# Triangulated measurement of articulable Tacit Knowledge with an emphasis on Formal Concept Analysis

Peter Anthony Busch
Debbie Richards

Department of Computing
Macquarie University
Sydney, Australia 2109
Email: {busch, richards}@ics.mq.edu.au

## ABSTRACT

*This paper provides a methodology aimed at better acquiring tacit knowledge in an organisational context. Although one could hypothesise that different computing roles within the organisation are likely to utilise varying amounts of Tacit Knowledge, it was felt that a more practical means of assessing which IS individuals made more use of such knowledge could be formulated. Although codified knowledge and its capture is commonplace, tacit knowledge has up until recent years proved elusive in its inclusion within the organisation's knowledge base. We choose to use a triangulated combination of Psychology based testing to extract the Tacit Knowledge of computing personnel, Formal Concept Analysis as a tool to graph results from our initial testing and Social Network Analysis as a means of determining how the flow of Tacit Knowledge is effected between personnel. Initial results would seem to indicate that our methodology is useful in mapping knowledge that does not lend itself easily to being articulated. Consequently we feel such knowledge capture will prove invaluable within the IS domain.*

**Keywords**

AL01 Knowledge representation; AL04 Knowledge acquisition; AP Psychology; AI0801 Positivist perspective; DD07 Information flows; FC15 IS models; FC16 Interviewing; HB26 Simulation and modelling IS; Formal Concept Analysis; Social Network Analysis; Codified Knowledge; Tacit Knowledge; articulable Tacit Knowledge

## 1. INTRODUCTION

All of us are familiar with codified knowledge, however few of us are comfortable with the concept of tacit knowledge for: "it is generally accepted that tacit knowledge (as distinct from intangible investment more generally) is non – codified, disembodied know how that is acquired in the informal take – up of learned behaviour and procedures" (Howells 1995 :2). Indeed, it is Tacit Knowledge or what we label *articulable Tacit Knowledge* (*aTK*) that provides the competitive edge to many an organisation (Zucker *et.al*. 1998; Johannessen *et.al*. 1997; Lei 1997; Howells 1995; Senker 1995; Sternberg *et.al*. 1995). We say *articulable*, because we do not believe that *all* Tacit Knowledge is able to be articulated for practical and also competitive reasons. What we are seeking to do is to extract levels of articulable Tacit Knowledge within the Information Systems domain. Our reasons for doing so are primarily altruistic, as the transference of intra – organisational *aTK* would not only lead to increased organisational competitiveness, but more effectively enable the transfer of productive hard to define 'know-how' (as opposed to 'know – that/what') to junior personnel who typically

possess less of it than senior personnel as studies in for example psychology and business management have shown (Sternberg *et.al*. 1995). Because we as humans make use of language as a means to extract and convey information, much articulable Tacit Knowledge is also hidden in our thoughts and deeds which may nevertheless be able to be interpreted through the correct usage of tools. Our role as researchers is thus to

> …. explicate the tacit knowledge of semiotics if it exists, [and] to develop new knowledge if it does not, and thereby to make the information generation – information dissipation – organisation cycle more effective and efficient (Ramaprasad *et.al.* 1996 :192)

Although a great many researchers make mention of (*articulable*) Tacit Knowledge, we have largely only Sternberg's Yale research group (Horvath *et.al*. 1999; 1999; Torff *et.al*. 1999; Wagner *et.a*l. 1999; 1998a; 1998b; 1995; *et.al*. 1995; *et.al*. 1993; Wagner *et.al*. 1990; 1989; 1987; Wagner *et.al*. 1987; Wagner *et.al*. 1985;) to thank for having provided to date the most effective instrument for being able to measure tacit knowledge in general and as a management potentiality test specifically (Wagner *et.al*. 1991a; Wagner *et.al*. 1991b).

## 2. THE KNOWLEDGE HIERARCHY

Whilst most of us are familiar with the concept of data comprising information and information comprising knowledge, we may also envision a hierarchy of knowledge ranging from *Tacit Knowledge* (thoughts, deeds, skills, techniques, 'know – how', 'know - why', etc.), through to *articulable Tacit Knowledge* (that majority subset of the former that is eventually codified e.g. etiquette sets), through to *Articulated Knowledge* (all manner of print and electronic media), then on to *Codified Knowledge* (e.g. classification systems) and finally *Formalised Knowledge* (e.g. mathematical formulae and models) (Busch *et.al*. (b) 2000 submitted for publication). How then do we define Tacit knowledge and more specifically articulable Tacit Knowledge? We begin with Polanyi's (1966) definition "*we can know more than we can tell* …. We know a person's face, and can recognise it among a thousand, indeed among a million. Yet we usually cannot tell how we recognise a face we know. So most of this knowledge cannot be put into words" (:4). Other definitions also exist, Horvath (*et.al*. in press in Sternberg *et.al*. 1995) considers it to be "action oriented knowledge, acquired without direct help from others, that allows individuals to achieve goals they personally value" (:916). Sternberg (*et.al*. 1995) consider tacit knowledge to comprise the following attributes:

> *First*, tacit knowledge is procedural in nature. *Second*, tacit knowledge is relevant to the attainment of goals people value. *Third*, tacit knowledge is acquired with little help from others. Knowledge containing these three properties is called tacit because it often must be inferred from actions or statements. ……. the intention or content of the tacit knowledge concept is not fully captured by the meaning of the lexical item *tacit*. Tacit knowledge is typically implied rather than stated explicitly – but there is more to the tacit knowledge concept than this most salient feature (:916 italics added).

We choose thus to define articulable Tacit Knowledge as the set of actions and experiences that through careful usage of tools and methodologies may *largely* be expressed and transferred from one individual to the next.

## 3. TACIT INFORMATION IN THE INDIVIDUAL

We begin by presenting a model (Figure 1)(Busch *et.al*. (a) 2000) which attempts to display the relationship of individual articulable Tacit Knowledge over one's career. The first inner

blue spiral could be said to represent the *Articulate Knowledge* (*AK*) learning 'adoption' of the individual over a career lifetime, significant when first employed, gradually becoming less important as one becomes more senior within the organisation. The red spiral represents *aTK*, which is not entirely 'non – existent' as the 'apprentice' enters the workforce, however is likely to increase significantly over the years. In actual fact it is highly likely that the pattern is not likely to be an outward branching spiral, but rather a waveform like spiral that will continually oscillate with an individuals career. For instance, we have noted in Model 1, and this is supported by significant evidence (Wagner *et.al.* 1985; Sternberg *et.al.* 1995), that senior/more experienced people tend to score 'higher' on a *aTK* scale, while making less use of more formalised rule sets, algorithms or procedures (Polya 1973, Michener 1978, Soloway *et. al.* 1982, Scriber 1983 in Wagner *et. al.* 1985).

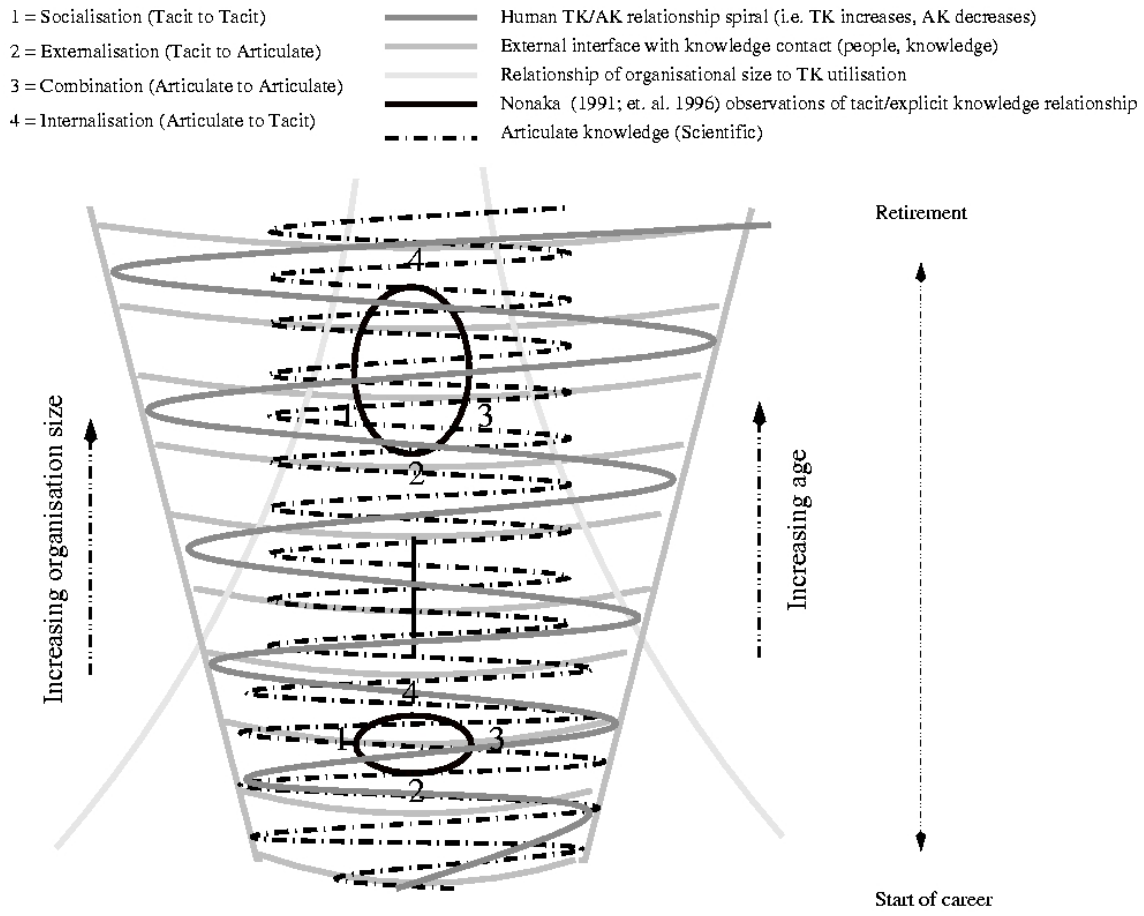



**Figure 1: Model illustrating the adoption of TK by an individual over a career (source: Busch and Dampney 2000)**

The green 'cone' represents the external interface with which an individual interacts with 'knowledge' or 'people'. In other words, the overwhelming access to forms of knowledge stem from either *AK* which is typically represented by written (i.e. electronic or non – electronic), in other words traditional forms of information. The inner 'volume' of the cone represents the individual for whom *AK* and *aTK* is 'stored' over time, and able to be transferred to other individuals. The external surface of the cone represents contact with 'reality' or the outside world. The brown dashed lines in essentially serve to indicate the relationship between *aTK* and the size of an organisation, for it has been noted (Caves *et. al* 1976 and Imai 1980 in Hedlund 1994), for example that Japanese firms are generally smaller

than western ones and that this is likely to influence *aTK* adoption. We feel as such that the smaller the organisation, the more likely it is to make use of *aTK*.

Finally the purple 'ring's represent work Nonaka (1991) and Nonaka and colleagues (*et. al.* 1996) have undertaken into the relationship between TK and AK. In essence, 4 stages have been identified: (1) *Socialisation*: from tacit knowledge to tacit knowledge; 2. *Externalisation*: from tacit knowledge to explicit knowledge; 3. *Combination*: from explicit knowledge to explicit knowledge; 4. *Internalisation*: from explicit knowledge to tacit knowledge (:835, italics added). We consider however that the cycle may typically be acyclic, particularly in later working life as senior personnel come to rely further on *aTK*, more so than AK.

# 4. METHODOLOGY

Although a great deal of literature commencing with works by Polanyi (1958; 1966), has established the notion of *Tacit Knowledge*, the actual ability to extract this phenomenon is understandably limited. As a means of increasing rigour associated with our research we feel it beneficial to adopt a triangulated approach (Jick 1983 in Scott 1990) which will incorporate (a) the Sternberg based psychological testing instruments; (b) Social Network Analysis as a tool to track the information dissipation cycle, and (c) Formal Concept Analysis as a means to balance results with those achieved by way of (a) Sternberg's method, and the dissipation (through personnel) of *aTK* viewed by way of (b) SNA (Figure 2).

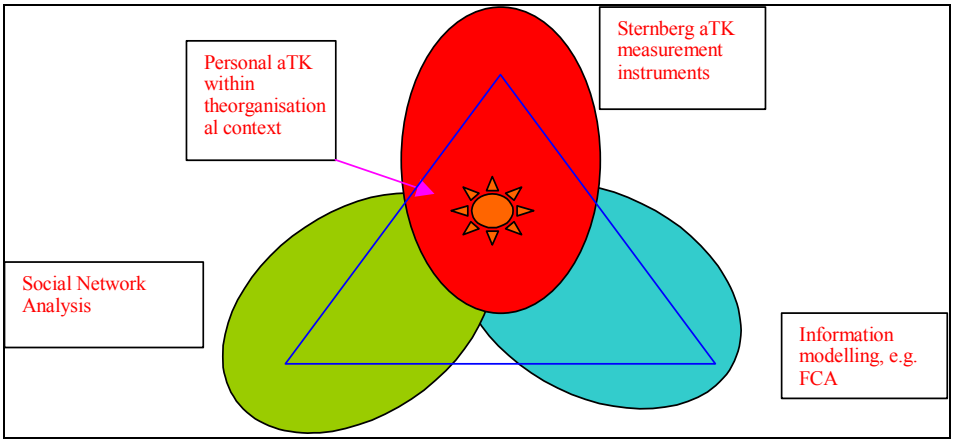



**Figure 2: Macromethodology utilising triangulation to test for aTK at the individual level**

### 4.1.1 Step 0: Interviews

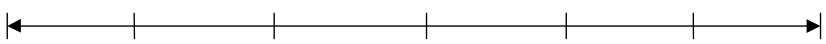
Interviews were conducted as part of a pilot study with 12 computing related personnel of varying degrees of IT experience. IT personnel were chosen on the basis of their 'front office' and 'back office' experience, as we felt this provided a cross section of the computing domain. We define 'front office' in this instance as being IS personnel who liase with external clients of the company, roles which include Data Architect, Business Analyst, Directors of firms, Consultants, Chief Information Officers, and 'Back Office' roles as Data Base Administrators, Programmers, Operators, Network personnel and Technical Analysts, in other words the technical computing roles or those that liase with 'equipment' rather than 'external personnel'. Identities of individuals were kept confidential. Interviews were conducted on the basis of asking senior personnel tasks that progressed well and poorly and who within the organisation (without necessarily requiring names) could be considered proficient at their tasks and those

not so. In gaining such information, scenarios could then be constructed along the lines of Sternberg (*et.al* 1995).

### 4.1.2 Step 1: Psychologically based testing

Although to date a great deal of literature exists on the phenomenon of *aTK* in the workplace (Johannessen, *et.al.* 1997; Lei 1997; Nonaka 1991; *et.al.* 1996; Raghuram 1996; Zucker *et.al*. 1998), little in the way of methodology is available for measurement of *aTK* other than that proposed by Sternberg (*et.al*. 1993; 1995; 1997; 1998a; 1998b; 1999; and his Yale University research group. The Yale approach (Wagner *et.al*. 1991a; *et.al*. 1991b), typically makes use of a Likert scale for a sequence of scenarios for which respondents are asked to pick a rank (Figure 3). An alternative approach is for individuals to write 'plans of action' for how they would handle each of a series of complex problem situations (Williams *et.al*. in Sternberg *et.al*.1995). Descriptive statistics along academic psychology lines then permit generalisations to be made as to the *aTK* inherent in individuals. One could say this is methodologically individualistic in its approach, insofar as testing is done at the individual level with a view to generalising upwards and outwards. There appears to be even less in the way of a methodology at the present stage that would enable the testing of *aTK* at a holistic organisational level. It is hoped that current research being undertaken by the authors may produce a means by which this latter concept is able to be extrapolated.

**Rate the following points on a 1 - 7 point scale**



1 2 3 4 5 6 7

Extremely bad Neither good nor bad Extremely good

**Scenario 1**

You have been assigned to a team of 6 people to work on a new database system for NSW Health. This system is somewhat contentious as it will involve accessing private information on clients, nevertheless you feel that the system will favourably capture 'management reporting' information, even if privacy may be impinged upon. Nevertheless the security policies and safeguards within the organisation are felt by you to be secure enough. Although you are new to the organisation, your previous work experience is respected and you realise that there are other jobs 'out there' should you decide 'create waves'. Within this team you are second in charge. How do you handle this situation? Do you:

1. Assign someone else to the team in your place and hope that the problem will eventually go away
2. Fully agree to the implementation of the system in the hope that the boss will notice your enthusiasm, thereby hopefully gaining you a promotion in years to come
3. Sabotage the implementation of the system, not necessarily physically but by allowing certain documentation to accidentally get 'mislaid'
4. Find that all of a sudden your diary is very full and you are unable to participate in the project because of this upcoming paper you had suddenly thought of, that you need to be giving at a conference in the Singapore next month
5. Threaten to 'blow the whistle' on the project because you are concerned about ethical considerations

**Figure 3: A sample scenario used in the pilot study**

### 4.1.3 Step 2: Social Network Analysis

Participant observation in a triangulated methodology dealing with nursing interaction had been used by Scott (1990; 1992) to provide balance to the methodology proposed by Sternberg (*et.al*.): "the questionnaire identified liberal attitudinal norms…….. In contrast, the observational methods identified behavioural norms that were conservative. …… The qualitative methods thus acted as a check on the quantitative method and provided valuable data on proposed role modification at the program development and practice levels" (Scott

1990 :567). Direct observation (Leedy 1997) rather than participant observation would have been more appropriate in our studies given the tendency of Information Systems work to be undertaken at a monitor where body language and otherwise obvious workplace activities are minimised. We consider a more appropriate technique however to be the application of Social Network Analysis (Wasserman *et.al*. 1994; Koehly *et.al*. 1998; Paxton *et.al*. 1999) which will be used to ascertain how *aTK* is conveyed from one individual to another. Our SNA questions will be incorporated within our *aTK* inventory questionnaire so that we may ascertain with whom personnel in organisations are experiencing positive and negative working relationships. We would expect for instance, that a negative working relationship within IS is likely to diminish the transfer of *aTK*, a positive relationship enhancing transference however.

### 4.1.4 Step 3: Formal Concept Analysis

A further means of providing balance in relation to tacit knowledge testing is that of modelling and comparing the results of Sternberg (*et.al*.) using a set-theoretic approach known as Formal Concept Analysis (FCA) (Wille 1982, 1997). FCA views a concept as being comprised of a set of objects, (G)egenstande, and a set of attributes, (M)erkmale, and the relationship between them (I). A binary K(ontext) may be formally expressed thus:

$$K := (G, M, I)$$

A multivalued context may be expressed a quadtuple:

$$K := (G, M, W, I) \text{ and } I \subseteq G \times M \times W$$

where the relationship I is a subset of the combined components of Objects (G), Attributes (M) and MerksmaleWerte (W) (Attribute-values).

We may interpret the responses to the Sternberg-style scenario as a formal context, a cross table, which can be constructed thus:

K = Formal table with its corresponding data
G = The participant
M = The responses
W = The value of the response
I = Relationship between the responses, their values and the participants

Using the notion of a galois connection, formal concepts are found by determining the set of attributes shared by a set of objects or conversely the set of objects which share a set of attributes. More formally, the derivation operators:

$$X \subseteq G: \; X \mapsto X' := \{m \in M \mid gIm \text{ for all } g \in X\} \qquad \text{(Formula 1)}$$

$$Y \subseteq M: \; Y \mapsto Y' := \{g \in G \mid gIm \text{ for all } m \in Y\} \qquad \text{(Formula 2)}$$

are used to construct all formal concepts of a formal context, by finding the pairs $(X'',X')$ and $(Y',Y'')$. We can obtain all extents $X'$ by determining all row-intents $\{g\}'$ with $g \in G$ and then finding all their intersections. Alternatively $Y'$ can be obtained by determining all column-extents $\{m\}'$ with $m \in M$ and then finding all their intersection. This is specified as:

$$X' = \bigcap_{g \in X} \{g\}' \qquad \text{(Formula 3)}$$

$$Y' = \bigcap_{m \in Y} \{m\}' \qquad \text{(Formula 4)}$$

Having found the set of formal concepts we can order these using the subsumption relation ≥ on the set of all concepts formed such that (X1,Y1) ≤ (X2,Y2) iff X1 ⊆ X2. By finding the predecessors and successors of each concept we can produce a visualisation of the concepts as a complete lattice, as shown in Figure 4. For a family (Xi,Yi) of formal concepts of K the greatest subconcept, the join, and the smallest superconcept, the meet, are respectively given by:

$$\bigvee_{i \in I}(X_i,B_i) := \left(\left(\bigcup_{i \in I} A_i\right)'', \bigcap_{i \in I} B_i\right) \qquad \text{(Formula 5)}$$

$$\bigwedge_{i \in I}(X_i,B_i) := \left(\bigcap_{i \in I} A_i, \left(\bigcup_{i \in I} B_i\right)''\right) \qquad \text{(Formula 6)}$$

Kollewe (1989) has also used survey data to construct a formal context but he treats the data of the table as the context (K), the units of questioning as the objects (G), the questions as the attributes (M) and the answers to the questions as the attribute-values (W). We chose to represent the data differently as it seemed more intuitive to regard the participant as the object that has a number of features such as age and position in addition to a set of responses and their values. Our approach also made data entry and validation easier and there was a one-to-one correspondence between the survey returned and the participant.

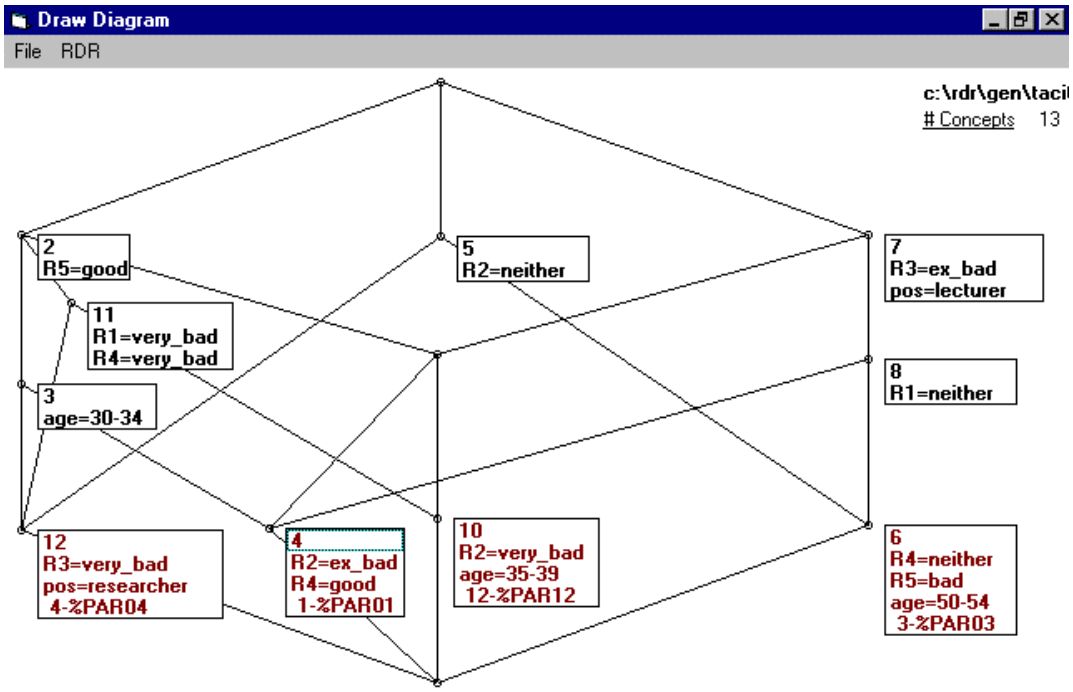



**Figure 4: The concept matrix for all participants who share more than 1 response with participant 1.**

The data used for modelling will be based on the Sternberg scenarios and Likert scales. Some scenarios will also be presented in crosstable format. Our motivation is twofold. Firstly, we are interested to see whether the answers given by respondents to a scenario differ when asked to provide answers in alternative formats. If answers are consistent this will add rigour to our results. Secondly, we want to avoid biasing the data we use for modelling which could occur if we apply our own interpretation of the data from Step 2. Once we have the data in a crosstable we are able to automatically generate formal concepts by finding intersections of

attributes and objects that share them, and display them as a complete lattice as shown in Figure 4. Although there are 49 concepts in the crosstable represented in Appendix 1 (48 shown, as no respondent was between 60 – 64 years of age), this crosstable is only representative of a slice of the complete crosstable which would include over 180 primitive concepts, (12 scenarios × 10 – 20 answer options per scenario + biographical information) which would in turn be multiplied by potentially 200 respondents spread over several organisations. We use a tool we have developed, known as MCRDR/FCA, to restrict the context so that the number of concepts may comprehensibly be displayed on a typical computer screen. We have conducted a small pilot with 14 participants using the scenario given in this paper (Figure 3). The crosstable in Appendix 1 thus tabulates our results. The concept lattice of Figure 4 includes participants who shared two or more responses with participant 1, that is, participants 1, 3, 4, and 12. The concept lattice in Figure 5 compares the responses of participants 1 and 3.

Concepts in Figures 4 and 5 are shown as small circles. Labels are attached to the right of the circle. Labelling has been reduced for clarity. Remember in FCA that a concept is a set of attributes and the set of objects that share them. The set of attributes that belong to a concept are reached by ascending paths and the objects that belong to a concept are reached by descending paths. Thus, we can see in Figure 4 that concept number 11 includes the attributes (or in our usage the participant's choices and features) {S5=good, S1=very_bad, S4=very_bad} and the objects (the participants as identified by the rule number and the conclusion code which begins with %) {Participant 4, Participant 12}. While these two participants made the same choice for responses 5, 1 and 4 to scenario 1, they differ in their positions held, their ages and choices to response 2 and 3. We can also see that participant 3 is the least similar to the other participants included this lattice as he/she has 3 attributes that it does not share with anyone else (concept number 6). Figure 5 provides a clearer look at how Participant 1 and 3 are similar and dissimilar. Concept number 1, the top concept shows that both participants share the same position and choices to response 1 and 3. Concepts number 2 and 3 show the differences between the two participants.

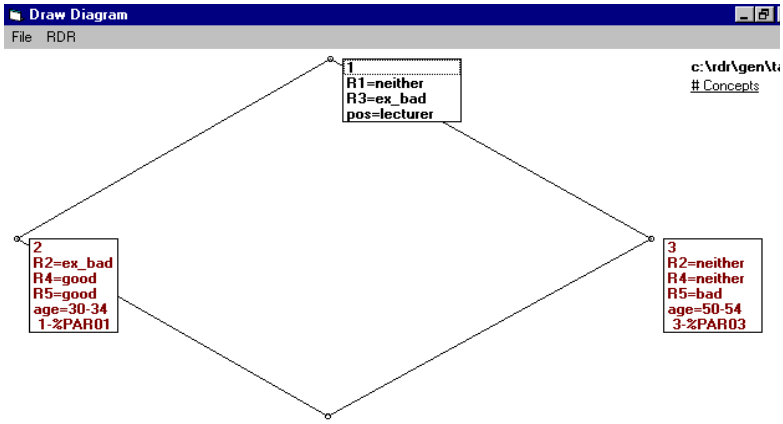



**Figure 5: The Concept Lattice for Participant's 1 and 3.**

## 5. CONCLUSION

We anticipate that the structure and patterns that appear in the concept lattice, together with the results using Sternberg's measurements, will enable us to determine, 1. To what extent *aTK* exists in the IS domain within an organisation; 2. How closely *aTK* measured by way of the Sternberg approach matches with that of Formal Concept Analysis and the various strengths of both approaches; 3. What features differentiate IS individuals who have accumulated more *aTK* from those with significantly less *aTK*; and 4. Some insights into how *aTK* may be made explicit and passed on to those with less *aTK*.

In summary, our primary tool will be to use a Sternberg approach to *aTK* measurement, however, we seek to balance these findings with those of another quantitative methodology, namely Formal Concept Analysis, whilst also making use of Social Network Theory as a means of measuring the 'flow' of *aTK* from one individual to the next.

The aim of this paper has thus firstly been to present a research approach into the externalisation of *aTK,* focused particularly within the Information Systems domain. We have also presented some of our micromethodology and given an example of a Sternberg-style scenario and some data captured in a small pilot study, which we have formalised and modelled using FCA. We are currently analysing the interviews (from Step 0) to develop scenarios and corresponding crosstables for our complete study, which will be conducted in the near future. Secondly we seek to determine whether there are differing levels of *aTK* between 'front office' and 'back office' roles. Thirdly we want to test whether, given the competitive nature of *aTK* and indeed just TK, we may consider the private sector to perhaps retain staff with a higher concentration of such knowledge versus the public sector for whom interorganisational competition is less intense given their essentially monopolistic missions.

## REFERENCES


Busch, P., Dampney, C., (a) (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., Dampney, C., (b) (2000) "The measurement of articulable Tacit Knowledge within the Knowledge Hierarchy" *International Conference on Information Systems* December 12 – 15th Brisbane Australia (submitted for publication)

Greeno, J., (1987) "Instructional representations based on research about understanding" in *Cognitive science and mathematics education* Schoenfeld, A., (ed.) Lawrence Erlbaum Associates Hillsdale New Jersey U.S.A. :61 – 88

Hedlund, G., (1994) "A model of knowledge management and the N – form corporation" *Strategic management journal* Vol 15 Special Summer issue :73 – 90

Horvath, J., Forsythe, G., Bullis, R., Sweeney, P., Williams, W., McNally, J., Wattendorf, J., Sternberg, R., (1999) "Experience, knowledge and military leadership" 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. :39 – 57

Howells, J., (1995) *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

Johannessen, J., Olsen, B., Olaisen, J., (1997) "Organising for innovation" *Long range planning* 30(1) February :96 – 109

Koehly, L., Shivy, V., (1998) "Social network analysis: A new methodology for counseling research" *Journal of Counseling Psychology* 45(1) January :3 – 17

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

Leedy, P., (1997) *Practical research: Planning and design* 6th. Ed. Merrill New York U.S.A.

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

Nonaka, I., (1991) "The knowledge creating company" *Harvard Business Review* 69(6) November – December :96 – 104

Nonaka, I., Takeuchi, H., Umemoto, K., (1996) "A theory of organisational knowledge creation" *International Journal of Technology Management* 11(7/8) :833 – 845

Paxton, S., Schutz, H., Wertheim, E., Muir, S., (1999) "Friendship clique and peer influences on body image concerns, dietary restraint, extreme weight – loss behaviours, and binge eating in adolescent girls" *Journal of Abnormal Psychology* 108(2) May :255 – 266

Polanyi, M., (1958) *Personal knowledge: Towards a post - critical philosophy* Routledge & Kegan Paul London U.K.

Polanyi, M., (1966) *The tacit dimension* Routledge & Kegan Paul London U.K.

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

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

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

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

Sternberg, R., (1995) "Theory and management of tacit knowledge as a part of practical intelligence" *Zeitschrift für Psychologie* 203(4) :319 – 334

Sternberg, R., (1997) "Cognitive concepts of expertise" in *Expertise in context: Human and machine* (Feltovich, P., Ford, K., Hoffman, R., (eds.)) AAAI Press/The MIT Press Menlo Park California U.S.A. :149 - 162

Sternberg, R., (1998a) "A balance theory of wisdom" *Review of General Psychology* 2(4) December :347 – 365

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., (1989) "The fate of the trait: A reply of the Cantor and Kihlstrom" *Advances in social cognition Vol 2: Social intelligence and cognitive assessments of personality* (Wyer, R., Srull, T., eds.) Lawrence Erlbaum Associates Hillsdale New Jersey U.S.A. :175 – 185.

Sternberg, R., Wagner, R., Okagaki, L., (1993) "Practical intelligence: The nature and role of tacit knowledge in work and at school" in *Mechanisms of everyday cognition*

(Puckett, J ed.) Lawrence Erlbaum Associates Hillsdale New Jersey U.S.A. :205 – 227

Sternberg, R., Wagner, R., Williams, W., Horvath, J., (1995) "Testing common sense" *American psychologist* 50(11) November :912 – 927

Sternberg, R., (1998b) "Applying the triarchic theory of human intelligence in the classroom" *Intelligence, instruction and assessment: Theory into practice* (Sternberg, R., Williams, W., eds.) Lawrence Erlbaum Associates Mahwah New Jersey U.S.A. :1 - 15

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

Torff, B., Sternberg, R., (1998) "Changing mind, changing world: Practical intelligence and tacit knowledge in adult learning" in *Adult learning and development: Perspectives from educational psychology* (Smith, M., Pourchot, T., eds.) Lawrence Erlbaum Associates Mahwah New Jersey U.S.A. :109 - 126

Wagner, R., Sternberg, R., (1985) "Practical intelligence in real – world pursuits: The role of tacit knowledge" *Journal of personality and social psychology* 49(2) August :436 – 458

Wagner, R., Sternberg, R., (1987) "Tacit knowledge in managerial success" *Journal of business and psychology* 1(4) Summer :301 - 312

Wagner, R., Sternberg, R., (1990) "Street smarts" in *Measures of leadership* (Clark, K., Clark, M., eds.) Leadership library of America West Orange New Jersey U.S.A. :493 – 504

Wagner, R., Sternberg, R., (1991a) *TKIM: The common sense manager: Tacit knowledge inventory for managers: Test Booklet* The Psychological Corporation Harcourt Brace Jovanovich San Antonio U.S.A.

Wagner, R., Sternberg, R., (1991b) *TKIM: The common sense manager: Tacit knowledge inventory for managers: User Manual* The Psychological Corporation Harcourt Brace Jovanovich San Antonio U.S.A.

Wagner, R., Sujan, H., Sujan, M., Rashotte, C., Sternberg, R., (1999) "Tacit knowledge in sales" 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. :155 – 182

Wasserman, S., Faust, K., (1994) *Social Network Analysis: Methods and Applications* Cambridge University Press Cambridge U.K.

Wille, R. (1982) "Restructuring Lattice Theory: An Approach Based on Hierarchies of Concepts" In I. Rival, I., (ed) *Ordered Sets* Reidel Dordrecht Holland 445-470.

Wille, R. (1997) "Conceptual Graphs and Formal Concept Analysis" In Dickson Lukose, Harry Delugach, Marry Keeler, Leroy Searle, and John F. Sowa, (Eds) (1997), *Conceptual Structures: Fulfilling Peirce's Dream, Proceedings of the Fifth International Conference on Conceptual Structures (ICCS'97),* August 3 - 8, University of Washington, Seattle, USA, Lecture Notes in Artificial Intelligence, Number 1257, Springer Verlag, Berlin, 290-303.

Zucker, L., Darby, M., (1998) "Capturing technological opportunity via Japan's star scientists: Evidence from Japanese firms' biotech patents and products" *NBER Working*

*Paper Series  Working paper 6360*  National Bureau of Economic Research  Cambridge Massachusetts  January

# APPENDIX 1

| Subject topic | No. | Question meaning | Response options | Participants responses | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 |
| Privacy and management reporting | 1 | Personnel assignment | Extremely good | | | | | | | | | | | | | | |
| | | | Very good | | | | | | | | | | | | | | |
| | | | Good | | | | | | | | | | | | | | |
| | | | Neither good nor bad | X | | X | | | | | | X | | X | | | |
| | | | Bad | | | | | X | | | | | | | | X | X |
| | | | Very Bad | | X | | X | | | | X | | | | X | | |
| | | | Extremely bad | | | | | | X | X | | | X | | | | |
| | 2 | Boss notice | Extremely good | | | | | | X | | | | | | | | |
| | | | Very good | | | | | | | | | | | | | | |
| | | | Good | | | | | | | | | X | | | | | |
| | | | Neither good nor bad | | X | X | X | | | | | | | X | | | |
| | | | Bad | | | | | | | | | | | | | | X |
| | | | Very Bad | | | | | X | | X | | | X | | X | X | |
| | | | Extremely bad | X | | | | | | | X | | | | | | |
| | 3. | Sabotage | Extremely good | | | | | | | | | | | | | | |
| | | | Very good | | | | | | | | | | | | | | |
| | | | Good | | | | | | | | | | | | | | |
| | | | Neither good nor bad | | | | | | | | | | | | | | |
| | | | Bad | | | | | | | | | | | | | | X |
| | | | Very Bad | | | | X | X | | | | X | X | X | | X | |
| | | | Extremely bad | X | X | X | | | X | X | X | | | | X | | |
| | 4. | Full diary | Extremely good | | | | | | | | | | | | | | |
| | | | Very good | | | | | | | | | | | | | | |
| | | | Good | X | | | | | | | | | | | | | |
| | | | Neither good nor bad | | | X | | | | | | | | X | | | |
| | | | Bad | | | | | | | | | X | | | | | X |
| | | | Very Bad | | X | | X | X | | X | | | X | | X | | |
| | | | Extremely bad | | | | | | X | | X | | | | | X | |
| | 5. | Blow whistle | Extremely good | | | | | | | | | | | X | | | |
| | | | Very good | | | | | | | | | | | | | X | |
| | | | Good | X | | | X | | | | | | | | X | | X |
| | | | Neither good nor bad | | | | | X | | | | | | | | | |
| | | | Bad | | | X | | | | X | | X | | | | | |
| | | | Very Bad | | X | | | | | | X | | X | | | | |
| | | | Extremely bad | | | | | | X | | | | | | | | |
| Occupn | | | Lecturer | X | | X | | | X | X | | | X | X | X | | X |
| | | | Consultant | | | | | | | | | | | | | X | |
| | | | Researcher | | | | X | | | | | | | | | | |
| | | | Tutor | | | | | X | | | | | | | | | |
| | | | Computer Support | | X | | | | | | X | X | | | | | |
| Age | | | 20 – 24 | | | | | | | | | X | | | | | X |
| | | | 25 – 29 | | | | | X | | X | | | | | | | |
| | | | 30 – 34 | X | | | X | | | | | | | | | | |
| | | | 35 – 39 | | | | | | X | | | | | | X | | |
| | | | 40 – 44 | | X | | | | | | | | | | | X | |
| | | | 45 – 49 | | | | | | | | X | | | | | | |
| | | | 50 – 54 | | | X | | | | | | | | | | | |
| | | | 55 – 59 | | | | | | | | | | X | X | | | |

**Primary concept table derived from the pilot tacit knowledge scenario**

# COPYRIGHT

Peter Busch and Debbie Richards (c) 2000. The authors assign to ACIS and educational and non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full and this copyright statement is reproduced. The authors also grant a non-exclusive licence to ACIS to publish this document in full in the Conference Papers and Proceedings. Those documents may be published on the World Wide Web, CD-ROM, in printed form, and on mirror sites on the World Wide Web. Any other usage is prohibited without the express permission of the authors.