companies – they shared design rule-books and stories and myths in equal measure. When, in the case of the SPEs, there is evidence not just of a lack of mutuality but an actual attempt to coerce the transfer of knowledge [as in "*You have to tell me how you weigh risk; it's a contractual requirement*"], we find the protagonists going through the motions of co-creation. Meetings would take place at which no actual know-how was transferred.

One can interpret this in two ways within a model. First, we can view a coercive environment as a Habermasian constraint on communicative rationality (i.e. if we are coerced, we decline to communicate) and hence as a diminution of the channel capacity [Habermas, 1981]. We refer to this as *contextual conditioning* of the channel of communication. Second, we can interpret it

as a direct demotivation to transfer knowledge itself. In other words, the channel capacity is large enough, we have heterogeneous and therefore worthwhile things to say, but we choose not to because of some perceived dysbenefit in doing so. We refer to this aspect as *personalised valuation* of the availability of knowledge.

We then clearly see a distinction between

- *channel capacity* (the ability of the relationship to support knowledge transfer),
- rate or *quantity of knowledge transfer* (the potential for things not yet known to enter the knowing of the recipient), and
- the *value* (positive or negative) of that transfer.

Those familiar with the literature of Information Theory will see exact parallels with the associated concepts in the Shannon-Weaver conception of information transfer of *communication bandwidth*, *information measure*, measured by the well-known Shannon-Weaver information measure, and the value of that information transfer. Information Theory indulges in the separation of the first two points from the second, leaving any commentary on the economic benefit of the transfer to the economist. Here, however, it has been decided to deal with the structural issues of channel capacity, knowledge transfer and the value of that knowledge in one framework, not least because it would prove impossible to disaggregate the motivations for knowledge transfer from the underlying structural concepts. Put simply, the motivation to transfer knowledge derives from similar motivational aspects of the social environment to those that create the channel for communication itself.

Summary of the model

The model, then, of the way in which knowledge is co-created in these situations begins with the idea that a protagonist has both *explicit* and *tacit* knowledge (both known and unknown) and that a fraction of that knowledge is *available* in the sense that, to the extent that knowledge is known or known about, free will exists as to the desirability of transferring that knowledge to another. In the case of explicit knowledge, of course, the process of transfer is more visible to the transferor, whereas in the case of tacit (known) knowledge, some transfer may well be taking place without the conscious knowledge of the transferand. Similarly, in the case of tacit (unknown) knowledge, the very existence of the transferand and the process of transfer will be invisible to the transferor (but not necessarily invisible to the recipient) (see Figure 10).
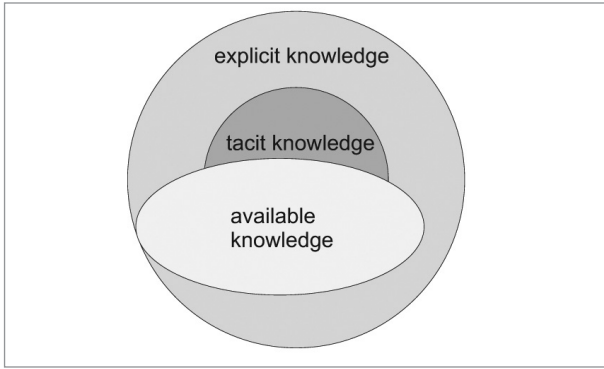
Figure 10: Protagonists possess both explicit and tacit knowledge, some of which they make available for transfer

When protagonists engage in communicative discourse, the conditions may be such that the co-creation of knowledge becomes possible. We discuss the conditions under which this is possible below, but where this is so, the amount of knowledge is increased and the participants can make that knowledge available for further communicative discourse, or not (see Figure 11).
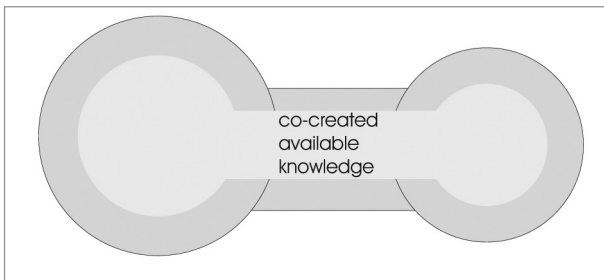

Figure 11: Available co-created knowledge emerges from the process of communicative discourse

It is the main subject of this paper to explore the conditions under which that co-created knowledge is great or small and the extent to which the co-created knowledge is made available (see Figure 12).
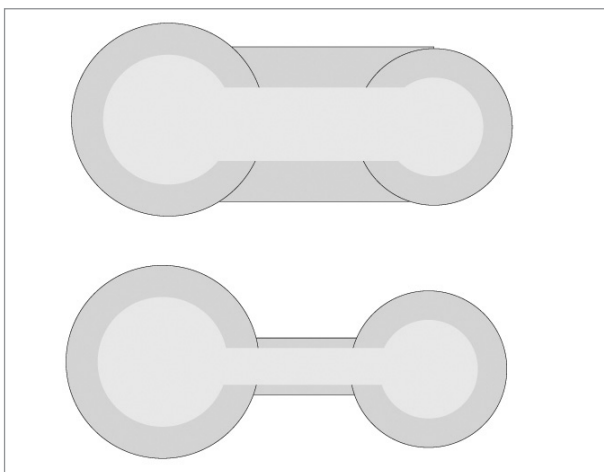

Figure 12: The amount of available co-created knowledge can vary according to the conditions

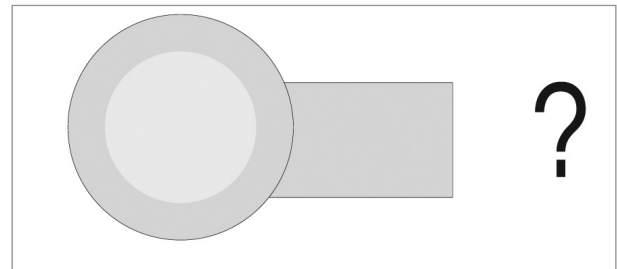## CONDITIONING THE KNOWLEDGE ENVIRONMENT
Existence

Figure 13: Co-creation requires the continuing existence of two parties

In the examples we have given, the continued existence of the protagonists was a function of the capacity of the host company to support the allocation of resources to that protagonist. The design authority (RO) in the naval gun example had no economic case for continuing to invest in supporting a high-cost specialised design function when it could not take an economic rent on that investment. We can generalise this to include all aspects of *force majeure*, but it is worth noting that not all *force majeure* is applied directly by the owners of the knowledge resource. In the naval gun example it was, in fact, the indirect action of the contracting authority (Her Majesty's government), which ensured the eventual disappearance of one side of the co-creating dyad. The irony of the situation is that, in the very act of attempting to ensure a dyad of co-creation by engendering competition in a claustrophobic monopoly, Her Majesty's government ensured the disappearance of the very source of that competition.

Sometimes the disappearance of one side of the dyad can be less obvious. For example, the nature of an organisation can change gradually over the life of the co-creation, so that the self-definition of the organisation can change incrementally, but so radically, that it makes no sense to talk of the organisation remaining the same. An example of this is the effect of very long-term agreements to collaborate on technology. Over the years, the competitive and regulatory context of American and UK firms has changed gradually but dramatically, so that an agreement to collaborate technically that was set up in 1980 will have little meaning when considered 25 years later from the perspective of the consolidated American and UK aerospace industries and under the markedly different competitive policy contexts of the Department of Defense and the Ministry of Defence respectively.

Capacity of channel

We observe in the examples above (and from others) that the channel capacity which creates the potential for co-creation and transfer of knowledge is conditioned by a number of factors. These can be divided into two groups, namely those deriving from the relativity of the knowledge structures in the dyad (the *homogeneity* of these structures) and those deriving from the extent to which the coercive or controlling nature of the *context* conditions the channel capacity (see Figure 14).
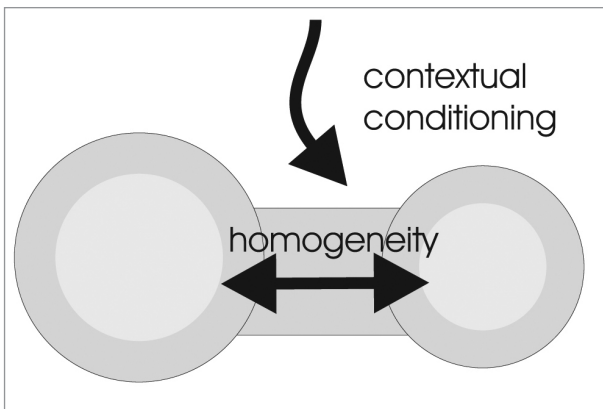

Figure 14: *Channel capacity derives from homogeneity and external conditioning*

Clearly, the frequency and effectiveness of contact between the protagonists is important. If a piano student is limited to being taught only one hour per year she will clearly not command sufficient channel capacity to make adequate progress, regardless of how excellent the teacher or how gifted the student. Similarly, in the project cases above we see that, in the case of the four companies involved in the Astute programme, the specialists were co-located whereas the SPEs remained enclaved in their government institutions, venturing forth only rarely to engage with the industrial experts. To a degree, one can interpret the socialisation component of social capital as a conditioning factor for knowledge co-creation in this way. More contact through social situations will mean a greater channel capacity, *ceteris paribus*, in addition to the beneficial effects of trust-building and perceived mutuality of endeavour. In the examples above, the stealth project experience of artificially limiting the channel capacity because of concerns over the inappropriate dissemination of classified information was, to begin with, catastrophic. Only when the channel capacity was increased, by the relaxation of the security rules to allow communication between the aerodynamicists and the electromagnetic experts, did co-creation of knowledge begin to appear.

However, the greatest conditioning factor for high channel capacity is the degree of homogeneity of knowing between the two sides of the co-creating dyad. This is particularly evident in the case of the stealth project, where the common experience of the military requirement, the technology and the commercial context created the conditions for co-creation.

We can interpret the contextual conditioning of the channel capacity through the lens of Habermas's communicative rationality. Habermas's extended argument in *Theorie des Komunikativen Handelns* starts from the observation that the "concept of communicative rationality carries with it connotations based ultimately on the central experience of the unconstrained, unifying, consensus-bringing force of argumentative speech…" (Habermas, 1981a, p. 10). He draws on the work of Schutz and Luckman in showing how "the teleological aspect of realising one's aims (or carrying out one's plan of action) and the communicative aspect of … arriving at an agreement" (Habermas, 1981b, p. 126.) contribute one with the other to produce strategic action in the world. In summary, the argument is that the communicative capacity of a discourse dyad is a function of the sincerity of the constituent speech acts and that that communicative capacity is the only sustainable basis for appropriate action (the *teleological aspect* above).

This has important consequences in our model of co-creation, since it leads us to enquire into the degree of coerciveness (or, to be more positive, the sincerity of the speech acts) of the surrounding environment. If we detect high power gradients, extensive localised interests and coerciveness in the context of the co-creation, we should, according to Habermas, be suspicious of the extent to which rationality can be communicated. Our procedure then is to investigate the motivations of the conditioning authorities (in our examples, the government, the board of directors, the special interests of the expert groups) in distorting the sincerity of the discourse. To put it simply, a coercive context will produce a narrow channel of communication, since there will be a general motivation not to communicate for fear of lending hostages to fortune. We shall see later that the concept of communicative rationality throws light on the specific valuation of communication, as well upon the capacity of the channel in general.

Content of transfer

The potential of the channel to support communication is not enough, however, to ensure the actual transfer. Just as the homogeneity of the knowledge structures of

the two sides of the discourse dyad engenders communicative capacity through the expansion of the channel, so the heterogeneity of those structures ensures the worth of that transfer and creates the valuation conditions for applying work in exercising the communicative function. We see this accommodation of heterogeneity and homogeneity in previous, more mathematical work [Swart and Powell, 2005], where we show that, for any knowledge structure, there is an optimum mix of homogeneity and heterogeneity between the two knowledge structures.

By heterogeneity we mean the extent to which the knowledge sets of the two protagonists are different. In the case of the stealth project, for example, one could investigate the spread of essential concepts held to be relevant by the two parties and find, on the one hand (for the aerodynamicists) the ideas of aero-elastic behaviour, weight, transonic airflow, separation, thermodynamic energy transfer, etc., and on the other hand (for the electromagnetic experts) that concepts of surface current, resonant structures and reflective configurations dominate. Both will hold certain concepts such as weight, structural integrity and overall military requirement in common, but the ways in which the two parties think about the problem of airframe design are very different. Heterogeneity is high.

As a consequence, it is worthwhile talking across the boundary, since, *pace* our conception of knowledge as residing in the interconnections of a concept space [Powell and Swart, 2008; Swart and Powell, 2005], it will be relatively worthwhile and cost effective to acquire a new concept (or even a dozen) from this heterodox group. Moreover, having acquired these new concepts, the benefit in terms of richness of interconnection in knotting them into the existing concept space will lead to a relatively large increase in knowledge in terms of the richness of interconnections among the members of the new, enlarged concept space. In practical terms, if the object of attention is aircraft design (as opposed to aerodynamics alone), the benefit to an aerodynamicist of acquiring concepts of radiating structures strongly informs his understanding of aero-structures. The associated opportunity for the co-creation of knowledge about how the electromagnetic factors of wing design are linked with the aero-elastic and aerodynamic considerations provides a large boost of knowledge compared with the hard graft of seeking more and more difficult interconnections among the smaller set of electromagnetically-uninformed aerodynamics knowledge.

Note that we distinguish between the content of the transfer, as measured by the establishment of inter-connections among and between the concept spaces of the two protagonists, and the valuation of that knowledge, to which we now turn.

Availability function (enthalpy)

Lastly, we note that the willingness of the protagonists actually to put work into the knowledge transfer and to make available the knowledge of which they are aware is a function of their local valuations of the worth of that knowledge transfer. Consequently, it is not the same as either the channel capacity nor the quantity of knowledge transferred of itself.

How are the activities enacted for the different types of K?

We can deploy this schema of structuralisation and degree of explication (Figure 9) to enquire how the knowledge of an organisation develops from *point data*, known at the TKu level, towards the more valuable systemic knowledge, whether that is known at the explicit, TKc or TKu level.

Figure 15 shows a very conventional conception of knowledge growth and dissemination. Here we see that the joint ambitions are to make explicit and subsequently to grow the applicability (structuralisation) of the knowledge.
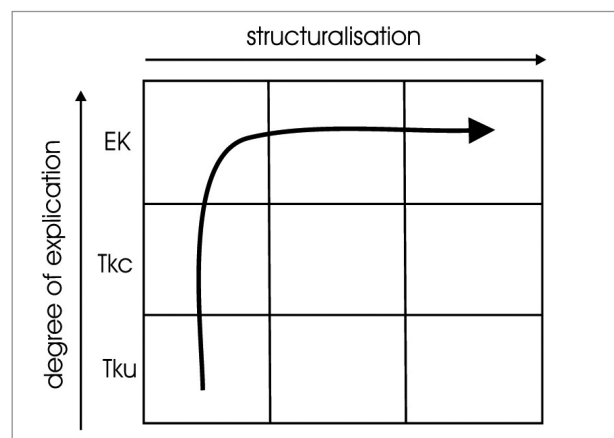

Figure 15: *Path 1, declaration - explication - structuralisation*

Figure 16, on the other hand, shows an entirely different path to explicit system knowledge. Here the structuralisation is achieved at the TKu level, before any attempt is made to declare and subsequently explicate that (now system-directed) knowledge. We have seen an example of this in our informant who is a skilled seaman and navigator. His acquisition of TKu knowledge,

enacted in the form of intuitively and unconsciously adjusting the sails on a sailing boat, was acquired through a process of accretion of point data and their connections, and integrating these into some system understanding, which, while it is limited to the relatively narrow endeavour of setting a sail on a boat in this case, is nevertheless a substantial example of TKu system knowledge. During the process of this informant's training and development as a sailing instructor, his huge TKu knowledge is declared and then explicated (in so far as it can be) into procedures for teaching at the explicit level, but it is also utilised at the tacit level in his teaching, as he co-experiences with his students and they learn from the common observation of the realities
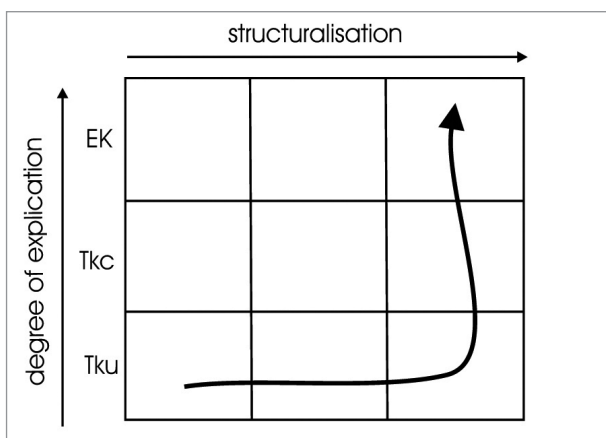

Figure 16: *Path 2, structuralisation - declaration - explication path*

Such a development path for knowledge runs counter to the generally expected process of engendering explication, of 'raising' knowledge from the inaccessible depths of the tacit unknown and making organisational knowers more aware of what they know and how they know it. The alternative route, of growing systemicity in understanding at the tacit levels before explicating it, appears counterintuitive, almost unsafe, because, being submerged, it is unobservable and therefore uncontrolled.

Lastly, one observes that the assumption that systemicity is more valuable than point knowledge (i.e. that one wishes that knowing in an organisation would proceed comfortably, visibly towards the top right-hand corners of these epistemic maps) is, in fact, unnecessarily strict. What is desirable is to move towards the right-hand side, towards greater systemicity, but that systemicity is as likely to be valuable even if tacit. Thus, even if the paths followed are more in line with the idea of t-e-e-t development (see Figure 17), the limitations of which served as the starting point for this

expanded concept, if the result is a greater usefulness because of a greater systemicity of knowledge, the result, managerially, is still a desirable one.
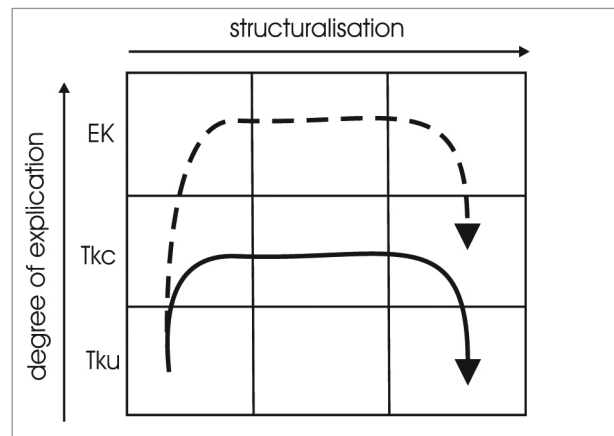

Figure 17: *Declaration/explication – structuralisation, followed by individuation*

SUMMARY

The key managerial conclusions which emerge from this study are that

- systemic knowledge vis-à-vis point knowledge is highly desirable in the organisation and should be engendered wherever possible
- systemic knowledge does not need to be explicated in order to be co-created. Indeed, explicated, systemic knowledge can be created by at least two paths, namely the accepted route of explication followed by systematisation, and the route of systemisation at the tacit (even tacit unknown) level followed by explication.
- the generation and co-creation of tacit knowledge in the organisation is subject to these enabling factors:
  - Existence of the two co-creating agents.
  - The capacity of the channel through which the communicative acts supporting the co-creation are enabled. There are many factors relevant to this, but an important one is the Habermasian ideal of a power-free speech act, where the transfer of knowledge is unencumbered by power gradients between the co-creators.
  - The content of transfer is relevant, as is the valuation of that content by the co-creators.
  - The 'enthalpy' or available knowledge is relevant, since, because of the 'sticky nature' of knowledge, not all that is wished to be transferred can be. This places limits on the transfer content.

This paper takes the position that the ubiquitous model of knowledge development in an organisation, namely

that tacit knowledge should and indeed must be made explicit before it can be mobilised and disseminated, is unnecessarily restrictive. It is entirely possible to adopt an approach, which builds on the characteristics of knowledge co-creation seen in the case examples to develop tacit knowledge towards a systemic understanding before any explication is undertaken. This, together with the characteristics resulting from the cases, is a significant agenda for knowledge management, stressing as it does the importance in practice of unexplicated knowledge and transfer. This is not new; it has been the approach of apprenticeship and professional learning for centuries. Neither is it unsupported in the Knowledge Management literature, but it provides a complementary and viable route for knowledge development in the organisation.

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