Visual mapping of articulable tacit knowledge

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Abstract

Tacit knowledge has long been recognised, however its research has focused largely on who is more likely to have this store of knowledge, rather than taking this one step further and elaborating on just how well this knowledge is diffused throughout the organisational domain. We focus our efforts on the IS organisational domain, by which we mean computing workplace professionals as opposed to the entire intra-organisational workplace. Our methodology largely follows the Sternberg example, however we seek also to include information flows through the incorporation of Social Network Analysis techniques. We present here, some qualitative interpretations of our understanding of tacit knowledge and also results from a complete pilot study in Organisation X which illustrates how the pivotal role a even a single individual could affect tacit knowledge information flows within the IS domain.

Keywords: AL01 Knowledge representation; AL04 Knowledge acquisition; AI0102 Case study, AI0106 Exploratory study, AI0801 Positivist perspective; AI0802 Interpretivist perspective, DD07 Information flows; FC15 IS models; Social Network Analysis; Codified Knowledge; Tacit Knowledge; articulable Tacit Knowledge; Diffusion of knowledge.

1 Introduction

More than strong evidence exists for the social nature of tacit knowledge, that is to say the means of transferral is not through books, or electronic media so much, but overwhelmingly through human-to-human contact (Colonia-Willner 1999; Sternberg 1999; Howells 1995a; 1995b; Reber 1993). The role of tacit knowledge in knowledge management is also critical (Curtain 1998), and will become even more so as organisations attempt to 'cash in' on know - how that exists within their frontiers rather than look for this externally.

> Through 2001, more than 50 percent of the effort to implement knowledge management [in knowledge organisations], will be spent on cultural change and motivating knowledge sharing (0.8 probability) (Casonato and Harris 1999).

Tacit knowledge plays a direct role in enabling an organisation to attain a competitive advantage as the knowledge is itself difficult to acquire (Johannessen, Olsen and Olaisen 1997; Lei 1997), or as Sternberg (*et.al*. 1995) would say, "is acquired [in the face of] low environmental support". If the knowledge is difficult to acquire it is also difficult to transfer. And it is precisely the issues of transferral or non-transferral that we would like to focus on in this paper. Let us begin however by discussing from a qualitative perspective, what tacit knowledge could be said to encompass, commencing with how it has been perceived historically. We then present some initial results we have uncovered from what we shall refer to as Organisation X.

2 Tacit knowledge historically

In turning our attention to historical issues we do not mean to infer that tacit knowledge has a starting date, or a history that is necessarily tied to any one particular period or socio-cultural location. Naturally tacit knowledge is as old as humankind, however the way in which it was dealt with historically is interesting. Although by far and away one of the most commonly cited historical examples of tacit knowledge in action was that of Collins' (1972) work dealing with the building of lasers, whereby those scientist's whose lasers actually worked had incorporated tacit knowledge into their methodology (Collins 1972 in Henderson 1975; Collins 1974 in Meerabeau 1992; Collins 1974 in Senker 1995), historical examples exist far further back in time. For example as Ivins (1953 in Henderson 1975) notes, ancient Greek citizens often faced technological advancement hurdles due to a Platonic mind/body schism. Furthermore, the fact that slaves directly worked with technological know–how in performing their many acts of labour, (namely slave labour which was not considered worthy of energy saving innovation as far as the citizens were concerned), meant consequently that tacit knowledge was less likely to be recorded socially upwards

Another example concerned artists historically (and still today), with particular reference to engravers depicting Newcomen engines [early English steam invention: 1712], "…. artists either failed to understand the principles of the valve gear, and drew it indistinctly or inaccurately, or else they copied their predecessors' work" (Rolt in Henderson 1995 :205). Indeed historically Chinese copies of Western technical drawings seemed to represent a similar problem, namely a failure to

incorporate perspective, and consequently an understanding of how the technology worked (Edgerton 1980 in Henderson 1995). Actually Hindle (1981 in Henderson 1995) had gone further, declaring that as the apprentice system of learning (meaning the ability to transfer tacit knowledge) was lost, a consequent rise in explicit or (articulate) drawings became necessary, to the extent that we have CAD/CAM equipment today. We must realise that all of this explicit knowledge is nevertheless based on our tacit understanding of the technology underneath. Certainly if we were to examine the IS domain it could well be argued all of our knowledge resides at an underlying tacit level. There would be little point explaining to a stone age hunter - gatherer what recursion within software code entails, without the hunter – gatherer having at first seen how a computer is structured of hardware and software and that the latter (with the addition of electricity (in itself requiring an understanding of tacit knowledge)) runs the former. Indeed when we examine disciplines as complex as computing, based as they are on a multitude of other disciplines (mathematics, electronics, logic, heuristics, linguistics, ergonomics), we draw upon tacit knowledge to interpret not just computing specific concepts such as data communications bus typologies, but all of the tacit knowledge inherent in the underlying fields. Given the complexity of the fields in which tacit knowledge is utilised, how has it been defined?

3 Tacit knowledge and culture

> Saint-Onge (1996) includes intuition, perspectives, beliefs, and values people form as a result of their experiences in his definition of tacit knowledge. When Saint-Onge's description of tacit knowledge at the individual level is congregated into an organizational level, it can approach the definition of culture (Hatch 1993; Schein 1985 in Brockmann and Anthony 1998).

Within a western environment the importance attached to articulated knowledge has always been paramount and far superseded that attached to what has traditionally otherwise been seen as 'fuzzy', 'soft', dare one say 'unreliable' tacit knowledge. Computers were designed as numerical processing instruments, and as such dealt with articulated knowledge. Computers can deal with unarticulated knowledge by mimicking expertise, the patterns of fact employed to diagnose conditions even though the facts do not reduce to a sound set of principles. This, coupled with the fact that western managers see the organization as a centre for 'scientific management', with computers as machines for information processing (Takeuchi 1998), means that a western perspective has always tended to play down the role of tacit knowledge within organisational knowledge creation. The majority of references relating to tacit knowledge literature from a cultural standpoint discuss the differences between western (typically Anglo - American), and eastern (meaning Japanese (e.g. Prahalad and Hamel 1990 in Lei, Hitt and Bettis 1996)) points of view. Certainly, the Japanese approach towards knowledge management differs from a western one, from anything as taken for granted as *nemawashi* (discussion behind the scenes to finalise a deal), to agreement on contracts, which is typically tacit in the Japanese case, to more formally contracted in the U.S. example (Yamadori 1984). The differences in the cultures have also meant that Japanese car designers for example, but not their U.S. counterparts were able to detect reasons why a vehicle had not been selling well because of the shape of it's grille and headlights (Leonard and Sensiper 1998), to Japanese work practices that include a morning discussion session where staff are able to 'air' their viewpoints (*cho rei*), which to visiting U.S. staff had initially seemed a waste of time (Nonaka and Takeuchi in Durrance 1998).

Japanese firms also appear to differ with respect to knowledge sharing at an intra – organisational level. The Japanese approach was often to involve many people, whereas the western approach tends to reflect a 'need – to – know' basis, meaning not only that knowledge is not so readily transmitted in the latter example (Hamel 1991 in West and Meyer 1997). Certainly, the Australian approach tends to follow the U.S. example. Meetings are conducted on a basis of only involving directly concerned personnel and information is typically transferred on a 'need to know basis'. From an articulate/codified knowledge point of view, this makes sense, and indeed is practical given the 'information overload' of most professional personnel today. What we do not have sitting on our desks in front of us, we can easily acquire, either through libraries or the Internet. The disadvantage culturally within western spheres is that articulable tacit knowledge is not being transferred, because of a codified knowledge management 'mindset', rather than an 'articulable tacit knowledge' appreciation frame of mind.

4 Metaphor and analogy

Nonaka, Takeuchi and Umemoto (1996) consider the articulate/tacit knowledge process to be roughly broken into 4 phases, socialisation (tacit to tacit), externalisation (tacit to explicit), internalisation (explicit to tacit), combination (explicit to explicit), and we (Busch and Dampney 2000) have shown how we consider this process to occur in a conical fashion, with perhaps greater emphasis likely to be placed and made use of externalisation in senior years as such people externalise their tacit knowledge in favour of typically younger and less experienced personnel. Certainly, the most obvious form of externalisation is that of the act of writing (Nonaka, Takeuchi and Umemoto 1996), however what enables the externalisation of tacit knowledge to a large degree is the role played by both metaphors and analogies. *Metaphor* may be defined as "a figure of speech in which a term or phrase is applied to something to which it is not literally applicable, in order to suggest a resemblance" (*Macquarie Dictionary* 1997 :1353). Whereas an *analogy* may be defined as "… a partial similarity in particular circumstances on which a comparison may be based …. A form of reasoning in which similarities are inferred from a similarity of two or more things in certain particulars" (*Macquarie Dictionary* 1997 :72). Notably however contradictions between two

thoughts in a metaphor are then harmonised by analogy, which reduces the unknown by highlighting the 'commonness' of two different things. Metaphor and analogy are often confused. Association of two things through metaphor is driven mostly by intuition and holistic images and does not aim to find differences between them. On the other hand, association through analogy is carried out by rational thinking and focuses on structural/functional similarities between two things and hence their differences. Thus, analogy helps us to understand the unknown through the known and bridges the gap between an image and a logical model (Nonaka, Takeuchi and Umemoto 1996 :839)

The role of metaphor and analogy is reinforced by the fact that language (syntax and semantics) is often not powerful enough to capture knowledge that we may wish to transmit. An emphasis needs to be placed at this stage on the fact that we refer not to data or information, rather knowledge, that combination of data and information with attached human processed meaning. In other words we consider knowledge to incorporate a 'tacit' component, whereas information is purely articulate in nature and words. Most noticeably Leonard and Sensiper (1998) note that the more innovative a product, process or service, the more likely the intellectual property or knowledge is to be tacit in form. Certainly within the IS domain much product innovation takes place, and metaphors abound, for example we use the term 'web' to describe a software interface to the internet which links computers globally. Literally of course the web is quite unlike a spider's web, for it is not biological, nor typically symmetrical, nor emanating from necessarily and one centre, nor 'sticky', even though knowledge may be described as sticky (Ramaprasad and Rai 1996; von Hippel 1994 in Raghuram 1996; Ghemawat 1991, Polanyi 1967, Dosi 1988, Hoskisson and Hitt 1994, Wright 1994 in Lei 1997). Other examples include 'firing up' an application or document (nowhere is flame involved), rebooting a machine (we do not actually kick the machine), spreadsheeting (we do not actually spread a sheet out, rather we manipulate figures and to a minor extent text, in matrices), debugging (we do not actually remove insects or arachnids from programs, even if this may once have occurred). As Lei, Hitt and Bettis (1996) had noted, it is difficult for outsiders to decode metaphors, certainly unless one has had experience with computers one would understand the concept 'debugging', let alone actually performing the task. Similarly 'pipelining' has entirely different connotations depending on the computer literacy of the interpreter.

5 Tacit knowledge as a phenomenon

It is tacit knowledge, which underpins much of our understanding of codified knowledge. In other words, what begins as a pool of tacit knowledge, leads to some becoming articulated, then categorisation and finally codification based on emergent principles taking place (Busch and Dampney 2000; Busch and Richards 2000a, 2000b). Naturally one of the most commonly asked questions relating to tacit knowledge is what it could be said to constitute. The textual nature of tacit knowledge definitions lead us to conclude that an ideal means of defining the concept of tacit knowledge would be through qualitative processes. By using qualitative software such as Atlas.ti™ (Muhr 1997), we are able to graphically model what would otherwise not be possible in a purely textual way.

Articulable Tacit Knowledge	Inarticulable Tacit Knowledge
{Know how, Culture, Externalisation, Understanding, Process, Practice, Behaviour, Beliefs, Face to face transfer, Goal attainment, Maxims, Perceptions, Procedural in nature, Routine, Subjectivity, Tasks, Technology, Values, Common sense, Decision making, Information, Judgement, Everyday situations, Interaction, Job knowledge, Riding a bicycle, Rule, Schema, Wisdom, Abstraction, Access constraints, Competitive advantage, Ideals, Meaning, Observation, Performance, Procedures, Rules of thumb, Semantics, Convincing people, Crafts, Customs, Data, Expectations, Hunches, Imitation, Innovation, Knowledge of designs, Negotiation, Perspectives, Practical know how, Reproduction, Stories, Swimming, Technique, Tradition, Tricks, Way things are done, All purpose algorithms, Analogies, Aphorisms, Artistic vision, Assumptions, Business knowledge, Understanding of categories, Concepts, Constructs, Content, Contradiction, Customer's attitudes, Descriptors, Discussion, Examples can be articulated, Grammatical rules, Gut feel, Habits, Heuristics, Impressions, Justified true belief, Knowledge base that enables us to face the everyday world, Logical rules, Information placed in meaningful context - eg. Message, Methods, Complex multiconditional rules, Abstract high level plans, Political correctness, Prescriptive knowledge, Principles, Private knowledge, Proverbs, Ritual, Script/Scripted, Shop lore, Task management, Team coordination, Theories, Trial and error} ∈ aTK	{Skill, Experience, Intuition, Action, Expertise, Knowing, Sub-consciousness, Mental models, Abilities, Management, Society, Inferences, Learning by doing, Non awareness, Pattern recognition, Implicit, Implied, No idea, Unconscious, Know more than we can tell, Physical control, Touch sensitivity, Awareness, Emotions, Focal awareness, Insight, Motor skills, Practical intelligence, Selective comparison, Sense perception, Accomplishment, Action oriented know how, Adaptation, Automatic, Between the lines, Lip service, Rooted, Semiconscious, Short term, Weltanschauung, See as' rather than see, Accidental, Action slips, Ad hoc, After the fact, Analysis, Application, Attention, Automatic knowledge, Background knowledge, Body language, Charisma, Concentration, Coordination, Diagnostic closure, Executive commitment, Exists, Force/tension required, Gaining promotion, Gaining respect, Getting one's feet wet, Hands on teaching, Have a feeling, Here and now, Hidden, High level goals, How to seek out, create and enjoy challenges, Idiosyncratic, Immutable, Indeterminacy, Informating, Ingrained, Inspiration, Instinctive reaction, Intangibility, Intimacy, Involuntary, Know why, Knowledge possessed by itself, Learning the ropes, Managing relationships, Managing subordinates, Manual dexterity, Meaning requires tacit component, Mediation, Metacognitive understanding, Motivation, Inferred from actions/statements, Networking, Noiseless, Holistic in nature, Non focus on parts, Orientation, Way things ought to be, Out of the corner of the eye, Paradigms, Personality, Place, Possessed, Power, Practice wisdom, Preciousness, Presuppositions, Principles, Product of process, Proximal knowledge, Psychomotor skills, Recognition, Reflection in action, Reflection upon reflection, Relativity, Residual category, Second hand, Second nature, Smell, Socialisation, Spatial awareness, Spontaneity, Thinking in practice, Tool, Recognition of musical note, Unanalysed, Vision, Vivid, Wholeness} ∈ iTK

Table 1 listing prior definitions by authors of tacit knowledge (we have chosen to separate them according to our views on articulability and inarticulability)

The creation of a 'hermeneutic unit' labelled `Tacit Knowledge` involved coding up 64 primary text documents, which contained separately the refined definitions of previous author's attempts at defining this knowledge type. We list these definitions in table 1 below and have subjectively categorised them, according to our beliefs as to whether they are of an articulable or inarticulable class of tacit knowledge.

Although the documents included are too numerous to mention here, they include works by Sternberg (1999), as well as Howells (1995a; 1995b) and Arora (1995; 1996). We had a total of 1,310 code instances in our qualitative database, which was derived from marking up the documents. Coding up of the documents permits us from a content analysis point of view to determine which of the above definitions appear most frequently in the literature. Not surprisingly, `Knowledge` is the most common keyword theme of seen in the literature, with 80 instances within the 64 coded up textual documents. `Individuals/Individuality:` (50 instances) and role of the `Organisational Domain:` (46 instances) also featured prominently. The occurrence of other representative codes such as `Context Specific:` (24 instances), `Action:` (12 instances), `Practical:` (9) instances is also not trivial. Altogether there were 1,310 instances of marking up taking place in the Tacit knowledge hermeneutic unit, a significant proportion of the terms coded up were however occurring only once in our hermeneutic unit for tacit knowledge, and they are too numerous to mention here. Thus the region occupied by tacit knowledge in a generally agreed upon ontology is suggested, together with the implication of some diversity in the term's meaning.

5.1 Network map interpretation

Network map interpretation is necessarily subjective, but proximity and connectives of concepts broadly imply the nature of the concept being examined in this case tacit knowledge. Encoding documents is only a component of the Atlas.ti™ software, which permits us to use the codes as nodes within a network diagram. The power of network information modelling naturally also permits the user to understand relationship related information. Whilst there is only one relation able to be expressed between any two nodes, and this relation is fixed throughout the hermeneutic unit, any number of relations may be created, representing all sorts of relationships between the other nodes. Ideally however limitations in relationship diversity is necessary as the application of a similar relation to another set of codes enables easier comparison both visually (by way of colour) and in terms of hierarchy that may exist between one relation and another. For example whilst others subsume some relations, some are at the same level of hierarchy, but simply represent different relationships between nodes. Typical relations are those of: `is - associated - with`; `is - part - of`; `is - cause - of`; `is - composed - of`; `contradicts`; `is - an - example - of`; `is - a`; `leads - to`; and `is - property - of`. Notice the importance of colour. Although network maps may be represented in black and white, a consequence is that a large amount of information is then lost.

In order to create network maps one must first create a code family that encapsulates codes that are similar. We have to that end created a code family entitled `Social Networking` and included all relevant codes from our hermeneutic unit relates to this topic. The results of are to be seen within figure 1. Note that some of the codes are linked to others as they have had their relationships identified in different network maps. A relationship that is created in one network map between any two or more codes remains this way for the duration of the hermeneutic unit. The first numerical value on each node relates to the groundedness of the code or its instance within the 'marked up' literature. The latter numerical value relates to the code's density, or the number of relationships the code has with others within the Tacit Knowledge hermeneutic unit. Given that we are focused on Social Network Analysis within this paper, we wished to examine the groundedness and density of codes such as `poor circulation` (2:8), `collaboration` (1:2), `common good` (1:4), `convincing people` (2:3) and `culture` (10:2) to name but a few that appear in figure 1. We can see that the density and groundedness of each of these codes is rather low. This would tend to indicate to us that the presence of these themes within the literature is not as significant as might be imagined, however we need to balance this with other approaches. Notice however that `common good` (1:4) clearly contradicts `individuals` (50:41). The groundedness and density of the latter code clearly indicates its importance, which in turn lends support to the focus of tacit knowledge amongst individuals, which helps to explain the competitive nature of tacit knowledge where acquisition takes place under conditions of low environmental support. Codes such as `poor circulation` (2:8) and `not freely accessed` (1:1) reinforces this.

Our next Network map (figure 2) deals with our code family relating to tacit knowledge and organisations. The centrality of `organisational domain` (groundedness of 46, density of 21) is obvious from the network map. Note however other pivotal codes such as `competitive advantage` (3:8), competitive (2:1), `sub-consciousness` (9:13), `job knowledge` (4:5), `tasks` (6:2) and particularly the centrality of codes such as `task management` (1:8). The role of `apprenticeship` (7:8) is noticeable in the diagram as indeed it is in the literature, reflecting the teacher – student relationship in tacit knowledge transfer. What network mapping has enabled us to do is to unearth dominant themes within tacit knowledge so that we may gain a better understanding of the phenomenon that we are faced with.

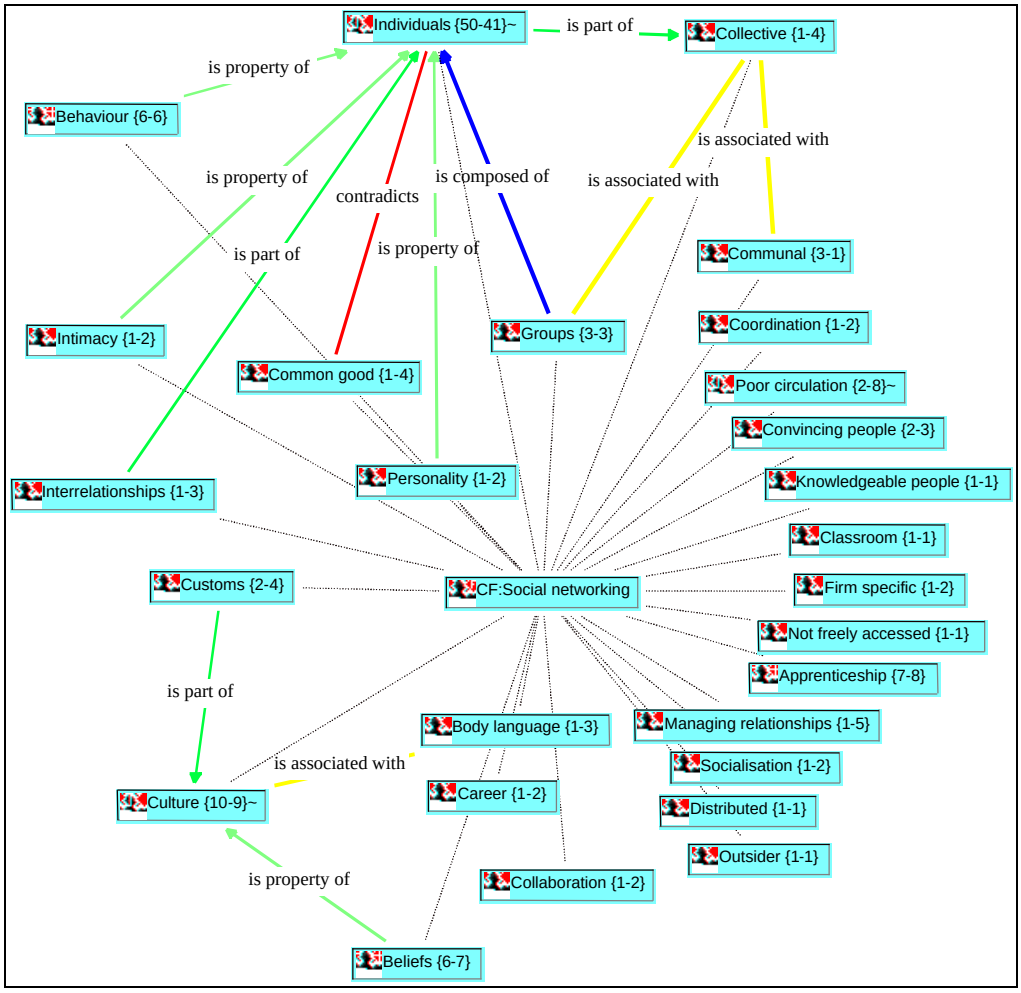

Figure 1: Information model illustrating Social networking as a central theme with a code family that relates to social networking

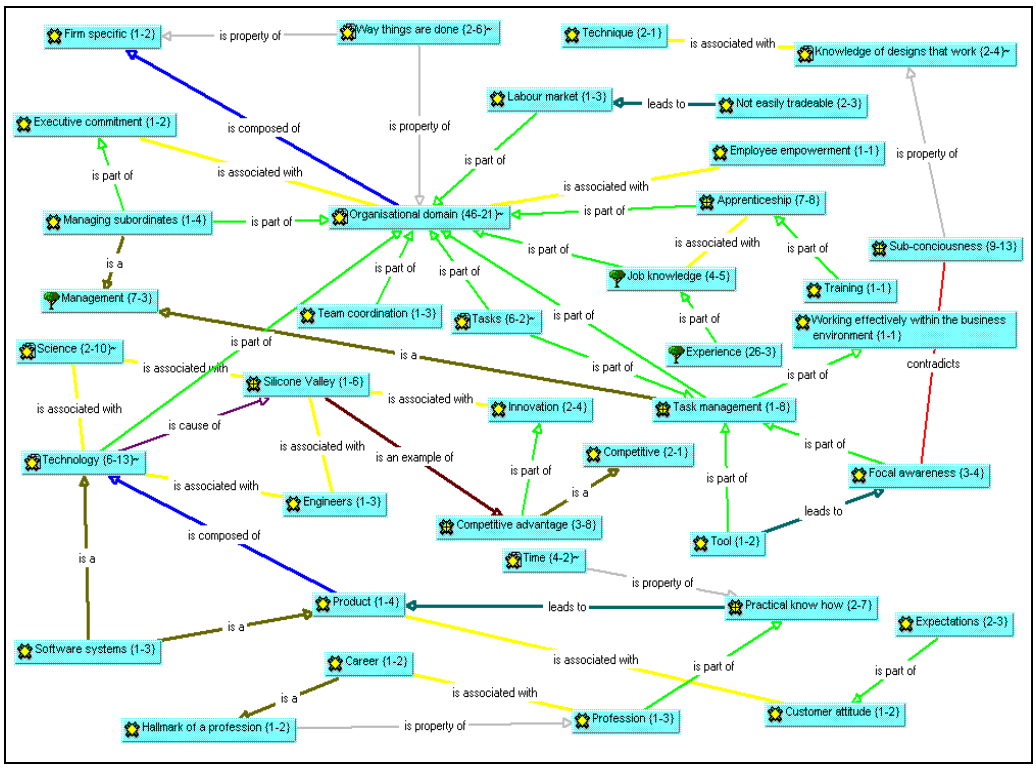

Figure 2: Information model illustrating code groundedness, density and relationships within the Workplace code family

6 Methodology

As we aim to explore the diffusion of 'soft' tacit knowledge among IS personnel within organisation X, we combine a number of approaches, both qualitative and quantitative in nature to achieve our aims. Our research along with others (Colonia-Willner 1999; Sternberg 1999) makes use of expert vs. novice comparisons as a means of determining who may be considered to have more of this 'resource' so that we may in turn better discover how such knowledge may be passed on intra-organisationally within the IS domain. We also wish to use Social Network Analysis as a tool and to this end we have processed data in UcinetV™ and Krackplot™.

6.1 The pilot studies

A sequence of pilot studies took place in the year 2000 in which we were aiming to test our approach to using a questionnaire along the lines of Sternberg's team at Yale University. Incorporating Formal Concept Analysis also meant that we had to test the practicability of using such a tool to process results along with the standard descriptive statistics that are made use of within the psychological domain. To that end, the first pilot study used FCA to process results along the lines of Kollewe (1989). The results of this testing can be seen in our previous publications (Busch and Richards 2000; Richards and Busch 2000; Busch and Richards 2001). Although these initial scenarios had been coded in early 2000 based upon interviews with 14 IT practitioners both within and external to the university environment, it was felt that a 'reality check' was necessary before the scenarios could be considered industrially rigorous. Having completed the second 'reality check' pilot study on 20 IT practitioners (not students or academics) gaining feedback on the quality of scenarios used, the complete questionnaire, including biographical and social network analysis questions was then able to be coded into Javascript with Perl and a CGI backend. It is this complete questionnaire that was used to gather results presented in this paper.

Late in 2000, an organisation selection process took place, and of some 28 suitable organisations contacted, 8 - 10 (some have still to decide) had indicated an interest in our research. Of these, organisation X was chosen as the pilot study organisation because its CIO expressed more than usual interest in our research area. Their CIO volunteered two respondent groups and one expert group, and a presentation to these personnel was conducted in January 2001 implicitly seeking their participatory approval. Because of the social network analysis component respondents were not anonymous to us as researchers, although of course the answers of respondents were anonymous to their colleagues. Results were de-identified by us before they are presented to management[1].

The first section focused on biographical details. The second section on Social Network Analysis questions, asking respondents to indicate essentially 4 things. Firstly which individual they were in contact with in their day-to-day office lives, secondly how often they saw that person. Thirdly what the importance of the person was in relation to themselves, in other words 'did they have to see the person', down to 'try not to see the person'. Fourthly, what was the type of occasion, in other words, a formal organisational meeting, through to informal meetings, through to simply email or fax the individual? The third and final section of the questionnaire included the tacit knowledge inventory along Sternberg lines although made specific to the IT workplace. We focus on part B, dealing with the interaction of individuals who participated in our research.

6.2 Result processing

We have used Sternberg's technique of workplace scenarios with Likert scales for answer options which is discussed in greater detail elsewhere (concurrently submitted paper), here we present partial results from our social network analysis processing, in this case using UcinetV™ and Krackplot™. The complexity of results has been reduced and we focus on only some knowledge diffusion issues.

7 Results

There were in effect two pilot groups within our latest pilot study, that of 'experts' (7 people) who were considered by their peers to be effective at what they did in their daily working lives. And secondly, a pilot group of 20 other individuals who were asked by their CIO to participate, as the CIO in question had a particular interest in tacit knowledge diffusion. The pilot group was made up of two teams, each headed by a manager. In general, although both control and expert groups were similar in makeup, the expert group was smaller. The make up of the two groups is presented in table 2, which we portray numerically rather than percentage-wise given the small sample sizes of our pilot groups.

7.1 Descriptive statistics

Busch, Richards and Dampney (2001) discusses the breakdown of the statistics in greater detail. We state here that we can easily see that our control and expert groups fit typically within the 35 – 44 age bracket and tend to be tertiary educated IT management

[1] While our University Ethics Committee had tentatively agreed to our research as early as September 1999, formal approval was required and ultimately given once the questionnaire in its entirety had been examined, based upon the understanding respondents would be de-identified.

practitioners. Although the confidence levels are not great, it is interesting to note the gender and language background similarities between the expert and pilot control groups, and that our expert sample tended to allocate more negative scores on the Likert scale than the pilot control group.

Figure 3 illustrates by Formal Concept Analysis (FCA) which is based upon work by Wille and Ganter (Ganter and Wille 1999), the bibliographic similarities of respondents within our study. Their lattice theory based approaches provide a graphical means of representing data whereby objects are reached in descending fashion and attributes by ascending means. For example, the respondents in this instance have been modelled as objects and their attributes (such as years of experience) are shown as an attribute in the top of each box. The complexity of this lattice has been simplified considerably to illustrate likenesses in experience ranges, whilst ignoring other attribute types.

Biographical information	
Pilot 'Expert' Group	**Pilot 'Control' Groups**
No: of People: 7 No. of Females: 3 Age Group: Unknown ;0 Age Group: 20 – 24: 0 Age Group: 25 – 29: 0 Age Group: 30 – 34: 0 Age Group: 35 – 39: 4 Age Group: 40 – 44: 2 Age Group: 45 – 49: 1 Languages other English: Cantonese: 2, Hindi: 1 Years of IT experience: From 10 to 29 Highest qualification: Bachelor (4), Grad. Dip. (1), Grad Bach. (1), Masters (1) Type of employment: Permanent (4), Contract (3) ACS Equivalence levels ACS-2 (1), ACS-3 (5), ACS-4 (1)	No. of People20 No. of Females: 8 Age Group: Unknown: 1 Age Group: 20 – 24: 1 Age Group: 25 – 29: 1 Age Group: 30 – 34: 1 Age Group: 35 – 39: 8 Age Group: 40 – 44: 7 Age Group: 45 – 49: 1 Languages other than English: Cantonese 4, Serbian 3, Kannada 1, Japanese 1 Years of IT experience: From 0 (1 individual) to 29 Highest qualification: HSC (4), Ass. Dip. (1), Bachelor (6), B. (Hons) (1), Grad. Certificate (1), Grad. Dip (2), Masters (5) Type of employment: Permanent (11), Contract (9) ACS Equivalence levels: Undef. (1), ACS-1 (1), ACS-2 (4), ACS-3 (13), ACS-4 (1)
Descriptive statistics	
Likert scale values 1 Extremely Bad 7 Extremely. Good Total scenarios attempted: 6 Average mean for experts: 3.4 Average median for experts: 2.5 Average St.Dev. for experts: 2.1	**Likert scale values** 1 Extremely. Bad 7 Extremely. Good Total scenarios attempted: 6 Average mean for pilot 3.66 Average median for pilot 3.38 Average St.Dev. for pilot 1.77

Table 2: Descriptive statistics from the pilot control and expert groups

An examination of figure 3 reveals very clearly that the experience ranges of both the pilot groups and expert group fit overwhelmingly within the 10 – 14 and 15 – 19 year experience range. Comparing the number of years of experience of the participants and experts, it is interesting to consider whether some of the differences in responses by different participants are due to some feature of the participant such as their number of years of experience in the field. As we found from statistical analysis there is no general trend in responses and the biographical qualities of the participants, however we are processing results from a small complete pilot study. Results processed through FCA from up to 1,400 IT personnel in organisation X and hundreds of other personnel in other selected organisations, will of course prove far more informative and will act as a check on the results processed through traditional statistical means.

7.2 Social Network Analysis

Social Network Analysis (SNA) replaced as a technique our earlier vision of using participant observation, as a means of measuring the tacit knowledge diffusion we assumed would take place within the organisational domain (Richards and Busch 2000). Social Network Analysis essentially maps the relationships between individuals and has numerous practical applications having its origins in fields as diverse as anthropology, graph theory and sociology (Knoke and Kuklinski 1982; Scott 1991). The advantage of using SNA is multitudinous. Participant observation of tacit knowledge is difficult because IT practitioners on the whole do not undertake physically active tasks to the extent of say nurses (Scott 1990; 1992), police officers or fire-fighters, therefore attempting to view the actions and knowledge transferral of IT practitioners is difficult. Our use of social network analysis is for the purposes of this paper restricted to clique patterns produced using UcinetV™ and its graphical backend Krackplot™, for we merely seek to illustrate the approaches we are using to track tacit knowledge flows within the IS domain.

The advantage of electronically coding the questionnaire in Javascript meant that drop down menus could provide a simple interface for respondents to select the individuals they networked with and the type of relationship this entailed. The initial results of this section of the questionnaire can be seen in table 3 illustrating the popularity of particular individuals in terms of the number of times they have been identified as being a contact. Individuals 006, 008, 011, 014, 021, 027 and 028 appear to be particularly popular.

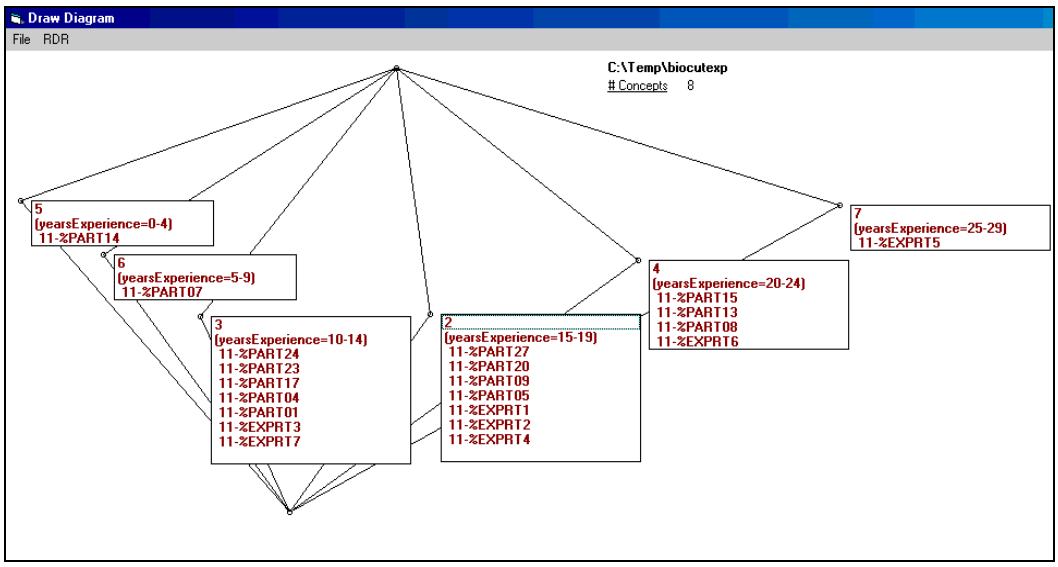

Figure 3: Representing a Formal Concept Analysis breakdown of biographical similarities in our pilot and expert groups.

Individual's password	No. of times chosen as a contact
001	8
002	6
003	6
004	6
005	8
006	**11**
007	8
008	**11**
009	5
010	6
011	**12**
012	7
013	7
014	**10**
015	8
016	6
017	5
019	9
020	7
021	**12**
022	5
023	5
024	8
025	8
027	**10**
028	**13**

Table 3 illustrating 'popularity' of individuals, with an emphasis on the most popular

What makes this all the more interesting from a tacit knowledge diffusion point of view is that none of these 'popular' individuals were actually managers, that is to say people in senior positions. The managers in this scenario were 019 and 012. One would ordinarily expect managers to be the more popular ones if we presume they have a pivotal role within the organisational domain. Those individuals we have identified as being popular could quite possibly be the holders or charismatic conveyors of the (organisational) soft knowledge.

If we now turn our attention to figure 4 we can see that person 020 (20) holds a gatekeeper role. Interestingly this individual is not a manager but clearly acts as an intermediary between the two cliques that we may see in the Social Network map. The two cliques incidentally represent a perfect positive correlation between our two sub-pilot groups mentioned above. Person 020 also happens from our processing of results using Formal Concept Analysis (concurrent paper), to share some likenesses with the expert sample. This leads us to conclude (if not with high levels of confidence), that person 020 may prove to be a valuable storehouse of tacit knowledge. Incidentally person 020 was made (by their boss), our contact person for the organisation, through whom we were to turn with any queries.

The density of the clique on the left in figure 4 is noticeable, but is also influenced by the fact that it is made up of a larger number of personnel (15) versus 11 in the other clique on the right of the figure. Person 026 and 018 illustrated in the top right hand corner of the figure represent fliers who had been included in the social network analysis section of the question, but were actually not members of either of these two work groups in Organisation X. This provides us with further confidence that the questionnaire respondents were taking the questionnaire more seriously, and not simply selecting individuals with whom they *did not* actually network. Our usage of Netmap™ software (Sbarcea 1999) will permit us to map more effectively by way of colour and sub cliques exactly, which sub cliques form based upon social patterns of interaction.

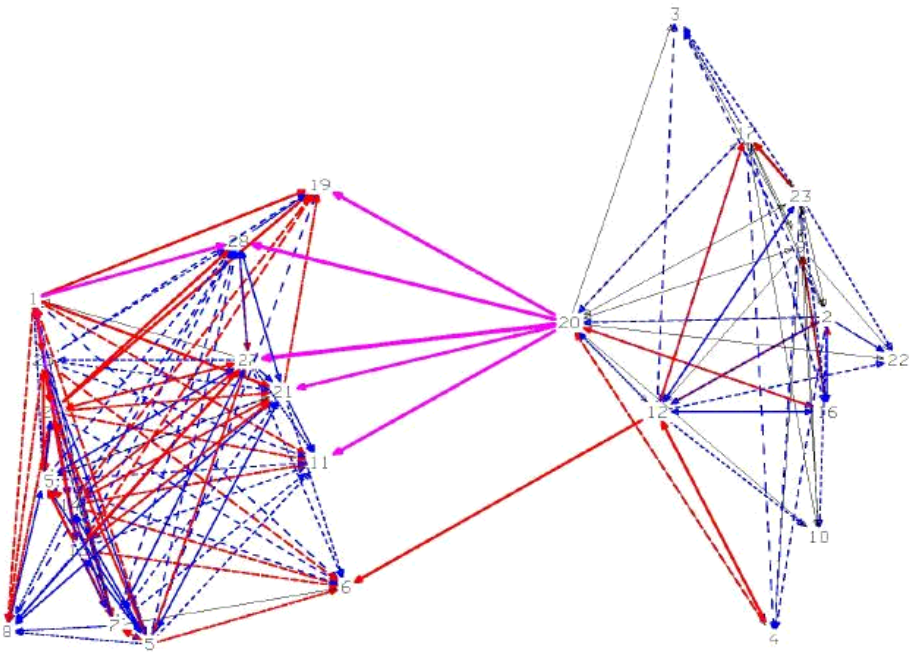

Figure 4: Network graphs illustrating the clique relationships between individuals participating in the survey. Notice the prominent 'gatekeeper' position of 20 (020). Staff groupings correspond perfectly to 2 pilot groups in the study

Although our questionnaire asked for the type of interaction, choices being those of {`Routine/formal organisational meeting; Fairly spontaneous yet nevertheless pre-arranged meeting; Lunch/Morning Tea/Afternoon Tea; Tend to just 'bump into' the person around the workplace; Send the person an email; Send the person a fax; Phone them; Usually see the person outside of work`}, for the purposes of tacit knowledge diffusion the evidence seems overwhelming (Sternberg 1999; Curtain 1998; Howells 1995a, 1995b), that tacit knowledge is diffused in human to human interaction. Such evidence would tend to indicate that the medium of phone, fax and email is likely to be far less effective in tacit knowledge transferral, due to its ability to transmit only the codified rather than the soft tacit knowledge, such as body language, for in,

> … the traditional work environment, organisational members gain a 'feel' for their work from the presence of familiar faces, bulletin boards documents, telephones and interaction with colleagues. The traditional work environment is embedded with cues, nuances, gossip and other unspoken, unwritten sources of vital information. When we sit face to face, words represent only about 20% of the communication; the remainder is in the form of non – verbal communication (P. C. World 1994 in Raghuram 1996 :861).

We expect in our complete study that people who choose these means of communication may be hindered in their reception of tacit knowledge.

8 Conclusion

Given the social nature of tacit knowledge it is only reasonable that a social network analysis tool has been adopted to map the likely diffusion of tacit knowledge within the intra – organisational IT domain. Cliquing has revealed that individuals 20, 28, 8 and 5 tend to be the important in terms of their pivotal role of information transferral between the two work groups. Furthermore, person 20's answers tend to indicate a certain similarity in our results (only a subset of which is presented here), to answer options preferred by our expert sample. This may mean that person 20 is an effective intra-organisational tacit knowledge contact point. We have used the expert sample largely as a means of providing a reference as to how people should ideally answer tacit knowledge related questions. The expert sample was not directly included in the social network component of the questionnaire because to do so would have meant including all 400 IT members of organisation X, which is something that will be undertaken in the next complete phase of the research. Here we have only presented pilot study results highlighting our macromethodology with an emphasis in this paper on the social network relationships between people in the pilot groups. Any discussion of tacit knowledge must nevertheless address the issue of what such knowledge entails, and as such, we have covered this from a largely qualitative perspective here, with particular code family emphasis on tacit knowledge within the organisational domain.

References

ARORA, A., (1995) "Licensing tacit knowledge: Intellectual property rights and the market for know – how" *Economics of innovation and new technology* 4(1) :41 – 59

ARORA, A., (1996) "Contracting for tacit knowledge: The provision of technical services in technology licensing contracts" *Journal of Development Economics* 50(2) August :233 – 256

BROCKMANN, E., ANTHONY, W., (1998) "The influence of tacit knowledge and collective mind on strategic planning" *Journal of Managerial Issues* Pittsburg; Summer

BUSCH, P., DAMPNEY, C., (2000) "Tacit knowledge acquisition and processing within the computing domain: An exploratory study" *2000 Information Resources Management Association International Conference* Anchorage, AK, U.S.A :1014 – 1015

BUSCH, P., RICHARDS, D., (2000a) "Measurement of articulable Tacit Knowledge using Formal Concept Analysis" *Australasian Conference on Information Systems* (ACIS2000) Queensland University of Technology December 6th – 8th

BUSCH, P., RICHARDS, D., (2000b) "Graphically defining articulable Tacit Knowledge" *VIP2000 Pan – Sydney Area workshop on visual information processing* December 1st. University of Sydney

BUSCH, P., RICHARDS, D., DAMPNEY, C., (2001) "Mapping tacit knowledge flows within organisation X" *Australasian Conference on Information Systems (ACIS2001)* December 5th – 7th 2001 Coffs Harbour N.S.W. (accepted)

CASONATO, R., HARRIS, K., (1999) "Can an Enterprise Really Capture "Tacit Knowledge": We answer two top questions on knowledge management from the Electronic Workplace 1999 Conference"? Gartner Group *Research Note Select Q&A* 16th March

COLONIA-WILLNER, R., (1999) "Investing in practical intelligence: Ageing and efficiency among executives" *International Journal of Behavioural* Development 23(3) :591-614

CURTAIN, R., (1998) "The workplace of the future: Insights from futures scenarios and today's high performance workplaces" *Australian Bulletin of Labour* 24(4) December :279 – 294

DURRANCE, B., (1998) "Some explicit thoughts on tacit learning" (Cover Story) *Training & Development* 52(12) p24(6) Dec

GANTER, R., WILLE, R., (1999) *Formal concept analysis: Mathematical foundations* Springer - Verlag Berlin Germany

HENDERSON, K., (1995) "The visual culture of engineers" in *The cultures of computing* (Star, S. ed.) Blackwell publishers/The sociological review Oxford U.K. :196 – 218

HOWELLS, J., (1995a) "Tacit knowledge and technology transfer" *Working paper No. 16* ESRC Centre for Business Research and Judge Institute of Management studies, University of Cambridge U.K. September

HOWELLS, J., (1995b) "A socio – cognitive approach to innovation" *Research Policy* 24(6) November :883 – 894

JOHANNESSEN, J., OLSEN, B., OLAISEN, J., (1997) "Organising for innovation" *Long range planning* 30(1) February :96 – 109

KNOKE, D., KUKLINSKI, J., (1982) *Network Analysis* Sage publications Beverly Hills U.S.A.

KOLLEWE, W., (1989) "Evaluation of a survey with methods of formal concept analysis" in *Conceptual and numerical analysis of data: Proceedings of the 13th conference of the Gesellschaft für Klassifikation* e. V. University of Augsburg, April 10 - 12, 1989 Springer -Verlag Berlin Germany :123 - 134

LEI, D., (1997) "Competence building, technology fusion and competitive advantage: the key roles of organisational learning and strategic alliances" *International Journal of Technology Management* 14(2/3/4) :208 – 237

LEI, D., HITT, M., BETTIS, R., (1996) "Dynamic core competences through meta – learning and strategic context" *Journal of management* 22(4) :549 – 569

LEONARD, D., SENSIPER, S., (1998) "The role of tacit knowledge in group innovation" *California Management Review* Berkeley; Spring

MACQUARIE DICTIONARY (1997) Published by the Macquarie Library Macquarie University Australia

MEERABEAU, L., (1992) "Tacit nursing knowledge: An untapped resource or a methodological headache?" *Journal of advanced nursing* 17(1) January :108 – 112

MUHR, T., (1997) *ATLAS.ti: The knowledge workbench: Short User's Manual* Scientific Software Development Berlin Germany

NONAKA, I., RAY, T., UMEMOTO, K., (1998) "Japanese organizational knowledge creation in Anglo – American Environments" *Prometheus* 16(4) :421 – 439

RAGHURAM, S., (1996) "Knowledge creation in the telework context" *International Journal of Technology Management* 11(7/8) :859 – 870

REBER, A., (1993) *Implicit learning and tacit knowledge: An essay on the cognitive unconscious* Oxford Psychology Series No. 19 New York Oxford Oxford University Press Clarendon Press

RICHARDS, D., BUSCH, P., (2000) "Measuring, formalising and modelling Tacit Knowledge" *International Congress on Intelligent Systems and Applications* (ISA2000) December 12 – 15

RAMAPRASAD, A., RAI, A., (1996) "Envisioning management of information" Omega: International *Journal of Management Science* 24(2) April :179 – 193

SBARCEA, K., (1999) "Mapping the pathways to knowledge" *Image & Data Manager* September/October :32 – 33

SCOTT, D., (1990) "Practice wisdom: The neglected source of practice research" *Social work* 35(6) :564 – 568

SCOTT, D., (1992) "Reaching vulnerable populations: A framework for primary service expansion" *American journal of Orthopsychiatry* 62(3) :333 – 341

SCOTT, J., (1991) *Social Network Analysis: A handbook* Sage Publications London U.K.

SENKER, J., (1995) "Networks and tacit knowledge in innovation" *Economies et societes* 29(9) September :99 – 118

STERNBERG, R., (1999) "Epilogue – What do we know about tacit knowledge?: Making the tacit become explicit" in *Tacit Knowledge in Professional Practice: Researcher and Practitioner Perspectives* (Eds. Sternberg, R., Horvath, J.) Lawrence Erlbaum and Associates Mahwah New Jersey U.S.A. :231 – 236

STERNBERG, R., WAGNER, R., WILLIAMS, W., HORVATH, J., (1995) "Testing common sense" *American psychologist* 50(11) November :912 – 927

TAKEUCHI, H., (1998) "Beyond knowledge management: Lessons from Japan" *Monash Mt. Eliza Business Review* 1(1) :21 - 29

WEST, G., MEYER, G., (1997) "Communicated knowledge as a learning foundation" *International Journal of Organizational Analysis* January

YAMADORI, Y., (1984) "Office automation in Japan" *Science and technology in Japan* 3(10) April/June :24 – 26