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# The Relational Tacit Dimensions of Knowledge used within the Explicit Standardised Processes of Professional Practice in the Irish Forensic Science Laboratory

By

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## ABSTRACT

The organisational literature explaining tacit knowledge as a whole has remained conceptual and there is now a need to know empirically about the nature of tacit knowledge at the process level where the knowledge worker carries out work. This doctoral research case study empirically examines the tacit dimensions of knowledge that occur between knowledge worker practitioners especially within an explicit environment of codified standardised operating procedures and intranet knowledge databases.

In this case the evidence comes from a multi-method approach. The empirical findings are based on a case study of a forensic science community of practice, at the micro-level between knowledge workers, where quantitative social network analysis and qualitative interviewing, ethnographic studies, and document review were carried out. The quantitative picture, using social network analysis was used to give a fixed perspective on the actors sharing tacit knowledge during advice seeking transactions within the communities. An interpretive qualitative approach was used where the intent was to understand the relational dimensions of tacit knowledge being shared between the same actors.

Social theories of learning perspectives are used, in particular with the emphasis on communities of practice as a framework, to study structured relational mechanisms that shape tacit knowledge flows. Organisational learning can be seen as a function of relationships between actors within a dynamic environment of social interaction, and matter most when collegiate interactions involve the exchange of tacit knowledge. Within a micro-level case study of a highly technical forensic science expert community, this research emphasizes the relational tacit dimensions of knowledge provided by human social capital surrounding and encircling the standardised organisational production process. Trust, respect, friendship, identity and

social norms are the kinds of personal relationships people have developed through a history of interactions, which have been discussed in the literature. Answering the call of researchers, for the empirical analysis of knowledge sharing practices using the relational thinking concept, this doctoral case study has found more, including processual, experiential, capability, mentoring, informal, helping, openness/sharing, approachability, respect, proximal, cohort/clique, interpretative and bureaucratic structural relationships, and unique to forensic scientists, an adversarial relationship.

Most of the literature within the community of practice teachings describes the performative advantages of such communities but there has been very little discussion on the rich tacitness embodied within the actual processes of how such communities work, especially those within a quality management structure. Eventhough processes are explicit by nature there is still a tacit element attached where a base line of minimum acceptable performance from protocols is supplemented by interactions with colleagues and one's own thought processes. Such concepts are only being discussed at a nascent level in the Quality Management System literature, where the tacit world has not yet diffused into the very explicit world found in qualitative management writings. In looking at the process level, findings are presented with respect to the interplay of the explicit knowledge within standard operating procedures and the practitioners' tacit knowledge requirements needed in actually completing the process.

Ultimately these findings will help improve the way process is carried out in a knowledge intensive environment by having insights in how tacit knowledge works, and make conclusions on tacit knowledge within the world of process governed by standard operating procedures.

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# PART ONE

# 1 INTRODUCTION

The knowledge management thinking has placed the knowledge worker[1] in an explicit world of codified knowledge where one can easily work and rectify any problems by perusing a database of quick-fix suggestions or a standard operating procedure. Those solutions that can not be solved need the assistance of others who can help from their tacit knowledge reserves. These previous words summarise the explicit/tacit knowledge dichotomy that is very prevalent in the colloquial management understanding of today. Continuously, tacit knowledge has been easily described as the opposite to explicit knowledge and its conversion from its tacitness to an explicit form is all that is needed for the workings of a knowledge worker. Likewise with the multiple generations of explicit standard operating procedures that purposefully set out to cover all aspects of the operators' *processes*, the explicit knowledge world (or the tacit knowledge that has supposedly been made explicit) has taken the centre stage in describing the way those with knowledge work – in doing so, the tacit dimension of knowledge required has become submersed and somewhat lost in the mix. An increased understanding of the tacit nature of the process knowledge required for knowledge workers is needed, within the sphere in which tacit knowledge is created and shared – the

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[1] Knowledge workers are defined as individuals with high education and training in a particular profession. These characteristics are normally combined with a high capability in problem solving (Giuliani & Bell 2005).

community of practice (Brown & Duguid 2001).

One should not be conceptualising the knowledge continuum as – an explicit environment helped on by the simple conversion of the dyadic tacit opposite. One should think instead about the tacit *dimensions* of knowledge within the practicing sphere of a knowledge continuum for the knowledge worker both at the individual and organisational levels. Forms of explicit knowledge held by a firm, including manufacturing knowledge, process knowledge, design knowledge, and technical knowledge increase in value when they can be effectively leveraged via the tacit knowledge held inside the firm (Collins & Hitt 2006).

When compared to the work on explicit knowledge, the management understanding of tacit knowledge is relatively unexplored. Giving recognition to the *tacit* aspects of knowledge, enables one to focus on the actual *mechanisms* of the knowledge worker. Presently, tacit knowledge has a mythical presence in the simplistic dichotomy of knowledge as explained in the colloquial management literature, allowing the knowledge worker to think and problem solve in general. However, this is all that is espoused – there is no examination at the micro-level of procedures.

Here, explored is the tacit knowledge dimensions of the processes at the centre of the knowledge workers' procedural needs within the knowledge management thinking. Eventhough processes are explicit by their nature, this research intends to show that there is still a very much tacit element attached to the process which has been overlooked. The phenomenon of individuals practising together in a business/operational environment is well known as is apparent in the professions such as law, accountancy, medicine, military, and the sciences. It has been well documented that in the instances where those practising within such professions rely heavily on explicit knowledge, they do also depend on a unique kind of tacit knowledge in order to excel at what they do (Sternberg & Horvath 1999;Tschannen-Moran & Nestor-Baker 2004). Conceptually, the proposal here is to redefine the conventional explanation of tacit knowledge, in order to show that tacit knowledge comprises a *relational* nature, embedded in social networks, from this study of tacit knowledge exchange at a micro-level between social actors – forensic scientists. The interest here is what happens, how does one gain or indeed give knowledge in the processes of one's work. For gaining knowledge, often of the tacit nature is needed for one to become a fully functioning practising technical expert.

## *Research Justification*

The literature catalogues *tacit* knowledge as the counterpart to explicit knowledge within the knowledge dichotomy or as a component within the knowledge continuum (Brown & Duguid 2001;Polanyi 1966). However, tacit knowledge 'has been greatly misunderstood in management studies (Tsoukas 2003, p.15)', leading to a deep concern that those knowledge management initiatives in companies are 'limited to the transfer of explicit (codifiable) knowledge...' as is evident in the standardised operating procedures characteristic of Quality Management Systems, and 'that this may relegate tacit knowledge to the background (Johannessen, Olaisen, & Olsen 2001: p. 4)'. There is a pattern nowadays of explicit knowledge being the predominant partner in the explicit/tacit dichotomy. The concept of knowledge has been defined too narrowly by those looking to explicate it, whereas it should be viewed as a stratified whole, not ignoring the tacit dimension. One needs to have a fuller understanding of the tacit dimensions of knowledge, where now there is only 'a nascent understanding of tacit knowledge (Leonard & Sensiper 1998, p.127)'. This incompleteness has afforded those who speak about knowledge in organisations to explain through the well honed arguments based within the explicit realm of the knowledge continuum.

However, knowledge by its nature has a fully human dimension and does not 'exist independently of humans (Gill 2000: p.9)'. Although the tacit co-operates with the explicit, when the tacit predominates to the extent that its articulation is virtually impossible, it is no wonder that those trying to explain the tacit aspects reach a difficulty, because of its 'ineffable domain', as defined by Polanyi ( 1958: p.87). The literature explaining tacit knowledge 'as a whole has remained conceptual' and there is now 'a need to know much more empirically about the nature of tacit knowledge (Ambrosini & Bowman 2001: p.811)'. There are those who have tried to measure (Wagner & Sternberg 1985) or to narrowly define (Nonaka & Takeuchi 1995) the tacit aspects of knowledge which go against the concepts of the tacit dimensions of personal knowing as prescribed by Polanyi ( 1966). Those who have tried to empirically measure the tacit dimension of knowledge (Herbig, Bussing, & Ewert 2001;Wagner & Sternberg 1985) have transformed the tacit to explicit for measurement. Hence there is a tendency to reduce tacit knowledge to the describable thereby causing it to become explicit – translating it into something that supposedly cannot be captured or converted (Tsoukas 2003).

Conceptually, tacit knowledge can be looked at as being a major part of organisational process. Tacit knowledge is important to the development of professional practice, and can be a source of highly effective performance in the workplace (Sternberg & Horvath 1999). In research on large scale engineering projects, individuals rather than turning to databases and standardised operating procedure manuals to obtain information, seek knowledge in a tacit form from trusted and capable colleagues (Koskinen, Pihlanto, & Vanharanta 2003) built up through relationships over time. Tacit knowledge is a personal knowledge grounded in experience which because of its intricacies cannot be fully expressed (Horvath et al. 1999).

With the onset of quality management system Standard Operating Procedures as the central theme in the explicit world, it is worth considering how these explicit collections of SOPs and databases should be treated within the tacit arguments proposed. Here, taking a holistic perspective, this doctoral research study tries to empirically examine the tacit dimensions of knowledge that occur between practitioners, because it is the very tacitness of knowledge that requires an investigative exploration. Just because of the 'ineffability of tacit knowledge' it 'does not mean that we cannot discuss the skilled performances in which we are involved (Tsoukas 2003: p.15)'. Tsoukas (*ibid.*) urges that one should indeed discuss these tacit performances 'provided we stop insisting on converting tacit knowledge' and start to recursively look at the whole tacit processes. Although the tacit nature of knowledge is well understood and catalogued at a 'performative abstract level' in the organisational literature (Davenport & Hall 2002, p.180), there has been no real empirical evidence to help one understand the minutiae and nuances of the tacit dimensions, that lubricate the very processes that allow the knowledge worker to practice his or her working processes. Those studies of an empirical nature have been of the ethnographic type such as those based on communities of practice (Lathlean & le May 2002;Orr 1996;Wenger 1998), which are written mostly from a qualitative perspective, highlighting the advantages of organising and managing such a group of expert workers in low-tech organisational environments, such as claim processors in an insurance company. Overall there is little empirical work published on the knowledge dynamics occurring between the participant actors in communities of practice in knowledge intensive environments, and none in standardised operational procedural environments such as in this case study.

***Theoretical Positioning***

Since the explicit domain of knowledge has been overly examined it is appropriate to formalise the arguments set out in the introduction through conceptualising Polanyi's treatment of tacit knowing, who defines the cognitive experience of humans as a function of the interplay between the explicit and tacit components of knowledge (cf. Gill 2000: pg. 37-57;& 1966;Polanyi 1958). This research sets its footing within Polanyi's epistemological view challenging the modernist philosophy that all knowledge is and must be explicit in nature. Polanyi ( 1958: p.15), the Hungarian theoretical chemist turned epistemological philosopher during his professorial ventures in the UK dismisses the 'cult of objectivity' predominant in the sciences, and criticises the 'prevailing conception of science' which he describes as being wrongly 'based on the disjunction of subjectivity and objectivity' which 'seeks – and must seek at all costs – to eliminate from science such passionate, personal, human appraisals of theories, or at least to minimize their function to that of a negligible by-play'. Opining, he adds that 'it is used to play down man's real and indispensable intellectual powers for the sake of maintaining an 'objectivist' framework which in fact cannot account for them (*ibid* pg. 16-17)'. Hence the whole of Polanyi's work is to be understood as an attempt to counteract the one-sided emphasis on explicit objectivity and turn to concentrating on tacit knowledge by establishing the personal dimension of cognitive activity. Suitably stated, and part of the theme of this research, Polanyi (*ibid*: pg. 64) tries 'to lay bare the inarticulate manifestations of intelligence by which we know things'.

With regard to the structure of knowledge, Polanyi ( 1966: p. 4) prescribes that all knowing is or derives from tacit knowing and that because it is the anchor for explicit knowing, it follows that always one will 'know more than we can tell'. Although the tacit factors cannot be articulated fully when knowledge is used, it is very much relied on, in order to focus on the more explicit factors. Indeed Tsoukas ( 2003: p. 3) maintains in using codified knowledge itself, that 'far from being as objective, self-sustaining, and explicit as it is often taken to be', that 'it is actually grounded on personal judgements and tacit commitments'.

There is good reason that this doctoral study is anchored around the exploration of 'tacit knowledge' as the key component of knowledge, because 'as common experience can verify, the knowledge people use in organisations is so practical and deeply familiar to them that when people are asked to describe how they do what they do, they often find it hard to express it in words (*ibid.*)'. It is finding out more about the *tacit* dimensions of *processes* within professional practice that is the positioning of this research, which is somewhat difficult if it is hard to find. This case study adds to the school of thought on tacit knowledge, building on the epistemology of organisational practice. In this research one of the explorations will be to look at the codified operating procedures in order to examine if a practitioner can carry them out sufficiently as written. Interestingly, Polanyi has eluded to the sets of procedures required to carry out a task performed by an expert exercising a skill. He divides the skill, on a practitioner carrying out the task (eg. Hammering a nail) into two different kinds of awareness – a subsidiary and a focal awareness (Polanyi 1958: p.55;Polanyi & Prosch 1975: p.33). The focal awareness captures the whole completed task through one's skillset, whereas a subsidiary awareness is one who would hone in on all the individual parts that make up the whole task, making the action in the task clumsy. Importantly, this sense of philosophy and one of the arms of this research 'is that we do not work our way from the parts to the whole, but rather from the whole to the parts (Gill 2000: p. 44)' – a very valid point to keep in mind when looking at how practitioners use standard operating procedures. Polanyi describes the skill of a practitioner as one who has an 'indwelling' – the interaction between subsidiary awareness and bodily activity that gives rise to tacit knowing (Polanyi & Prosch 1975: p. 37).

In extension to the theoretical framework on the concepts of tacit knowledge, this research uses perspectives of social theory of learning, in particular the emphasis on communities of practice as a framework, to study the environment of where tacit knowledge is used – originally presented by Lave and Wenger ( 1991) and expanded by Wenger (Wenger 1998;Wenger, McDermott, & Snyder 2002). These communities of practice are relatively tight-knit groups of individuals engaged in a shared practice who know each other well and work together directly. Lave and Wenger's (1991) account of situated learning in five sample communities of practice, shows that the learning process is tied to ongoing activities and shared practice amongst communities of people through *social* interaction rather than *isolated* individuals (Fox 2000), 'pointing to a social theory of knowledge in regard to cross-communal relations (Osterlund & Carlile 2005: p.100)'. Polanyi in explaining any practical skill suggests it is 'the capacity for carrying out a great number of particular movements with a view to achieving a comprehensive result (Polanyi & Prosch 1975: p.37)'. In considering organisations as knowledge systems, one can highlight the irreducibly *social* character of individual skilled action (Tsoukas 2002). Learning in the sense of becoming a practitioner within these expert communities of practice, requires knowing how, the tacit art of *practice* – engaging fully in a task, job or profession (Brown & Duguid 2001) – much of which lies tacit in a community of practice (Duguid 2005). It is within such a community of practice framework that this study on the tacit relational networks amongst forensic scientists will be explored. In conceptualising the richness of learning within the community of practice, one realises that it is not just a place to exchange knowledge, but it is a place where the tacitness of practice can become assimilated by actors working in close proximity to each other, which in itself is a necessary requirement for such work to be successfully carried out. In sharing a practice, people will then 'share know how, or tacit knowledge (Brown & Duguid 2001: p.204)'. I have placed myself at the observation junction where 'new knowledge comes about not when the tacit becomes explicit' but at the point when 'skilled performance is punctuated in new ways through social interaction (Tsoukas 2003: p.1)'. Learning, the descriptor of the way we gain knowledge has very much a social dimension, where as Tsoukas (2003: p. 14) critically states, and the crux of this research, that 'we learn to engage in practical activities through our participation in social practices, under the guidance of people who are more experienced than us', who, 'by drawing our attention to certain things, make us see connections'.

Szulanski ( 1996) defines practice as the organisation's routine use of knowledge, often having a tacit component, embedded partly in individual skills and partly in collaborative social arrangements. Where attention is called to the importance of tacit knowledge held by individuals (Nonaka & Takeuchi 1995), the community of practice concept helps one to understand how tacit knowledge is created and shared within these bounded groups of people all involved in a shared practice. Most of the literature within the community of practice teachings describes the performative advantages of such communities *but* there has been very little discussion on the rich tacitness embodied within the actual processes of how such communities work. Hence it is within the organisational processes, that I will consider tacit knowledge acquisition and application, as *a function* of participation in communities of practice (Tschannen-Moran & Nestor-Baker 2004), *present* in the situation (Giroux & Taylor 2002) within a complex social process (Brown & Duguid 2001), and in the flow of practice (Duguid 2005). Through the prism of practice where knowledge is created, I am proposing to look at tacit knowledge exchange.

## *Research Setting*

In this case study at the Forensic Science Laboratory (FSL), Ireland, I propose that tacit knowledge can be seen as an integral part in the activities of technical expert forensic scientist practitioners who continually add to their knowledge repertoire by engaging other fellow scientist practitioners through communities of practice.

FSL is Ireland's national forensic examination and analytical service for all criminal casework encompassing drugs, arson, DNA, mobile phones, toolmarks, paint and glass, explosives, firearm residue, fibre transfer and other trace type cases. At the time this research was undertaken FSL employed over 43 forensic scientists at the one headquarters. Outside of their own organisationally anchored local communities, the forensic scientists gain access to new knowledge through their participation in professional associations and their respective conferences. The scientists at FSL are largely influenced by forensic scientists who practice in fifty three other forensic laboratories, distributed over thirty-one European countries under the European *Network* of Forensic Science Institutes (ENFSI). ENFSI was established in 1995 with the purpose of sharing knowledge, exchanging experiences and coming to mutual agreements in the field of forensic science.

## *Research Questions*

### i Tacit knowledge within the process

At the level of the knowledge worker within practicing communities, one needs a clearer picture as to how such technical experts operate and share knowledge together within their *process* environment. Other than the well-documented ethnographic macro-studies which were based on physicists, molecular biologists, biochemists, service and low-tech industry communities (Knorr-Cetina 1999;Latour & Woolgar 1979;Lave & Wenger 1991;Orr 1996), there is a scarcity of *empirical* research at a more detailed micro-level on the knowledge processes between actors within a community of practice setting, especially in the high-tech process environment populated by highly educated knowledge workers. This micro-level study is designed to give one an understanding of how knowledge workers actually operate at the *process* level – carrying out standard operating procedures – within such communities. It is intended to look at the *process* level primarily to demystify the concept of *tacit knowledge* used by knowledge workers where 'knowledge is an activity which would be better described as a process of knowing (Polanyi 1969: p.132)'. This answers the call of exploration from current researchers who state that 'little is known about the process of knowing in complex organisations (Orlikowski 2002: p.253)'. The literature is now only beginning to address this issue, getting down to the more micro-levels of exploring knowledge exchange between knowledge workers (Assimakopoulos 2007;Assimakopoulos & Yan 2006;Borgatti & Cross 2003;Gherardi & Nicolini 2000). Comparatively speaking, there has been too much published at the higher conceptual levels of how communities work but there has been little research done at the worker *process* level – the actual steps in allowing for such communities to function, and ultimately produce product.

ii Tacit knowledge – a relational dimension

The community of practice theory potentially gives a set of conceptual tools which helps one to understand how tacit knowledge is shared or transmitted between knowledge workers. A unifying concept of the knowledge and learning gained through participant practice, is its construction from '*relations among people engaged in an activity*' (Osterlund & Carlile 2005: p.92). In this research, I will focus on how an informal social structure allows for tacit knowledge to flow between practitioners inside and somewhat outside the organisation, answering the call for empirical analysis of knowledge sharing practices using the relational thinking concept (Osterlund & Carlile 2005), where the relationships among tie strength, tacitness, and ease of transfer have yet to be investigated (Reagans & McEvily 2003). In this study the empirical analysis of such relational tacit ties through interviews of forensic scientists will be carried out in order to explore the rich tacit dimensions encircling and permeating organisational processes.

Tacit knowledge, is both exchanged between actors at a bounded local community of practice level and is transferred to actors who share a common interest externally outside of an organisation to the open environment through Networks of Practice or otherwise known as Collaborative Networks (Wasko & Faraj 2005). Such widely scoped collaborative networks of practice tie in directly with community of practices, where a community from one particular organisation becomes linked through common practices to communities in other organisations. Tacit knowledge should not be looked upon only as a function of an organisation's internal operations but also to the outside where it can bring new energy into the organisation. Recent research has emphasized the need for a better understanding and characterisation of the basic principles and mechanisms of collaborative networks (Sofia Pereira & Soares 2007).

The actors within such networks rely very heavily on their network of relationships to find information and solve problems (Cross, Borgatti, & Parker 2002). The benefit of these collaborative networks is more than just a conjoining – a synergy is achieved by pooling the thinking of multiple actors and organizations. In this research, I will explore the proposition that the exchange of *tacit knowledge* is a major contributor to the functioning of such collaborative networks.

iii Tacit knowledge required in addition to SOPs

There is a lack of consideration of the interaction between the documented Quality Management System procedures and the human operator's needs which in some instances definitely require tacit dimensions. This work on all accounts has not been done before within the quality management movement. This research intends to show that the higher tacit level processes employed by an experienced forensic scientist, such as case interpretation and judgement of the work required for the circumstances of the case, are not covered by standard operating procedures (SOPs). Nevertheless, in this case study setting (FSL), the organisational knowledge management strategy is focused on codified standardised operating procedures and intranet knowledge databases for capturing and disseminating knowledge which by definition is explicit. There needs to be a recognition that practitioners in their daily processes, rather than from the use of SOPs, rely on their own tacit experience and training when faced with decisions to make, for SOPs do not cover every eventuality. In examining the standard operating procedures, I will set out to show that the actual social relational interplay of actors and their exchange of advice, comprising of tacit dimensions, is required for such explicit procedures to be carried out fully, when supposedly they are step wised automatic processes.

It is the procedural processes governed by the SOPs that are accredited, but not the way the practitioners in their own minds go about their work that are standardised. Tacit practitioner knowledge is effectively standards-free, whereas for organisational knowledge where standards do exist, they are not specifically related to knowledge.

iv Tacit knowledge in the cultivation of an organisation

The very basis of fully working procedures within an organisation depends on the availabilities of workers to carry out the process. Fundamentally, to keep an organisation in perpetuity one has to ensure that there is a fully trained staff along with a pool of new recruits to keep the staff to its full complement. In turn this leads one to consider the tacit knowledge involved in producing these new recruits in order that there is a smooth transition in replacing the old-timers who are retiring/moving on.

Participation within these communities is central to situated learning, where it involves both action in taking part and connection to others in the community. Variations in the degree of participation describe the status of the knowledge worker in the community: peripheral or full, describing an apprentice's journey from novice to master. I want to extend the notion of Legitimate Peripheral Participation by addressing it not only from the newcomers' perspective, but also from that of the very experienced actors who become newly peripheral when they move from their old community of practice to a new one due to a promotion or other career move. This concept of looking at what happens to old-timers is of significance in today's fast moving knowledge based economy with world career opportunities, when vast experience in one area of specialty is perhaps a barrier to exit from the old community of practice, and a barrier to entry to a new community of practice specialty.

## *Research Design*

This case study on a forensic science community uses both quantitative and qualitative research methodologies in order to fully examine how tacit knowledge interplays within the processes that forensic scientists carry out as technical expert practitioners in order to complete their casework. At first I will show the intricacies of tacit knowledge exchange, with an aim to allow one to understand from a quantitative viewpoint what happens between knowledge workers during their training and their daily work practice of carrying out processes. Quantitative social network analysis (Scott 2000;Wasserman & Faust 1994) will be used to examine empirically such tacit knowledge relations both at a local and at an inter-organisational collaborative level. The micro-level study will provide an informative insight into the process of how tacit knowledge *flows* within the FSL community of communities of practice and across networks of practice, and how it is an integral factor in the processual workings of such networks. For those networks outside of FSL, I will explore the digital evidence ENFSI working group through participant observation, where the networking of an FSL member with the collaborative group has allowed a nascent digital evidence service to be set up back at FSL. In addition I will view another collaborative group – IABPA.

Not only is quantitative research methodology used but answers are to be found using the traditional qualitative school of inquiry where the 'primary way a researcher can investigate an organization or process is through the experience of the individual people' (Seidman 1998, p. 4). As well as participant observation, semi-structured interviews are carried out on forensic scientists within FSL who were selected through purposeful sampling, as identified through the network analysis above. In this research a picture of tacit knowledge exchange is elaborated in the ethnography of actors in the communities of practice. Although the interviews entailed some degree of variation, the interview questions were selected around elements of tacit knowledge exchange/reciprocation covering the following topic areas: the learning of forensic science practice; the seeking/giving advice; establishment of how knowledge is gained/given; and the exploration of the concept of experience. The questions were developed to directly address the research question: how relational dimensions of tacit knowledge interplay in the processes within community of practices and outside in collaborative network linkages. I had access both to the SOPs and a wide range of official documentation, including strategy documents and internal memoranda, etc. The purpose of analysing the documents was to identify evidence of tacit knowledge exchange that supported the interview data.

## *Significance of the Study*

We need a better understanding of how tacit knowledge interacts in the organisational processes of professional practice, yielding a product or service. As such organisations have begun to align themselves along the quality movements such as the International Organisation of Standardization (ISO), we need to be aware of the tacit dimensions of the processes that yield final product – such tacit dimensions in themselves are not accredited. This study asks a predominating question – 'An exploration of the relational tacit knowledge dimensions powering the processes of professional practice' – a case study which is situated within the context of forensic scientists participating in a community of communities of practice.

Understanding the relational tacit dimensions of such professional practice processes will have an impact on how managers interpret the actual way practitioners work, demystifying the 'tacit' aspects that have until now been only spoken of conceptually. There has been a tendency of managers to easily accept the explicit dimensions of the way practitioners work, as shown with sometimes elaborate codified collections of protocols, but at the behest of ignoring the all important tacit aspects of how practitioners really operate.

This research is important for several reasons. First, it will advance the field of organisational management by empirically showing the importance of the tacit dimensions of organisational processes and how such thinking should be absorbed actively to bring it to a level similar to the already well known explicit dimensions of knowledge that we read of continuously. Second, this research will help one to consider conceptually, the relational mechanisms that shape tacit knowledge flows occurring between participant actors in communities of practice rather than relying on the largely more abstract qualitative thinkings of tacit knowledge. Third, the research findings will enhance the understanding of the interaction of practitioners within a Quality Management System SOP environment and discover the new competencies of the tacit dimensions required for successful process completion.

The implications of this study will inform organisational managers with an explication of the two poles within the knowledge continuum needed for the effective management of knowledge workers – yielding an organisation with a good base-line of explicit process protocols but one that has also nurtured the understanding of the relational tacit knowledge dimensions of the same processes.

# 2 LITERATURE REVIEW

Ahead, I endeavour to provide the background to and the justification for the research undertaken, setting a baseline of understanding in the pertinent literature from where my own original research can progress. This research undertaken intersects the organisational management field that has already ventured into the area of tacit knowledge, the philosophy field where tacit knowledge was conceptualised, and the sociology field where tacit knowledge is examined with regard to human behaviour. A thorough summary of these three fields has informed the research process and assisted in positioning the scope of this research. To this end, the scope of the literature examined covers nearly all the instances of where tacit knowledge is implicated in organisation management and includes (1) tacit knowledge defined, (2) the meaning of tacit knowledge itself, and tacit knowledge incorporated in (3) expert workers, (4) situated learning, (5) within professional practice organisations-communities of practice, (6) between organisations-networks of practice, and finally (7) a relatively new way of looking at such organisations through knowing in practice within the dynamic relational environment of social interaction, (8) using in part social network analysis. Also examined (9) are the ramifications of tacit knowledge being considered within the explicit knowledge dominated quality management system environment that tends to exclude anything tacit, favouring obvious explicitness.

## *Knowledge defined*

Conceptually, knowledge can be categorised into two different states: *explicit* and *tacit* knowledge, and at two levels, individual and collective (Nonaka & Takeuchi 1995). Presented here and preceding the literature review, is a snapshot of the definitions of both tacit and explicit knowledge informing the reader of a basic understanding of the two types of knowledge. An emphasis on tacit knowledge then follows – the focus of this research.

Explicit knowledge consists of facts, rules and policies that are codified in paper or electronic form where it can be readily transmitted to others and then shared without the need for discussion (Wyatt 2001). The most common forms of explicit knowledge are manuals, drawings, standard operating procedures, documents and the like. Information systems are usually seen as playing a central role in facilitating the dissemination of explicit knowledge assets over company intranets or between organizations via the internet. In the field of knowledge management the concept of tacit knowledge refers to a knowledge which is only known by an individual and that is difficult to communicate to the rest of an organization. By definition, tacit knowledge is knowledge that people carry in their minds and is, therefore, difficult to access. The word 'tacit', is derived from the Latin verb *tacere*, to be silent, and it means that which is implied but not actually expressed, or expressed or carried on without words or speech (Sapienza 2002). Effective transfer of tacit knowledge generally requires extensive personal contact and trust. The process of transforming tacit knowledge into explicit knowledge is known as codification or articulation. There are some who describe tacit knowledge as the opposite to explicit knowledge, where the conversion of its tacitness to an explicit form is all that is needed for the workings of a knowledge worker. Others maintain that tacit and explicit are two ends of the knowledge continuum where both forms are continuously juggled for the effective performance of knowledge workers [for an explanation of the explicit/tacit knowledge dichotomy, see appendix; the knowledge dichotomy].

Tacit knowledge (Gill 2000;Polanyi 1966) is entrained in action and involves more gut feeling, experience, and is therefore more difficult to articulate and express to others (Mitri 2003), and is usually learned during observation and practice, or from prior experiences (Epstein 1999). It is thought that its transfer is also facilitated by intensive interpersonal contact (Collins & Hitt 2006). Tacit knowledge has been described within a business context 'as that which is difficult to articulate in a way that is meaningful and complete' – 'knowing more than we can tell (Teece 1998: p. 63)'. Woo et al maintain that tacit knowledge is knowledge housed in the human brain, where it is evident as expertise or professional insight formed as a result of experience ( 2004). Knorr-Cetina ( 1999) describes the human body as a black box when it comes to the experiences it incorporates, attributing tacit knowledge as the term used to describe the body as a competent information processor in expert settings. Tacit knowledge is known to be embedded in holistic work processes, and is implicitly gained as an integral part of the accomplishment of working tasks (Herbig, Bussing, & Ewert 2001). Polanyi ( 1966: p.4) encapsulates the essence of tacit knowledge in the phrase 'we know more than we can tell', and maintains that knowledge always has an inarticulate component – calling this the tacit dimension. Wyatt (2001) states that tacit knowledge underlies personal skill, and its transfer requires face-to-face contact or apprenticeship. Others describe tacit knowledge as comprising the implicit understanding in an individual allowing the individual to know when to adapt to the environment (Horvath, Forsythe, Bullis, Williams, McNally, & Sternberg 1999).

***A Clarification on the understandings of Tacit Knowledge***

Even though Polanyi (1966) is regarded by tradition to be the authoritative source for the concept of tacit knowledge, there are others (Collins 2001a;Gourlay 2006;Tsoukas 2003) who argue that he has been misunderstood and that his ideas may not be particularly relevant for understanding tacit knowledge in organisations.

Polanyi's ( 1966) writings very much deal with tacit knowledge at the personal-self level, where tacit knowledge functions as a background knowledge, assisting the accomplishing task being carried out by the human actor which is in focus. In elucidation, an actor's subsidiary awareness and focal awareness are mutually exclusive – such as if a pianist shifts the attention from the piece he is playing, to the observation of what he is doing with his fingers while playing it, he gets confused and may have to stop (Sveiby 1999). Polanyi's theory is about how human beings acquire and use knowledge, who make it actionable though the process of knowing. Polanyi thus regards knowledge both in a static 'knowledge' and dynamic 'knowing' forms, where 'all knowing derives from tacit knowing (cited in Gill 2000: p.54)'. The dynamic properties describe how actors strive for acquiring, coming to know, new knowledge. Polanyi (1966) spends considerable energy on establishing the personal dimension of cognitive activity – from where tacit knowledge habitually operates. This *cognitivty* function of the human is the contribution that Polanyi has made to the structure of knowledge (Gill 2000: p.51).

Whereas Polanyi deals with tacit knowledge at a personified level, fixed to the individual, a more insightful understanding of tacit knowledge is made by Collins [see below], who speaks of tacit knowledge and the social dynamic environment at the same time, both being needed in order to truly understand the meaning of tacit knowledge [*obs.* from Hans Siggaard Jensen]. Hence tacit knowledge should be understood as *both* an individual and a collective type of knowledge, where the presence of others is generally regarded as essential for its acquisition (Gourlay 2006).

Collins ( 2001b; 2007) describes tacit knowledge as coming in two distinct types: somatic-limit tacit knowledge that is confined to the limitations of the human body and brain; and collective tacit knowledge that has to do with its location in the social collectivity. He maintains that the former type of tacit knowledge – somatic limit, is only tacit because the human brain cannot process the many steps needed to carry out an action and is the type of knowledge that could be encoded into machines. Collins uses the example of Polanyi's ( 1958) explanation of humans bike-riding, where there are many rules to keep the bicycle balanced and upright and at the same time pedalling to keep the forward momentum. These rules are tacit to the bike rider as they are not continuously regurgitated out aloud as the human actor actively cycles, and such rules are actually *not* made use of by humans whilst they ride bikes. For the latter type of tacit knowledge – collective, Collins again uses the example of the bicycle-riding, helpfully imaging collective tacit knowledge as that needed to understand the *social conventions* of traffic management whilst balancing the bike during bike riding (using the former somatic-limit tacit knowledge). Collins (2007: p.258) informs us that the two distinct types of tacit knowledge are 'rarely distinguished, because they are experienced and acquired by humans in the same way: through immersion in society and guided practice'.

Couched within a sociological explanation, Gill (2000: p.57) adds that 'tacit knowing begins within the embodied interaction of human beings with the surrounding physical and social environments'. Tsoukas ( 2003: p.410) follows with a social understanding of tacit knowledge, in that 'new knowledge comes about not when the tacit becomes explicit, but when our skilled performance is punctuated in new ways through social interaction'. Baumard ( 1999) proposes that tacit knowledge is best ascribed to what Greeks called phronesis – the wisdom acquired through social practice. Baumard (*ibid.* p.20) reminds us the ancient Greeks seldom dissociated technical expertise, science, or excellence from the knowledge acquired through socialisation. Most of the time Chu and Tsui ( 2008) have found that practice wisdom is tacit, embodied in actions and not easily articulated, where it is more likely to be transferred through word of mouth than through scholarly journals. In other studies tacit knowledge evokes a particular sensory feeling in individuals such as nurses' intuitions (Gourlay 2006;Herbig, Bussing, & Ewert 2001) or other peculiarities such as shipyard workers' feelings on engineering solution-sets (Gourlay 2006;Johannessen, Olaisen, & Olsen 2001).

According to Gourlay (2006), one of the most thorough investigations of tacit knowledge has been carried out by Collins ( 2001a) who has investigated a quality measurement exercise of sapphire crystals carried out by Russian scientists at Moscow State University. It was found that their experiments were not repeatable by Western scientists at other universities including Caltech, Standford, Perth and Glasgow, and were only so on close collaboration with face to face meetings both in Moscow where Glasgow University scientists visited, and back in Glasgow where the Moscowvites visited. Collins contends that the non-repeatabilities that occurred before the visits was as a direct result of tacit knowledge not being transferred, and was only brought about because of the important personal contact.

What was this tacit knowledge that led Collins to write a qualified diatribe around the one experiment, albeit carried out many times in many countries? He wanted to find out what was the *tacit* knowledge that allowed a complex experimental validation of the measurement of sapphire quality in one country to be acheived, namely Russia, which was missing in other countries, as is evident in dismissals by other nation scientists who were not able to repeat the Russian experiments given in the published accounts. In answering the question on tacit knowledge, Collins in this instance defines tacit knowledge as the 'knowledge or abilities that can be passed between scientists by *personal contact* but cannot be, or have not been, set out or passed on in formulae, diagrams, or verbal descriptions and instructions for action (Collins 2001a: p.72)'. For this *personal contact* can yield up to *four or five kinds of tacit* knowledge, where four kinds are explicated below: (1) Concealed Knowledge – 'tricks of the trade' which have not been revealed to others or in the shortened methodologies of leading journal artcles; (2) Mismatched pertinence – important experimental variables are not catered for as their import are not known by the scientist who has repeated the experiment only on reading a protocol, as opposed to the scientist who has carried the experiment out originally, who implicitly manages the variables on copious trial and error; (3) Ostensive knowledge – an explanation of explicit information captured in diagrams, photographs or indeed words, that can really only be shown by direct interface with an individual such as direct pointing or demonstration; and (4) Unrecognised Knowledge – a particular scientist carries out a protocol in a certain idiosyncratic way without realising the importance of such a methodological approach, only to be amplified by another scientist who themselves are in ignorance of such an approach, who may both realise later that the event they witnessed was indeed important. In real-time observation of the Russian experiments, the Glaswegian scientists found that trial and error in minutiae of experimental set-up such as degree of vacuum, and string length of suspended sapphire were tacit knowledge parameters that really mattered, in order to get the measurement of the Q (quality) of the sapphire to work. Even down to the level of suspension string mattered, where the Scots were using piano wire as opposed to silk thread being used by the Russians. Even at that level the string needed to be greased where it gripped the sapphire, the Russians dragged thread around the back of their ears giving a lighter emollient as opposed to the Scots who had used pork fat. Such detail of experimentation are detailed here by this researcher, only to show the many variables of human practice that make up tacit knowledge (cf. ibid. : p. 72, 77-81).

Collins ( 2007) implies because tacit knowledge is itself located in human collectivities, it can therefore never be the property of any one individual. Hence instruction manuals or books containing 'explicit' knowledge are *deceptive*, because Ribeiro and Collins ( 2007) in their bread-making experiments, mimicking but re-interpreting Nonaka and Takeuchi's ( 1995) seminal tacit knowledge studies, have discovered that their meaning are not carried within the protocols but are actually provided by us – humans. The potential of such documents lies in the tacit knowledge and social understanding brought to their use by both the original producers and their subsequent users (Ribeiro & Collins 2007: p.1430). In a clear example showing the 'fuzziness' of such documents, when Ribeiro (*ibid.*: p. 1429) was faced with reading a bread-making machine instruction manual, he had a problem with conceptualising the words describing different bread-dough consistencies, such as 'soft', 'wet', 'smooth' or 'elastic' dough, that are so important in getting correct to actually make the bread. Although the adjectives were written, they were not explicit. To have looked them up in the dictionary would have done no good. Collins (*ibid.*) wrote of Ribeiro that in order that he should understand such baking terms in practice, Ribeiro would need to start *socialising* with bakers. Such an example or indeed explicit pieces of knowledge captured in standard operating procedures 'can only be understood by others, or serve as a way of transferring knowledge, if the individuals concerned, already share some similar experiences or backgrounds (*ibid.*: p. 1429)'.

Hence it is the socialisation into, say a community of practice, which gives an individual the correct environment to understand such 'foreign' language. Referring back to the mechanisation of somatic-limit tacit knowledge, Collins makes clear that it is not possible from a collective social tacit knowledge viewpoint to write sets of instructions for machines (computers) that would replace the tacit social understandings of bread-making, McDonald's fast food front counter attendant, or indeed bike-riding (Collins & Kusch 1998;Collins 2007).

***Tacit knowledge in the organisation***

At the organisational level, tacit knowledge has been catalogued by leading researchers. There are those that believe that 'tacit knowledge not being available in an explicit form makes it difficult if not impossible to quickly spread or share it with in the organisation (Stenmark 2001)'. Sternberg & Horvath ( 1999) state that tacit knowledge is important to the development of professional practice, and can be a source of highly effective performance in the workplace. In their research on large scale projects, Koskinen, Pihlanto, & Vanharanta ( 2003) have found that individuals rather than turning to databases and procedure manuals to obtain information, seek knowledge in a tacit form from trusted and capable colleagues. However, Minstrell ( 1999) proposes that it is important that professionals work together, because from a tacit knowledge perspective, he states that those professionals that work in isolation may have only limited opportunities to acquire tacit knowledge, and as a result may become poorly adapted to their work environments. Others understand that tacit knowledge is a personal knowledge grounded in experience which because of its intricacies cannot be fully expressed (Horvath et al 1999). Baumard ( 1999) maintains that many organisational situations involve tacit knowledge. He describes how recent recruits without having read their company's internal regulations, come to respect them from their first weeks, knowing tacitly how to behave in a context of socialisation. 'The knowledge that actors have of each other, of each other's intentions, stakes, private goals, and territories...' is not explicit knowledge, but is rather tacit knowledge which is 'an essential and daily element of the management of organisations (Baumard 1999: p.22)'.

Tacit knowledge has been given various definitions within a broad spectrum of academic sources. In the sociology and psychology literature, Sternberg and his group of researchers, in taking a practical knowledge based approach in distinguishing individuals who are more successful from those who are less successful in their everyday lives, have found that much of the knowledge needed to succeed in real-world tasks is tacit (Sternberg et al. 2001;Sternberg 2000). Sternberg (2000) describes tacit knowledge as a part of practical intelligence – which in turn is defined as a subset of procedural knowledge that is acquired through personal experience. He states that these practical abilities are used to navigate everyday life which include interpersonal skills and the ability to solve practical problems. Sternberg (2001) in much of his research makes the psychological distinction between analytical/academic intelligence and practical intelligence. He suggests that conventional intelligence tests only tell a part, but not the whole story of a person's intelligence. He argues that practical intelligence is a better predictor of success than is the academic form of intelligence (Sternberg 2000). Brown and Duguid (2001) define 'practical knowledge' as distinct and separable from the more refined, cerebral knowledge. Investigations of tacit knowledge in the workplace and namely in the law, management, medicine and military professions have been carried out (Sternberg & Horvath 1999). In measuring tacit knowledge, Sternberg (2000) has found that individuals who exhibit the ability to use tacit knowledge are more effective. Based on theoretical and empirical findings, he has found that the difference between experts and novices is related to their inventory of tacit knowledge. Schmidt & Hunter ( 1993) state that measures of tacit knowledge have the potential to explain individual differences in performance that are not explained by traditional measures of job knowledge, which tend to assess more declarative explicit forms of knowledge.

i within expertise

In venturing from tacit knowledge within organisations to concentrating on the actor within such organisations one finds the notion of expertise has been adopted, where the actors are known as experts[2] in the field.

In the business world, practical intelligence can be viewed as a form of developing expertise (Sternberg 2000). Wenger, McDermott and Snyder ( 2002: p. 9) consider that tacit knowledge consists of embodied *expertise*. They define expertise as 'a deep understanding of complex interdependent systems that enables dynamic responses to context-specific problems'. Sternberg has formed the opinion that *expertise* requires practical skills (2000; p. 3), which he defines as 'the ongoing process of the acquisition and consolidation of a set of skills needed for a high level of mastery'. He asserts

[2] Experts: In this case study it is appropriate to cover the literature on expertise as the forensic scientists under study are known as experts in the court of law where they give evidence.

that tacit knowledge, part of the practical intelligence, is highly developed in experts. Polanyi ( 1958: p.49) in his long treatise on personal knowing, shows us his understanding on expertise by telling us in his example that 'science is operated by the skill of the scientist and it is through the exercise of his skill that he shapes his scientific knowledge'. The tacit dimension of such a skill is contained in Polanyi's statement of what a skilful performance is – one of an 'observance of a set of rules which are not known as such to the person following them'. Tacit knowledge may be seen as a thread woven through the development of expertise (Nestor-Baker & Hoy 2001). According to Stenmark ( 2001) expertise is a 'quality highly dependent on tacit knowledge, and can often only be observed and recognised through its resulting actions'. Indeed, Eraut ( 2000) suggests that the professional performance of an expert involves sequences of routinised action punctuated by rapid intuitive decisions based on tacit understanding of the situation. Indeed the competencies of the skilled and expert learner are characterised by 'involvement, rapidity, fluidity and intuition and that the rules governing performance of a particular activity can be forgotten because they are taken for granted (Gherardi, Nicolini, & Odella 1998: p. 276)'. Others base expertise on past experiences where 'the expert seems to remember holistic images from earlier experiences, matches and compares them and finds through the perception of diffuse signals that something in this situation is different from the memorized ones (Herbig, Bussing, & Ewert 2001: p. 690)'. The expert does not have to depend 'on time consuming sequential-analytical interpretation of information' and thereby 'is able to act in a critical situation (*Ibid*: p. 690)'. In her ethnographic study of molecular biologists, Knorr-Cetina ( 1999: p. 109) describes how the expert scientist brings his or her experiences to bear on the variations that are concocted for each new experiment, where the retries that are performed are never just any odd random alteration. Instead, they are based on what a scientist 'senses' to be a promising strategy in a problem case. Those experiences she describes are as a result of embodied tacit knowledge, a bodily archive of manual and instrumental knowledge that is not written down and only clumsily expressed, remaining inscribed in the body of the scientist, and tending to be lost when the scientist leaves the laboratory.

People at different levels of a hierarchy of expertise or of a hierarchy of an organisation have different tacit knowledge capacities (Cimino 1999), as is evidenced by newcomers who tend to rely too heavily on standard kinds of operating procedures, taking a cumbersome length of time to complete a relatively simple set of procedures that are carried out with ease by the more honed and experienced professional expert (pers. obsv.). Baumard ( 1999: p.8) suggests that 'the very nature of expertise lies in the reduced effort of searching required of an expert to solve a problem'. As an example he explains that 'a chess grand master considers far fewer alternatives when making a move than does an amateur player'. However, Wagner ( 1987) argues that whilst tacit knowledge increases with job experience, he believes that it is not a direct function of that period of experience, postulating that there are those with long years of service who do not evidence higher levels of tacit knowledge.

In literature documenting practice, Koskinen et al ( 2003) postulate that members of an engineering project team use a great deal of practical know-how, which they term as their tacit knowledge, a knowledge that is not written in documents but realised through their expertise. Epstein ( 1999) states that while explicit elements of practice are taught formally, tacit elements are usually learned during practice and observations whilst carrying out that practice. In anaesthetic practice, an explicit knowledge base is insufficient for the expert, and the clinical apprenticeship model of learning endures in order to pass on the other necessary form of knowledge, that of tacit knowledge (Pope et al. 2003). In the Architecture, Engineering and Construction industry 'firms rely on their experiences, professional intuition, and other forms of tacit knowledge to accomplish satisfactory work (Woo et al 2004: p. 204)'.

There are those that warn that sharing of tacit knowledge does not occur in all organisations because of a power play 'where expertise is highly regarded, but mentoring and assisting others is not'. 'Rational people may be unlikely to surrender the power they gain from being an important knowledge source – especially since sharing tacit know requires time devoted to personal contact (Leonard & Sensiper 1998: p. 123)'. In other instances they state that 'inequality in status among participants is a strong inhibitor to sharing' such as the relationship of nurses with doctors; 'distance', both 'physical and time'; and 'lack of personal intimacy' may all hinder tacit knowledge transfer (*Ibid*: p. 124).

## ***Sharing of tacit knowledge within a social environment***

Much has been written in the research on learning. In looking at experts one asks the question how such an expert becomes one. The whole social environment of multiple interactions with colleagues that allows the sharing of tacit knowledge needs investigation.

Blackler ( 1995), rather than talking about knowledge at an abstract level, finds it preferable to talk about the process of knowing. Eraut ( 2000) suggests that knowledge of the organisation is often acquired through a process of socialisation and increasing participation. The process of tacit knowledge acquisition is gained either through personal experience over time, or by serving in an apprenticeship fashion with someone who is senior and able to pass the knowledge on to the 'trainee' (Busch, Richards, & Dampney 2003). Social face to face encounters provide the context for tacit knowledge acquisition (Koskinen, Pihlanto, & Vanharanta 2003). Johannessen et al (2001: p. 16) argue that 'tacit knowledge can be made explicit by organizing teams based on apprenticeship where practical experience based on trust and a helping attitude predominates'. Lave & Wenger ( 1991) term this gaining of tacit knowledge during the apprentice formative years as *Legitimate Peripheral Participation*, a title coined from their study of five apprenticeships. They reject the transfer models of learning, such as the formal educational elements of traineeship (Parker 2006) that specifically exclude the complexities of practice and the community of practitioners setting, and propose that rather than learning through 'observation', that 'legitimate peripherality' 'crucially involves participation as a way of learning (Lave & Wenger 1991: p. 35)'. Crucially, they argue that learning 'is not merely situated in practice' but that it is 'an integral part of generative social practice (*Ibid*: p. 35)'. The authors suggest that the 'notion of participation thus dissolves dichotomies between cerebral and embodied activity (1991: p. 52)', which in my opinion, can be interpreted as the dissolving of the explicit-tacit knowledge dichotomy into the one continuum. Indeed, Polanyi ( 1958: p.53) speaks about how an apprentice behaves in acquiring knowledge from a knowledgeable master of authority – 'By watching the master and emulating his efforts in the presence of his example, the apprentice unconsciously picks up the rules of the art, including those which are not explicitly known to the master himself'. Brown and Duguid ( 2001: p. 200) add that 'learning any but the most simple job,' 'is a complex social process' and 'cannot simply be captured in the notion that all learning takes place inside individual human heads'. Gill (2000: p.126) also contributes by saying that 'since knowing is an active process grounded in integrative acts' that the 'deepest form of understanding will not be expressed in explicit definitions' but 'will rather be embodied in the posture and behaviour' of the person giving it.

The participation of apprentices within a community is at first legitimately peripheral but over a period of time increases gradually in engagement and complexity (Lave & Wenger 1991). Once 'newcomers have moved on from the role of peripheral participants to the status of fully legitimate members of the community, the learning they have acquired, together with its pattern and implicit complex logic, becomes part of their tacit knowledge (Gherardi, Nicolini, & Odella 1998: p. 291)'. Blackler ( 1995) treats Lave & Wenger's ( 1991) situated learning thesis as a contemporary version of activity theory, emphasizing the collective, situated and tentative nature of knowing. Lave & Wenger's ( 1991) legitimate peripheral participation theory is used to 'characterise the process by which newcomers become included in a Community of Practice (Wenger 1998: p. 100)'. Polanyi ( 1958: p.53) speaks of such communities as nurturers of knowledge –

'a society which wants to preserve a fund of personal knowledge must submit to tradition' where he defines tradition as 'an art' which is 'passed on only by example from master to apprentice'. Newcomers (apprentices) working in social contexts with more experienced old-timers become their students through a mentoring process. According to Leonard and Sensiper ( 1998: p. 123), mentoring and assisting should be highly regarded, otherwise 'rational people may be unlikely to surrender the power they gain from being an important knowledge source – especially since sharing tacit knowledge requires time devoted to personal contact'. The work by the newcomers is *legitimate* by being an authentic part of a community's work. However, being *peripheral*, affords access by the newcomers to the central work done by the old-timers while not being responsible for critical components themselves. *Peripheral participation* 'is about being located in the social world (Lave & Wenger 1991: p. 36)'. Gradually, through increasing levels of participation, the newcomer learns more about the ongoing practice of the organisation and moves from a position on the periphery to greater centrality. When a newcomer joins such a community, instead of learning abstract knowledge, s/he learns to become a member of the community by developing relationships with the more experienced members (Assimakopoulos 2007). With that transition the expert old-timers acknowledge the newcomers greater expertise with greater responsibility for the process/product of the community of practice.

From the sustained involvement, social interaction, and situated learning of newcomers, apprenticeships that *did* allow learning were those such as in the midwifery, tailor, navy quartermaster (Lave & Wenger 1991: p.

65), bread baking (Nonaka cited in Baumard 1999: p. 27), and construction managers (Gherardi, Nicolini, & Odella 1998). Lave & Wenger ( 1991: p. 76) described an instance where learning in an organisation *did not* work. In a supermarket butcher's apprenticeship the master butchers prevented learning by acting in effect as authoritarian figures, who viewed their apprentices as novices to be instructed rather than treating them as peripheral participants. Gherardi et al ( 1998: p. 290) found that 'the most conspicuous factor interfering with legitimate peripheral participation was the senior expert's jealous custodianship of their expertise', who were 'loath to give away the influence associated with their hard-won expertise too easily'.

i <u>yielding a community of practice concept</u>

Much work has been written about collections of practitioners – communities of practice. Lave and Wenger (1991) introduced the concept of communities of practice. Wenger (1998) significantly extended his early work with Lave by emphasizing the notion of identity and introduced an important cross-communal perspective to the discussion. Brown and Duguid (1991, 1998, 2001) brought the term to the organization studies field and the broader business community.

The 'idea of communities of practice is useful in that it helps to understand the process by which the transmission of tacit knowledge and of knowledge-in-action takes place (Gherardi, Nicolini, & Odella 1998: p. 277)', 'where the more tacit aspects of knowledge are created, nurtured and sustained' (Hildreth & Kimble 2002; p.8). Wenger, McDermott and Snyder ( 2002: p. 9) state that the sharing of tacit knowledge requires interaction and informal learning which are provided by storytelling, conversation, coaching and apprenticeship and found in a communities of practice setting. Indeed, Szulanski ( 1996) defines *practice* as the organisation's routine use of knowledge, often having a tacit component, embedded partly in individual skills and partly in collaborative social arrangements.

Tschannen-Moran & Nestor-Baker ( 2004) interpret Lave & Wenger's ( 1991)'learning as social practice' as giving rise to consideration of tacit knowledge acquisition and application, as a function of participation in communities of practice. They suggest that tacit knowledge generation shapes and is shaped by individual's roles within their communities of practice. Giroux and Taylor ( 2002: p. 500) suggest that 'tacit knowledge is located not in individual cognition, but in the situation', obviating 'the necessity of constantly making everything explicit to others in the team'. Eraut (2000) believes that within the context of a workplace community, where the people with whom one interacts is very important, that much knowledge of other people is tacit. He suggests that knowledge of another person is mainly gathered from a series of encounters (Eraut 2000). Spender ( 1996: p. 54) speaking of these social dimensions grandly states that 'our explicit knowledge is but the small communicable cap of the iceberg of preconscious collective human knowledge, the vast bulk of which is tacit, unseen, and embedded in our social identity and practice'. Communities of practice are a social instrument to create, share and steward knowledge, including tacit knowledge (Cox 2005).

*Community of practice*

By extension to social learning the various understandings on communities of practice are presented, where the scope of the literature covered is intended to capture the organisational thinking of this concept. According to Assimakopoulos (2007: pg. 28), 'above all the community of practice theory is a social learning theory stressing the importance of social participation for generating and sharing context-specific knowledge'.

Much has been written on the social learning theory upon which the communities of practice model is based, comprising four major elements: meaning, practice, community, and identity (Wenger 1998: p. 5), providing a framework for thinking about learning as a process of social participation. I will not be reviewing the exhaustive sources of literature on communities of practice as an instrument of learning, being beyond the scope of my thesis. Here, I will be examining how communities of practice contribute to knowledge creation through a social relational framework.

According to Wenger, McDermott and Snyder ( 2002) communities of practice are a practical way to frame the task of managing knowledge in organisations, which have been used in business and industry settings to better comprehend workplace dynamics. Wenger and Snyder ( 2000) espouse that the community of practice is the new organisational form that is emerging in companies that run on knowledge.

Communities of practice are groups of people who share a concern, set of problems, or passion about a topic, and deepen their knowledge and understanding of this common interest area by interacting on a consistent basis (Wenger, McDermott, & Snyder 2002). Such communities involve regular interactions with the development of a shared repertoire of beliefs, skills and resources (Lave & Wenger 1991;Wenger 1998). Assimakopoulos ( 2007:p. 29) shows that 'Wenger's research conceptualises an organisation not as a traditional set of formal functions, departments and the like, but rather as a constellation of communities of practice that allow members to learn and create knowledge through mutual engagement, joint enterprise and shared experiences'. Ayas and Zeniuk ( 2001: p. 71) believe that communities of practice have 'natural internal mechanisms where ideas and practices' are spread in work settings. Indeed, McDermott ( 1999: p. 35) believes communities of practice 'arise out of a natural desire to share ideas, get help, learn about new ideas, verify thinking and hear the latest professional gossip'.

Wenger et al ( 2002: p. 9) echo the debate on knowledge, believing that knowledge should not be reduced to an object, and state that knowledge is an 'integral part of the activities of expert practitioners who continually add to their knowledge repertoire by engaging other experts through communities of practice'. They espouse that communities of practice are in the best position to codify knowledge, because they can combine its tacit and explicit aspects. The community's strength derives from the desire to share knowledge and expertise, and is sustained by its members' passion and interests to achieve a shared outcome (Wenger & Snyder 2000). Brown and Duguid ( 2001: p. 203) join in the praise for communities of practice, stating that 'they are where a good deal of the work involved in knowledge creation and organisational learning gets done'. They recognise that 'while knowledge is often thought to be the property of individuals, a great deal of knowledge is both produced and held collectively', suggesting that 'such knowledge is readily generated when people work together in these tightly knit communities of practice (Brown & Duguid 1998: p. 91)'. Knowledge creation that occurs in the context of a community, occurs fluidly and evolves rather than being tightly bound or static (Powell, Koput, & Smith-Doerr 1996).

Practice is a tangled combination of tacit and explicit dimensions (Wenger, McDermott, & Snyder 2002: p. 236), and it is the 'activity involved in getting work done (Brown & Duguid 2000a: p. 97)'. Practice is the 'undertaking or engaging fully in a task, job, or profession (Brown & Duguid 2001: p. 203)'. In managing the tacit and explicit interplay, Brown and Duguid ( 2000b) see it as a balancing act between process and practice. They claim that the way things are formally organized in most companies – their processes – are not the same as the way things are actually done – their practices. Reliance on espoused practice (or canonical practice) can blind an organisation's core to the actual, and usually valuable practices of its members – including non-canonical practices, such as workarounds (Brown & Duguid 1991). They inform us that the difference between the two creates tension that can be very difficult for managers to handle. In their opinion, process and practice in every layer of an organization can be combined through communities of practice.

Brown and Duguid ( 1991) further developed the concept of communities of practice with the example of a community of technicians who repaired Xerox photocopier machines, based on Orr's (1996) detailed ethnographic study illustrating technicians' work practices. Problems arose when the directive documentation published by Xerox, providing a map to repair work that matched error codes in the photocopier to repair solutions, ran into a dead-end when undocumented erroneous processes took place. When following the service manual was not enough, Orr found that the technicians came together through social gatherings - over breakfast, at coffee breaks, at the end of the day - and talked about their best practices; rather than heretofore where the technicians were presumed to have worked alone (Brown & Duguid 2001). They had a culture of supporting each other. Because this group of people repaired many of the same types of machines, they were able to share information as well as their problems (Orr 1996), because of their use of tacit knowledge, or know-how (Brown & Duguid 2001). Orr's study as a whole suggested that even for apparently individual workers armed with extensive know-what, collective know-how was highly significant (Brown & Duguid 1998). Orr found that the use of war stories was a prominent feature of diagnosis among the technicians, was naturally apparent in their day to day discourse or in more purely social situations, and postulated that the ability to recant stories was a competency required amongst the group (Orr 1996: p. 125). It could be construed that once the newer technicians learned to tell stories, they were able to become full members of the community of practice. Brown and Duguid ( 1991) noted that the technicians continuously applied expertise and improvisation skills in their practices, in order to overcome the limitations in formal policies and procedures, diagnostic routines, rules and regulations and training provided by the organisation. The technicians were motivated by the much-welcome recognition for their creativity, resulting in local best practices being deployed companywide (Brown & Duguid 1991; 2000b). Indeed, Orr suggested that in addition to their diagnostic function, that the war stories 'preserved and circulated hard-won information and were used to make claims of membership or seniority within the community (Orr 1996: p. 126)'. It is evident that the technicians' work was not simply about maintaining machines, but also about maintaining social relations (Brown & Duguid 1991). These groups of interdependent participants collectively developed an outlook on work through shared identities and a social context (Brown & Duguid 2001: p. 202). As a result of Orr's work, Brown and Duguid ( 2000a: p. 111-112) inform us that rather than trying to support the technical representatives with yet more documented information, 'Xerox turned to reinforcing internal ties through the use of two-way radios' which allowed the technicians to talk to one another, even when working apart, and the adoption of a database controlled by the technicians which stored their tips and insights.

i <u>within the sciences</u>

As this case study is based around forensic scientists it is appropriate to study what research has been carried out on actors within the sciences.

Knorr-Cetina ( 1999: p. 106) in her studies on a community of experimental high energy particle physicists at CERN and of molecular biologists at a Max Planck Institute laboratory, described 'a communal stock of knowledge' that was evident in those scientific laboratories she had studied, where similarly to Orr (1996) with his photocopy technicians, she found that 'the scientists exchanged stories – scenarios of former experiences that participants had directly or had heard about'. They were told and retold, on appropriate occasions, travelling through the laboratory. She states that as long as they circulated, they kept the relevant experience alive within the community. From another case study, the process of gradually learning how to become a scientist can be explained in terms of the communities of practice concept (Hara et al. 2003: p. 957-8). Seen as relative novices in a community of scientists when taking their PhDs, the nascent scientists were able to articulate connections with other projects in their laboratory. As post-doctoral researchers, the scientists were found to have collaborated, having learned to become full standing members of the scientific community, by attending professional conferences, having had discussions with senior researchers, and having supervised graduate students.

Earlier studies of scientists were linked to an intense interest in their knowledge production – their purpose to 'open the black box of science so that outsiders may have a glimpse at it (Latour 1987: p.15)'. Polanyi ( 1969: p.138) in his assertions on scientists, informs us that 'scientific discovery cannot be achieved by explicit inference', and that 'discovery must be arrived at by the tacit powers of the mind'. Latour and Woolgar ( 1979) pursued scientists as actors looking at their laboratory decisions, their communication and above all, their interpretations. Although explicitly not mentioning a community theory because their research was being carried out a decade before Wenger's work, Bruno Latour's two years of field work in a neuro-biochemistry laboratory at the Salk Institute was one of the first studies of a scientific community of practice (*Ibid* 1979). Latour and Woolgar elicited how scientists from the perspective of the social world of the laboratory operated analytical instruments (inscription devices), prepared working papers and produced journal articles. Importantly, from the perspective of community of practice theory, Latour and Woolgar could say only a little about scientists as individuals, and found emerging from their field notes that each scientist member could only be looked upon as a part of the laboratory (community). Consequently, their observations on laboratory life consisted of the 'analysis of work sequences, networks, and techniques of argument' as opposed to the analysis of individuals. It is clear from their writings that Latour and Woolgar were observing a community of practice in play whose identity was the whole laboratory – 'On several occasions, informants reported that is was they who had had a certain idea; subsequently, however, other members of the laboratory reported the same idea to have resulted from "the group's thinking process" (Latour & Woolgar 1979: p. 188)'. Latour and Woolgar ( 1979: p. 111) came across 'two distinct communities of participants: insiders and outsiders', describing the *domain* of knowledge of this particular community of practice. The insiders were the laboratory community themselves isolating a neurotransmitter for whom it represented a life-time's work, and the outsiders were scientists from a variety of neighbouring disciplines who merely looked upon their results as just a description of an isolation technique.

ii a structural model

In order to show the current thinking, a summary of the understanding of the structural make up of communities is presented, showing that there is an opening to discuss the *process* parameters within such communities.

Despite the variety of forms that communities of practice take, and after a decade since the nature of communities of practice was first described, the belief is that they all share a basic structure of three fundamental elements

(Lave & Wenger 1991;Wenger 1990): a *domain* of knowledge, which Wenger and his co-authors understand as defining a set of issues; a *community* of people who they suggest care about this domain; and the shared *practice* which they inform us that the community are developing to be effective in their domain (Wenger, McDermott, & Snyder 2002: p. 27).

The *community* creates the social fabric of learning, and Wenger et al (2002: p. 28) suggest that a strong community fosters interactions and relationships based on mutual respect and trust. In interacting regularly, they state that members develop a shared understanding of their domain and an approach to their practice, building over time a sense of common history and identity sharing. According to the authors a community of practice needs a critical mass of people to sustain regular interaction. In stating a range of sizes, they say that communities with fewer than fifteen members are very intimate, and between fifteen and fifty participants, relationships become more fluid and differentiated, and those up to one hundred and fifty, communities tend to divide into subgroups around topics or geographic location, and beyond one hundred and fifty, the subgroups develop strong local identities (Wenger, McDermott, & Snyder 2002: p. 35).

Wenger et al (2002: p. 29) describe *practice* as a set of frameworks, ideas, tools, information, styles, language, stories, and documents that community members share. They state that practice is the specific knowledge that the community develops, shares and maintains. Indeed, when a community has been established for some time with its practice based on a strong foundation, they have found that members expect each other to have mastered the basic knowledge of the community. According to the authors, practice denotes a set of socially defined ways of doing things in a specific domain such as a set of common approaches and shared standards that create a basis for action, communication, problem solving, performance, and accountability. Brown and Duguid ( 2000a: p. 141) state that these practices in common allow practitioners to form social networks along which knowledge about that practice can both travel rapidly and be assimilated readily.

However, the sharing together within the community does in itself cause a *boundary* to form to either other local communities or to the outside world. Wenger ( 1998: p. 113) informs us that it is practice that is the source of its own boundary, where participants form close relationships and develop idiosyncratic ways of engaging with one another, thereby causing a barrier of entry to outsiders. For practice involves the interplay of both the tacit and explicit aspects of the community's knowledge (Wenger et al 2002: p. 39), where participants have a detailed and complex understanding of their enterprise (Wenger 1998: p. 113).

It must be noted however, that one must not become too complacent about communities of practice, where Wenger, McDermott and Snyder (2002: p. 139) warn that it is important not to romanticise about them or expect them to solve all problems without creating any – stating that they are not the silver bullet. On their downside, communities of practice can hoard knowledge and hold others hostage to their expertise. Other disorders include imperialism in the domain, cliques in the community, and dogmatism in the practice (*Ibid*: p. 150). In the main disorders can cause a community not to function well or indeed the opposite where they can function too well and the participants are beyond reproach (*Ibid*: p. 140).

iii in organisations

The literature largely describes the formation of communities of practice along with their benefits to the organisations. Here, these largely performative samples of communities of practice in organisations are presented in order to capture the positive view of what communities of practice do for knowledge creation.

Personnel at Qantas airline refused to use the newly installed knowledge management system, returning to repertoires of knowledge circulation they had always used – circulating knowledge through three communities of practice: flight staff, finance and marketing; which had formed over the course of the company's history (Baumard 1999: p. 134-135). Baumard (*Ibid*: p. 137) suggests that 'because the new explicit dimension of knowledge offered to the collective appeared foreign to it, the collectivity took refuge in the only reality that appeared familiar – that which lived on tacitly below the surface of the organisation'. Here Quantas is an example of a puzzled organisation in which communities of practice enabled it to resist the dissolution of internal socialisation.

At the World Bank, its president established the goal of making his organisation the 'knowledge bank', a global source for high quality information on economic development. The World Bank took the initiative to start communities of practice, providing specialised areas of development expertise whilst lending, which are now pervasive, counting at now over one hundred (Wenger & Snyder 2000).

In order to legitimise wider changes in work practices, the management of a large multinational with the major part of its healthcare business devoted to imaging products for medical diagnostics constructed a community of practice, which they built around a radical innovation (brachytherapy) for the treatment of prostate cancer (Swan, Scarbrough, & Robertson 2002). Importantly, this community of practice approach overcame inter-professional barriers to the sharing of knowledge, cutting across professionally and occupationally bounded work practices (Tsoukas 2002).

Communities of practice appear in nursing and medical settings. Interagency collaboration was facilitated where several agencies involved in different types of care were brought together to collaborate in both service design and delivery (Lathlean & le May 2002).

In a large Business Process Reengineering project, Xerox instead of using a matrix organisational structure, used a community of practice structure to launch a knowledge-sharing initiative that comprised fifty IT professionals responsible for managing numerous desktop workstations, many servers, and networking hardware on five continents. According to the authors, the community members provided high-quality, validated solutions; handled unstructured problems well; and dealt effectively with new developments in hardware and software (Storck & Hill 2000).

Within the internet environment, Hall and Graham ( 2004) studied how disparate individuals interacted electronically in a collective fashion, to from an e-group community. The e-group was set up on a Yahoo website around a code breaking competition with a resultant high worth prize. The e-group according to the authors tallied with that of Wenger's community of practice:

the e-community communicated through informal interactions; the members had a desire to share knowledge in code-breaking; its operation was determined by the membership without an agenda imposed from outside; and it was sustained by the passion, enthusiasm, and interests of the participants. Contrary to community of practice theory, the authors found in the context of this virtual community, where there were no face to face encounters, that strong social relationships were *not* necessarily crucial to its operation. They established that the 'soft rewards of enhanced reputation and personal satisfaction were important in encouraging individuals to engage in the group's dialogue (*Ibid*: p. 243)'. However, the authors somewhat contradict themselves, when it was found that the winners of the prize were actually a group of five individuals, that had worked together off-line as a team, from the beginning of the on-line community's existence. Yet, Assimakopoulos and Yan ( 2006) show in their study on technical information sharing amongst Chinese software engineers, how such astute experts seek advice, far beyond the organizational boundary by using Internet software technology forums.

iv case studies

Case studies have aimed to provide an explanation and an investigation into the workings of communities of practice, using ethnographic methodologies (Davenport & Hall 2002). Davenport and Hall in their review cite Latour and Woolgar's (1979) seminal study of the Salk laboratory (as discussed above, see *i* within the sciences) at the level of the firm analysing the interactions of internal communities. They notify us that research is now focusing on micro-level local studies in some fields – engineering, journalism, high energy physics – which they believe provide an opportunity for deep and informative empirical analysis of communities of practice in these sectors.

Davenport and Hall (2002) complain that discussions and case studies are written mostly from a performative perspective, on how good they are for organisations, or on how to form communities of practice (Wenger 1998;Wenger, McDermott, & Snyder 2002). I would tend to agree with the postulations of Davenport and Hall, where indeed their cited articles and others that I have come across (Hara 2002;Huang, Newell, & Galliers 2002;Lathlean & le May 2002;Lesser & Everest 2001;Lesser & Storck 2001;Wenger & Snyder 2000) would definitely confirm their discomfort. Davenport & Hall (2002: p. 183) claim that these perspective studies are uncritical, and that studies should be carried out that would identify what factors in communities of practice might work and in what ways. The case study in this doctoral thesis endeavours to explicate these factors through the study of tacit knowledge exchange between actors at FSL.

v networks of practice

The problem with much of the community of practice research is that it depicts them as largely independent and unconnected (Osterlund & Carlile 2005), where the focus is mainly on the processes of working and learning within the organisational boundary (Assimakopoulos 2007). There has been much literature over the past decade that has suggested that organisations who absorb knowledge from external sources see them as a more important source of creating and sustaining competitive advantage than managing the existing stock of knowledge from within the organisation's own boundaries. Much knowledge in high technology industries flows through inter-organisational collaborative linkages such as strategic alliances and joint ventures and also through informal personal networks (Assimakopoulos 2007). These larger numbers of participants organise into a 'network of practice', a term used by Brown and Duguid (2001: p. 206) to describe the category that comprises several communities of practice, which together form part of a larger network, not only across a company, but beyond it.

Collaborative networks of practice, where knowledge can flow, cut horizontally across vertically integrated local organisations (Brown & Duguid 2001;Brown & Duguid 2000a). The relations among network members are significantly looser than those within a localised community of practice (Brown & Duguid 2001), who commonly are geographically distributed (Wasko & Faraj 2005). From a network of practice perspective, individuals have practice and knowledge in common but are mostly unknown to each other, whereas from a community of practice perspective, individuals are tightly knit into groups who know each other well and work together directly (van Baalen, Bloemhof-Ruwaard, & van Heck 2006). Networks of practice show their strength in innovation when organizations that do not possess all required knowledge within their formal boundaries, must rely on linkages to outside organizations and individuals to acquire knowledge (Anand, Glick, & Manz 2002). As networks can by their nature be large, knowledge can become difficult to transfer within, especially where the discussion of ideas can be at the cutting edge and often require specialised expertise, which can be tacit (Bos et al. 2007).

Assimakopoulos (2007) describes how technological communities, which have a social locus of technological knowledge, are developed by a community of practitioners which create and follow a technological tradition of practice associated with the evolution of a particular technology. Indeed, this is the case of the Forensic Science Laboratory, which is a member of the European Network of Forensic Science Institutes (ENFSI, www.enfsi.eu). Brown and Duguid (2001: p. 206) inform us that 'professions make up still other such networks of practice, where similar practitioners, by virtue of their practice, are able to share professional knowledge through conferences, workshops, newsletters, list serves, web pages and the like'. Such professional groupings are well institutionalised, highly specialised and well defined social entities which embody knowledge, and innovation at the collective level (Assimakopoulos 2007). Indeed, studies of networks of practice in the engineering profession (Almeida & Kogut 1999), the automotive industry (Dyer & Nobeoka 2000), and in the biotechnology industry (Powell, Koput, & Smith-Doerr 1996), showed improved knowledge creation at the network level.

It is the technological tradition of *practice* that binds these communities of technological practitioners together (Assimakopoulos 2007), through sharing knowledge with socio-cultural dimensions. Assimakopoulos (2007: fig 2.2, p. 42) adopts a graphic model [see Figure 1] of the tradition of practice where the knowledge dimension includes scientific theory, methods, hardware and software; and the socio-cultural dimension includes social and communication structures as well as a system of values and beliefs (2007).

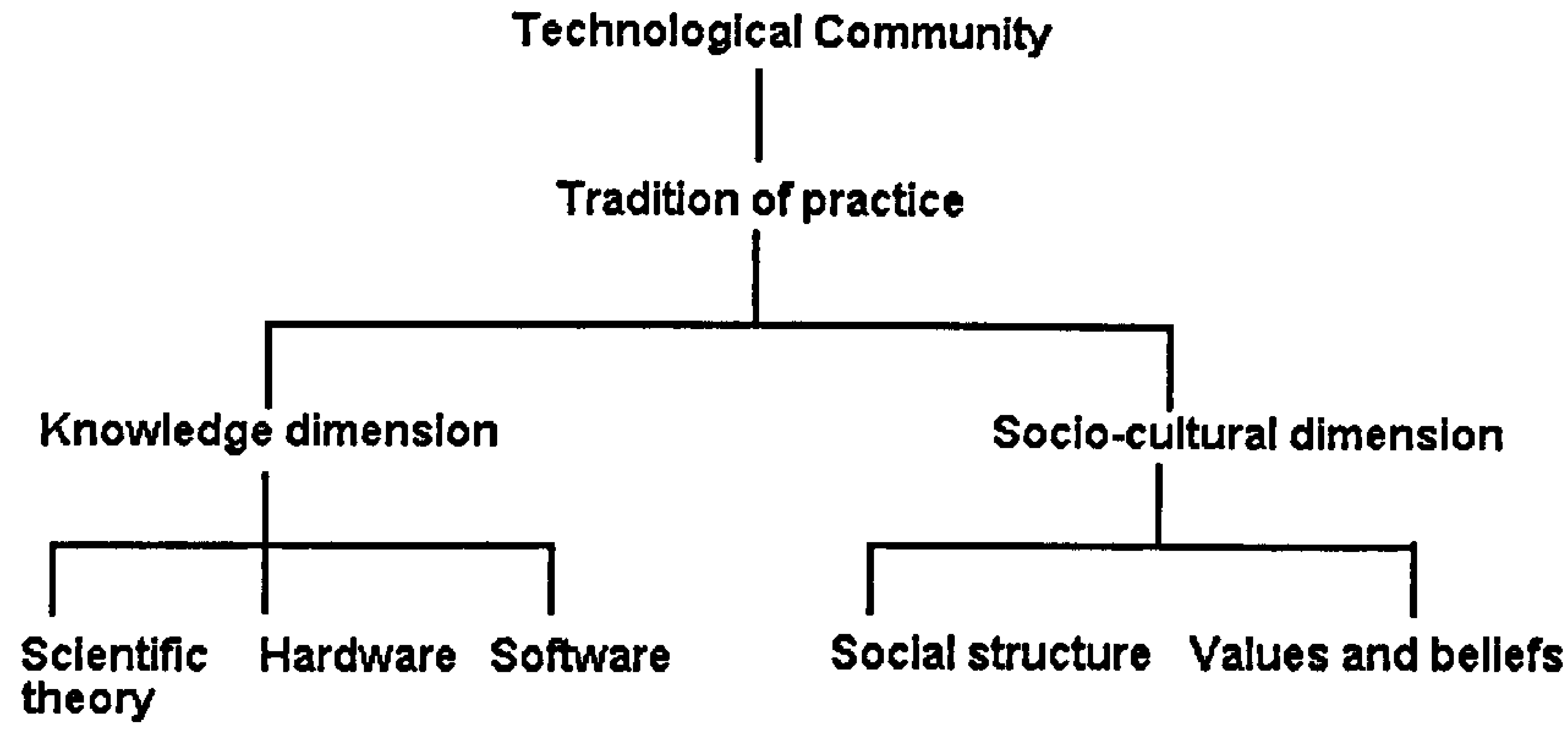



**Figure 1 Technological community and basic elements of its source concept of technological tradition of practice (source, Assimakopoulos 2007, fig 2.2).**

## *The process of sharing tacit knowledge*

At the level of the knowledge worker within the practicing community, one needs a clearer picture as to how such workers operate in their process environment with each other and within the organisational community. The literature is now only beginning to address this issue, getting down to the more micro-levels of doing business. Comparatively speaking, there has been too much published at the higher conceptual levels of how communities work but there has been little research done at the worker *process* level – the actual steps in allowing for such communities to function, yielding ultimately a new innovation, or indeed more practically a final product that adds to the bottom line of the business at hand.

Orlikowski (2002: p.253) states that while examinations of knowing have examined a variety of settings 'little is known about the process of knowing in complex organisations', and 'it suggests the importance of examining how people in their ongoing practices constitute knowing'.

Knowledge workers in local communities operate together within a network dimension sharing a common language and technical background. They 'seek advice from other peers of the same community and in so doing develop spontaneous (but not random) networking practices, which boost processes of knowledge exchange and generation (Giuliani & Bell 2005: p.50)'. This type of networking activity allows one to change their concept of knowledge from a passive part in the existence of such working communities, to an action view of knowledge – the process of knowing in practice. Indeed, sharing know-how should be seen as 'a process of enabling others to learn the practice (Orlikowski 2002: p.271)'. Such a knowing in practice 'perspective suggests that knowing is not a static embedded capability or stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors engage the world in practice (Orlikowski 2002: p.249)'.

One finds out why knowledge workers form such networks – they 'seek advice from other community members in search of complementarity, different solutions to their specific technical problems, or simply interconnect to exchange experiences and improve their technical knowledge accordingly (Giuliani & Bell 2005: p. 51)'. One can now see that the emphasis in knowledge management can be changed from a purely organisational perspective to the perspective that I am choosing to look at – the *process* of making knowledge level. This shift in emphasis is beginning in the literature – leading 'away from the focus on organizational knowledge occupying much of the contemporary discourse on knowledge management, and towards a focus on organizational knowing as emerging from the ongoing and situated actions of organizational members as they engage the world. It [knowing] is an explanation grounded in what it is people *do* every day to get their work done (Orlikowski 2002: p.249)'. So, as can be seen from the discussions above, the purely 'taxonomic perspective' of the tacit/explicit knowledge dichotomy only 'reifies knowledge by treating it as a stock or set of discrete elements', a view of which Orlikowski (*Ibid*: p. 249) and other researchers have been openly critical of. Tsoukas ( 1996: p.14) argues that tacit knowledge 'is the necessary component of all knowledge' and 'not made up of discrete beans which may be ground, lost or reconstituted', proposing 'instead for an integrated approach that affords a view of organizational knowledge as processual and dispersed (Tsoukas cited inOrlikowski 2002: p.250)'. Cook and Brown (1999) call this the 'traditional understanding of knowledge' which 'treats knowledge as something people possess' and that instead organisations should 'hold that knowledge is a tool of knowing' where 'knowing is an aspect of our interaction with the social and physical world'. Indeed Polanyi ( 1969: p.132) is definitive, stating that 'knowledge is an activity which would be better described as a process of knowing'. Hence new knowledge can be generated by the 'interplay of knowledge and knowing' within the 'situated social interaction of practice[3] (Cook & Brown 1999: p.381)'. In looking at the organisation with such concepts, one sees that the knowledge worker uses knowing along with a dynamic interaction with the environment in carrying out their practice. Cook and Brown (1999) who call for more case studies in knowing, maintain that the dynamic interaction affordance and knowing play

[3] Practice – refers to the coordinated activities of individuals and groups in doing their 'real work' as it is informed by a particular organisational or group context (Cook & Brown 1999).

an essential role in how we should now look at knowledge processes within the organisation. In their own research they give a good example where Boston based flutemakers make instruments of the highest quality, by using both the knowledge they possess and the ways they interact with the instruments and each other. Their understanding of the production of new knowledge does 'not lie in a continuous interaction between tacit and explicit knowledge but rather from their 'interaction with the world (Cook & Brown 1999: p.397)'. Carlile and Osterlund ( 2005: p.91) join the school of thought within the socially situated nature of knowing, stating that knowledge sharing is indeed 'a complex process that goes beyond the mere transfer of abstract bodies of knowledge'.

vi within a relational environment of social interaction

For the knowledge worker, the act of knowing must occur within the dynamic environment of social interaction, if knowledge is to be shared during practice. Indeed, Kogut and Zander ( 1992: p.384) suggest that 'organizations are social communities in which individual and social expertise' are 'transformed into economically useful products and services'. The assumptions that knowledge and learning are mainly individual and mental processes have been replaced in recent times by the concept that they are instead as a result of mainly social and cultural phenomena (Blackler 1995;Brown & Duguid 1991;Cook & Brown 1999;Gherardi & Nicolini 2000;Gherardi, Nicolini, & Odella 1998;Lave & Wenger 1991;Tsoukas 1996). These readings transform the thinking of organisational knowledge from that of a mental substance residing in actors' heads to a view that it is a 'form of distributed social expertise' a 'knowledge-in-practice' situated in a 'historical, socio-material, and cultural context (Gherardi & Nicolini 2000: p.330)'. Cook and Brown (1999) call the treatment of knowledge in which something people possess as the "epistemology of possession", and rather they maintain that knowledge should be looked at as something people do together – the "epistemology of practice". Moreover, the epistemology of possession tends to privilege explicit over tacit knowledge, and knowledge possessed by individuals over that possessed by groups. In taking the sociological view, 'knowledge always manifests itself as social action sustained by symbolics, technologies and relations', and hence it follows that 'knowledge is performed in, by and through social relations' (Gherardi & Nicolini 2000: p.331). Indeed, there is evidence suggesting that knowledge transfer is facilitated by intensive social interactions of organisational actors (Inkpen & Tsang 2005). A whole school of thought based on the concept of *social capital* has appeared, which was originally used to describe a set of *relational resources*, embedded in cross-cutting personal ties that are useful for the development of individuals in community social organisations (Tsai & Ghoshal 1998). These crosscutting personal relationships develop over time and provide the basis for trust, cooperation, and collective action in such communities (Jacobs 1965 cited inNahapiet & Ghoshal 1998). The central proposition of social capital theory is that 'networks of relationships constitute a valuable resource', providing actors of such networks with a 'collectivity-owned capital' (Nahapiet & Ghoshal 1998: p.243).

The literature has identified different aspects in the way we should look at social capital within actor networks. Some, mainly social network theorists, emphasize *structural* considerations and focus predominantly on the value of the network structure for the actor. Much attention has been focused on structural properties of networks, such as structural holes at the network level and tie strength at the actor to actor dyadic pair level ( Granovetter 1973;cf. Kostova & Roth 2003;Levin & Cross 2004). Broadly defined such work suggests that the network structure itself provides value where resources become accessible and available to the participant actors. In the structural concept, social capital is treated as the sum of the actual and potential resources that social actors can mobilise in their networks. However, rather that just the structure itself, the literature also describes the *relational* aspect of social capital, where the nature of the relationships in the social structure leads to certain benefits for the participant actors. The relational facet 'describes the kind of personal relationships people have developed with each other through a history of interactions (Nahapiet & Ghoshal 1998: p.244)'. Trust, respect, friendship, identity and social norms would be examples of such relational dyadic ties. Indeed for the trust relation, in a team project work context, Koskinen et al (2003) suggest that trust is often a significant facilitator of successful tacit knowledge acquisition and sharing amongst participants and that 'as trust increases, more participants become willing to share and so further contributions will be made (Davenport & Hall 2002)'.

Thus from the *relational* perspective, social capital reflects the potential benefits for social actors that are derived from the content of their social ties – that is the nature of their relationships with others. Such 'relationships are likely to lead to positive and cooperative behaviours, since they create a psychological environment conducive to collaboration and mutual support'. Allen (1970), an early adopter in relational thinking of the knowledge used by R&D workers, informs us that they tend to build very strong trust relationships with the peers with whom they collaborate and are more likely to turn to them, and not to an alternative explicit source, for assistance when it is required.

Social capital is defined as the 'potential value arising from certain psychological states, perceptions, and behavioural expectations that social actors form as a result of both their being part of social structures and the nature of their relationships in these structures (Kostova & Roth 2003: p.301)'. From a *relational* perspective – the *focal viewpoint* of this doctoral case study, 'high levels of social capital are reflected in a motivation for social actors to maintain those relationships, a felt obligation to reciprocate past favours of other social actors, and an expectation that other social actors will also reciprocate (*Ibid*: p.301)'.

With regard to interpersonal knowledge transfer, the importance of relational social capital is apparent where 'competence-based trust is especially important for tacit knowledge exchange (Levin & Cross 2004: p.1486)'. In the literature there is considerable evidence that trusting relationships lead to greater knowledge exchange (cf. Levin & Cross 2004), and that 'when trust exists, actors are more willing to give useful knowledge and are also more willing to listen to and absorb others' knowledge (*Ibid*: p.1478)'. This is an important concept to grasp because since tacit knowledge is difficult to articulate, transfer, and takes time to explain and learn, then the *trusting* environment is an important accommodation for tacit knowledge to be exchanged during practice. Tie strength – a concept ranging from weak ties at one extreme to strong ties at the other – characterises the closeness and interaction frequency of a relationship between two social actors. It is the strong tie that organisational managers need to be aware of as they are 'instrumental in providing knowledge of a tacit nature that a knowledge seeker will use (*Ibid*: p.1479)', where 'benevolence-' (compassion/kindness) 'and competence-based trust mediate the link between strong ties and receipt of useful knowledge (*Ibid*)'. For 'knowledge seekers who trust a source's competence to make suggestions and influence their thinking are more likely to listen to, absorb, and take action on that knowledge (*Ibid*: p.1480)'. Participant actors within communities are known to selectively seek out their advisors for requisite finite sets of knowledge. On two social actors developing a strong tie, each calibrates on the other's true skills and expertise and so learns to seek advice in those domains in which the other person is competent (Thomas-Hunt, Ogden, & Neale 2003). In summing up, 'acquiring tacit knowledge relies on the quality of a knowledge seeker's *relationship* with a knowledge source (Levin & Cross 2004: p.1481)'.

Indeed, in using relational thinking to think about practice, Osterlund and Carlile (2005) propose that it can be used as a tool to wade through the literature on knowledge sharing and to put at the core of any practice theory. In focusing on social practice, they emphasize the 'relational interdependencies between subject and object, person and world, individual and community, or community and network (*Ibid*: p.92)'. This relational thinking concept falls well into the already discussed theory of Lave and Wenger's (1991) situated knowledge in communities of practice, where knowing and learning are constructed by relations among actors engaged in an activity. Importantly, relational thinking allows one to recast the action of those actors working in such communities 'in such a way that structure and *process*, mental representation and skilful execution interpenetrate in everyday practices (Osterlund & Carlile 2005: p.92)'. These arguments support the contention that the formation of communities of practice themselves are not the solution to any knowledge sharing problem faced by an organisation, but that the relational thinking concept should be used – based on 'the fluidity of social relations and the structures within practice that they constitute (*Ibid.* p.105). The empirical analysis of knowledge sharing practices using the relational thinking concept is called for by the authors (*Ibid.* p.106). Levin and Cross (2004) call for the need to better understand the role of relational factors such as trust and emotion for effective knowledge transfer, in that they matter *most* when the exchange involves *tacit* knowledge. Indeed Collins and Hitt ( 2006: p.148), who have examined the 'link between relational capabilities (relational capital) and tacit knowledge transfer' call for 'firms to recognize the importance of inter-personal dynamics involved in the transfer of tacit knowledge' in which 'greater attention' is required to be given to the 'relational dimension of social capital'. For it is the '*social tacit* knowledge' that is 'embedded in the forms of social and institutional practice' residing in the 'tacit experiences and enactment of the collective'. Such knowledge 'may remain relatively hidden from individual actors' but becomes 'accessible and sustained' through each others' interaction (Nahapiet & Ghoshal 1998: p.247)'. This social tacit knowledge has been defined as routines or indeed processes, and it 'appears that much important organizational knowledge may exist in this form (*Ibid*)'. As a result there are those who maintain that organisations 'exist because they provide a social community of voluntaristic action structured' within (Kogut & Zander 1992: p.384).

*QMS – appropriateness in a relational tacit knowledge environment*

As the knowledge worker within this case study works within a regime of an explicitly controlled Quality Management System (QMS) it is fitting to review the current thinking around QMS and evaluate the present system with a view of seeing if any improvements are warranted in its operation or indeed examine its appropriateness in a relational tacit knowledge socially constructed environment which that nutures the knowledge worker.

The QMS defines the quality environment within an organisation, be it in service, manufacturing, or high technology. At a minimum quality is concerned with the delivery of a product or service to a high standard without faults or poor presentation. However, QMS is also about how you meet the customer's requirements: *defined* requirements-those which must be met by the delivered product or service often specified in a contract; and *implied* requirements-the customer's perception of the product or business gained through presentation or impression forming (Munro-Faure, Munro-Faure, & Bones 1993). Within the ensuring of the external customer requirements, one must be specific in the correct functioning of the organisation's internal processes – a number of processes may work together to meet the external requirements. The premise of a quality system is that output produced as a result of adding value to inputs during the documented process will have some form of innate variation. However, when the process is in control the output will vary in predetermined variation limits. In QMS the manager ensures processes are controlled so they produce outputs which vary between the acceptable limits as agreed in the customer requirements. In controlling the organisational macro-processes, the macro-processes have been broken down into discrete processes that can be controlled. Hence the whole process can be described as a series of micro-processes. A QMS operated organisation is successful when all the processes work in harmony to meet the requirement of the external customers. As quality is the focus of the system, the processes need to be carried out correctly the first time in order to maximise the rate of non-faulty product (cf. *ibid*, p. 15-30). Key parameters used to monitor the effectiveness of an organisation's QMS include internal audit reports, measures of business efficiencies (process yields, administration errors), and some measures of customer satisfaction (complaints, survey results) (*ibid*, p. 48).

In this case study, FSL as a laboratory is ISO17025 accredited (International Organisation for Standardization), where there is assurance that it has the ability to provide accurate test results. The ISO17025 accreditation contains judgement criteria dealing with the organisation, facilities, staff, equipment, and quality control, and as such goes hand in hand with the QMS (Garfield 1991). As a discipline-focused programme, the laboratory is accredited to conduct tests in broad areas or groups of products. ISO10725 is based on the widely adopted ISO9000 quality assurance system. Under the ISO standards, quality management includes quality control and quality assurance, and incorporates additional concepts of planning, improvement and policy changes with regards to quality. The ISO standards cover three aspects of quality: management of the quality system, methodology of the system, and maintenance of the system (Carr, Mak, & Needham 1997). Of those ENFSI laboratories/institutes accredited, most are to the ISO 17025 standard (ISO17025 2005), which specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling. The standard states the requirements for those practitioners responsible for the interpretation and opinions within the reports of the test results. In addition to the appropriate qualifications, training, experience and satisfactory knowledge of the testing carried out, a practitioner should have an understanding of the significance of deviations found with regard to the normal use of the protocols and materials concerned. The standard states that the training of the practitioners by the accredited workplace shall be relevant to the tasks of the laboratory. As can be seen this standard accounts for the micro-processes within the laboratory, but not for the more macro holistic practices inherent in the casework of forensic scientists. There are however, a minority of ENFSI laboratories/institutes who see this shortfall and have opted for the ISO 17020 standard (EN-ISO17020 2004) that accredits those bodies performing inspections, whose work normally requires the exercise of professional judgement in providing the service. This 17020 standard has the same qualification conditions required for the practitioners as mentioned in the 17025 standard, but in addition the standard stipulates that the practitioners shall have the ability to make professional judgements within the reports on those items examined. But there is no mention as how to measure or account for this ability that allows for the judgement to be made.

A criticism of the QMS/ISO programmes is that the whole management parameters are based around the variances of actual processes taking account that if the process is carried out correctly then the human operator behind the process is deemed to be performing. The ISO9000 and the other ISO standards require that the operators have sufficient skill, knowledge and experience to carry out the processes. The skills defined for an individual are presented as job specifications, and a general skill base of the workforce is assessed via competencies with a view to provide training where the need to attain such competencies is required. In demonstrating that the competencies are attained, resultant training records are updated and maintained. The form of training in attaining the competencies is not important – all that is required is that the training fulfils an identified need, where a record is kept of the training carried out (Munro-Faure, Munro-Faure, & Bones 1993). ISO standards in themselves only specify minimum standards which relate to quality systems and as such do not guarantee the quality of the product of service supplied (Carr, Mak, & Needham 1997). Slack et al ( 2001) argue that the emphasis on standards and procedures encourages management by manual and over-systematized decision-making and as such are too geared to the engineering industries. Indeed the investment of resources is considerable where the whole process of writing procedures, training staff and conducting internal audits is time-consuming.

Some have termed the movement toward improved quality requiring greater standardization and quantification in organisations as problematic for the professions where commitment to the organisation accompanies individual autonomy (Manley 2000). In such cases, increasing control through standardization to reduce variability challenges the contribution of professionals whose value resides in their ability to act autonomously on behalf of the organisation. Professionals can perceive QMS as another effort to limit autonomy and tighten management control (*ibid*, p.478). Yet, some authors think that focussing on process improvements should encourage front-line workers to share individual production problems and tacit knowledge of work processes (*ibid*, p.463). Supposedly, the goal of QMS initiated improvements is to take advantage of the knowledge that workers possess about the processes at hand and in turn facilitate learning and knowledge exchange throughout the organisation (*ibid*, p.464). Internal benefits of QMS include better documentation, greater quality awareness, and increased productivity and efficiency (Carr, Mak, & Needham 1997).

i <u>shortfall in SOPs relative to tacit knowledge workarounds</u>

The use of standard operating procedures (SOPs) play an integral role in QMS systems, improving the output consistency, efficiency, and learning rate of a given process. A SOP is a process document that describes in detail the way that an operator should perform a given operation – and includes the purpose of the operation, the equipment and materials required, how to perform the set-up and operations required for the process. The objective of SOPs is to ensure that all workers are performing tasks in the same way, which is a necessary condition to obtain consistent output from the process. Best practice SOP development calls for the active involvement of workers in development and refinement of SOPs. It is acknowledged that they can facilitate the accumulation and transfer of knowledge acquisition, leading to variability reduction and increased organisational effectiveness (De Treville, Antonakis, & Edelson 2005).

However, Carvalho, dos Santos, & Vidal ( 2005) who examined the cognitive processes of nuclear power plant operators during their decisions when dealing with microincidents, discovered that their rules appeared derived from experience and training, rather than from the use of Standard Operating Procedures. The authors had set out to determine whether the operators used a *naturalistic* (i.e. base decisions on pattern recognition, tacit knowledge, or condition-action rules) or *normative* (i.e. select the best possible action according to standard operating procedures) decision making strategy. That is, did they try to recognize a microincident as familiar and base decisions on pattern recognition, tacit knowledge, or condition-action rules (naturalistic), or did they need to concurrently compare and contrast options, before selecting the best possible according standard operating procedures (normative). Their main findings were that the operators' decision making was primarily based on *naturalistic* strategies where during microincidents decisions were made primarily based on pattern recognition and implicit condition–action rules, eighty percent of the time. They were found to select a course of action based on a recognition of the immediate situation as similar to a previous experience. Importantly, the authors' findings *contrasted* with the normative SOP selection behaviour prescribed by the nuclear plant organization's work design. Carvalho et al (2005) recognise the relevance of their findings for industry in that one should recognise the importance of how the sociotechnical environment affects the cognitive strategies of sharp end operators. What is evident from the results of this study is that the nuclear industry's SOPs and standards of competence used for the performance assessment of operators and training, *differs* from what is required for effective task performance, since they are based on normative decision theory and traditional (cognitivist) human factors findings prescribing the standards movement. The industry's approach is static and ignores important characteristics of work activities (e.g. dynamism, context dependency and so on). Indeed, the authors show that work is often accomplished through a dynamic tacit workaround of tasks or roles, involving interactions between individuals, in a cooperative, opportunistic and situated (naturalistic) way.

Nicholls and Cargill (2008) in their study on an aluminium smelting operation recognise the shortfall of SOPs, stating that they do not cover every eventuality. Instead they recommend that one should rely on the organisational collective tacit knowledge to make improvements in such procedures. Within the smelter business, because the management of microprocesses are difficult and that the procedures may not be fully explicated, the authors encourage the use of Communities of Practice to improve the clarification of steps in the difficult manufacturing process. In their case study, the authors state that a Community of Practice would potentially form the basis of providing the aluminium smelter with a 'framework' to manage the problems of a substantially tacit knowledge based manufacturing sub-process.

The relationship between the requirements that employees follow SOPs in completing a task and worker intrinsic task motivation have resulted in controversy. As reviewed by De Treville et al (2005) the literature in work motivation, job design and creativity suggest that SOP use reduces intrinsic task motivation and creativity because of the reduction in autonomy as already described above. In other literature such as that of organisation management and in the more psychological sphere of organisational behaviour, both positive and negative relationships to intrinsic motivation respectively are the suggested outcomes to SOP use. De Treville et al (2005) suggest that the differences of opinion of how SOPs affect intrinsic motivation are based on the conceptualisation of SOP use within organisations where the multidimensional nature of motivation and ambiguous definitions of autonomy are apparent. If intrinsic motivation is so affected by required SOP use either positively or negatively, then it is worth looking at the concept of intrinsic motivation itself. Spreitzer ( 1995) argues that intrinsic motivation is an antecedent to innovation and effectiveness, and substantiates four dimensions of intrinsic motivation: Competence-one is confident about their ability to carry the job; Meaning-the work is very important to oneself; Impact-one has a great deal of control over what happens in their workplace department; and Self determination-one can decide oneself in how they go about doing their work.

ii competencies lacking expert practitioner criteria

In focusing here on competencies as they are the cornerstone of SOP skill-set determinations, Eraut ( 2000: p.119) argues that important aspects of professional competence and expertise cannot be represented in a schematic form, embedded in a publicly accessible knowledge base. In his own study of the 'development of knowledge and skills in employment', Eraut (*ibid.*) is acutely aware of the difficulty of getting respondents not only to describe their job, when many aspects of it were likely to be taken for granted, but also to progress from that description, to discuss the nature of the competence and expertise which enabled them to do that job. He found that they were aware that they had learned implicitly to do many things which formed part of their job, but they could not easily describe their personal knowledge and know-how. Unlike some authors who use competency to define the minimum standard necessary to perform a job (Robbins, Bradley, & Spicer 2001), Eraut (*ibid.*) does not choose to restrict his definition of competence to that schematic propositional knowledge – a set of instructions. Rather he moves from a defined SOP view to the wider scope of knowledge thinking, and chooses to perceive competence and the knowledge required in the widest sense, as a theoretical and practical understanding born out, and developing through experience (Bradshaw 1998). According to Bradshaw (1998), Eraut believes that it is worth thinking about competence as based on how individuals approach their work rather than whether they should be judged as competent to do it – strengthening the case for intuition and tacit knowledge to be accounted for. Eraut does appreciate that assessment systems linked to qualifications are important quality assurance mechanisms to assure the public as well as employers that qualified persons are competent. However, it does not address the fact that a practitioner does not know what he or she does not know or indeed ought to know. As newly qualified novices enter their profession they need to consolidate their competencies under a mentoring system. On the other hand, Eraut warns that the novice practitioner cannot be sure whether the mentor him/herself is competent, and hence learning from experienced colleagues may not be adequate in ensuring competency. From the perspective of the expert practitioner, Eraut argues that professional competence is wide in scope and should allow for developmental aspects, linked to life-long learning. Yet this learning too does need to be defined. In the case of the nursing profession, in the UK, the nurse's competence and the acquisition of competencies are considered basic. Problematically, what is not covered is the achievement and degree of expertise needed in carrying out a required competency, leaving the practitioner wondering what level they should reach (Bradshaw 1998).

iii <u>shift from competency in process to that of whole interpretive practice</u>

One can conclude on surveying the literature, that it is the process itself of analytical tests that is accredited, but the way one goes about their work such as during case reasoning – the stage gates through which the practitioners go through in their own minds is not standardised. Hence, one could interpret that in considering advanced levels of expertise one should consider what makes the basic level of the whole-practice competency, that is taking the nurse example: what makes the basic level of nurs*ing* competency (Bradshaw 1998)? In judging competencies at the individual process level, where a series of processes (micro) leads to the full complement of actionable practice, there is a danger that the less experienced practitioner being confident and assertive based on him/her passing individual process competencies, over-optimistically underestimates his/her own fallibilities. The practitioner therefore needs to know the standard of *practice* competency and importantly needs to be accurately judged that he/she has reached that standard. Indeed, for the novice they need the necessary practical knowledge and skills, or for the more experienced they need to know that they have kept up the sufficient standards in case appraisals. Bradshaw (1998) suggests that the quality movements need to bring the standards addressing the micro-process level up an order of magnitude to a level addressing standards for practitioner knowledge practice. The emphasis on standardised analytical tests should be shifted to standardising/denoting competencies in interpretive judgement for practitioners. Hence competency tests of *whole practice* encompassing both theoretical and practical standards should be aimed for in those professions that seek standardisation, along with a continual update of each practitioner's skillsets as their years of service advance. Standards on critical appraisal and peer review (where used) should also be contemplated.

In a review on the quality of knowledge in professional social work practice-a knowledge intense environment for the practitioner, Pawson et al ( 2003) have come to the conclusion that tacit practitioner knowledge is effectively standards-free, whereas for organisational knowledge standards that do exist, they are not specifically related to knowledge. In their very comprehensive search for knowledge standards, they only found allusions or hints or ideas rather than substantive material on 'standards in knowledge source *x*'. Their literature searches did not uncover any explicit standards to appraise practitioner knowledge, which was not surprising for the authors since 'practitioner knowledge belongs to the personal dimension, and distilling everyday experience is not simple' as it is 'commonly tacit, passed on through word of mouth and observation (*ibid.* p.49)'. They suggest that it might be possible to derive some elemental quality standards, especially from the more formal cooperative encounters found during communication within education and training, requesting and receiving advice, attending team meetings and case conferences, and comparing notes.

iv practitioner knowledge not compatible with minimum standards

Sheppard et al ( 2000: p. 482) suggest that practitioner knowledge operates through a highly analytical and critical process. Through their process awareness studies of this knowledge domain, they comment that their understandings 'represent the beginnings of the means by which one can evaluate minimal standards of practice'. They suggest that alongside, but not in conflict with, the 'knowledge as product' paradigm that there is a 'knowledge as process' paradigm (Sheppard 1995), where the authors have analysed reflexive practice in order to identify and categorize the range of knowledge processes used collectively by all practitioners in their study. Importantly, they suggest that practitioners such as social workers (or indeed forensic scientists) go through a series of cognitive processes when during reflexive practice they make interpretations in a case, in progressive steps including: background information details, appraisal, hypothesis, alternatives to hypothesis, and conclusions thereof. These types of practitioners 'are not mere information gatherers', and 'not simply filling in details' for an understanding, but are 'highly analytical and critical' – reasonings permeating all aspects of their work (Sheppard et al 2000, p. 481). However, the authors found that different social work practitioners manifested different analytic abilities or capacity for reflexivity in their practice, and as a result raising very serious questions about minimum acceptable standards of practice, whenever standards for practitioners become implemented. At the same time, the capacity for reflexivity is crucial for practitioners, to an extent that if it is absent, the authors suggest that individual practitioners should not be considered competent to practice (*ibid.* p.482).

### ***In Summary a Conceptual View of Tacit Knowledge***

Throughout this thesis the reader will be informed of tacit knowledge transfer and flows between individuals. Because the theory behind tacit knowledge is complex, multifaceted and can have different interpretations attributed to it, this conceptual view is designed in the first instance to clarify this researcher's position on tacit knowledge and what it actually really means. This focusing exercise will try to bring together the many strands of published material on tacit knowledge as featured in the preceding literature review, thereby giving a finite understanding to the concept of tacit knowledge. The intension here is to give the reader of this thesis ammunition to tackle the empirical findings ahead all based around the all encompassing tacit knowledge phenomenon. Ahead, the term tacit knowledge is used as if it is a given that the reader understands all of its parameters.

#### i TK and the individual

Polanyi's ( 1966) writings very much deal with tacit knowledge at the personal-self level, where tacit knowledge functions as a background knowledge, assisting the accomplishing task being carried out by the human actor which is in focus. Whereas Polanyi deals with tacit knowledge at a personified level, fixed to the individual, a more insightful understanding of tacit knowledge is made by Collins (2007), who speaks of tacit knowledge and the social dynamic environment at the same time, both being needed in order to truly understand the meaning of tacit knowledge.

Individuals rather than turning to databases and procedure manuals to obtain information, seek knowledge in a tacit form from trusted and capable colleagues (Koskinen, Pihlanto, & Vanharanta 2003). While explicit elements of practice are taught formally, tacit elements are usually learned during practice and observations whilst carrying out that practice (Epstein 1999). Tacit knowledge is a personal knowledge grounded in experience which because of its intricacies cannot be fully expressed (Horvath, Forsythe, Bullis, Williams, McNally, & Sternberg 1999). Tacit knowledge consists of embodied expertise: 'a deep understanding of complex interdependent systems that enables dynamic responses to context-specific problems (Wenger, McDermott, & Snyder 2002: p. 9)', and may be seen as a thread woven through the development of expertise (Nestor-Baker & Hoy 2001). Professional performance of an expert involves sequences of routinised action punctuated by rapid intuitive decisions based on tacit understanding of the situation (Eraut 2000). Expertise is based on past experiences where 'the expert seems to remember holistic images from earlier experiences, matches and compares them and finds through the perception of diffuse signals that something in this situation is different from the memorized ones'. The expert does not have to depend 'on time consuming sequential-analytical interpretation of information', unlike the novice, and thereby 'is able to act in a critical situation (Herbig, Bussing, & Ewert 2001: p. 690)'.

ii <u>TK between individuals</u>

Tacit knowledge is embedded in holistic work processes, is implicitly gained and is an integral part in the accomplishment of working tasks (Herbig, Bussing, & Ewert 2001). The presence of others is generally regarded as essential for the acquisition of tacit knowledge, but not by everyone (Gourlay 2006). Collins ( 2007) implies because tacit knowledge is itself located in human collectivities, it can therefore never be the property of any one individual. Hence instruction manuals or books containing 'explicit' knowledge are *deceptive*, because their meaning are not carried within the protocols but are actually provided by us – humans. Recent academic discussions have highlighted the role that *communities of practice* play in enabling tacit knowledge creation and exchange between individuals (Eric & Kathryn 2001; Lathlean & le May 2002; Lesser & Storck 2001; Wenger & Snyder 2000).

Networks of practice tie in directly with community of practices, where a community from one particular organisation becomes linked through common practices to communities in other organisations. The relations among collaborative network members are significantly looser than those within a localised community of practice (Brown & Duguid 2001), who commonly are geographically distributed (Wasko & Faraj 2005). From a network of practice perspective, individuals have practice and knowledge in common but are mostly unknown to each other, whereas from a community of practice perspective, individuals are tightly knit into groups who know each other well and work together directly (van Baalen, Bloemhof-Ruwaard, & van Heck 2006).

iii TK in the organisation

Tacit knowledge is important to the development of professional practice, and can be a source of highly effective performance in the workplace (Sternberg & Horvath 1999). Lave and Wenger's (1991) account of situated learning in five sample communities of practice, shows that the learning process is tied to ongoing activities and shared practice amongst communities of people through *social* interaction rather than isolated *individuals* (Fox 2000), 'pointing to a social theory of knowledge in regard to cross-communal relations (Osterlund and Carlile 2005: p.100)'. In considering organisations as knowledge systems, one can highlight the irreducibly *social* character of individual skilled action (Tsoukas 2002). Learning in the sense of becoming a practitioner within these expert communities, requires knowing how, the art of *practice* – engaging fully in a task, job or profession (Brown & Duguid 2001) – much of which lies tacit in a community of practice (Duguid 2005). In sharing a practice, people will then share know how, or tacit knowledge (Brown & Duguid 2001: p.204). Szulanski (1996) defines practice as the organisation's routine use of knowledge, and often having a tacit component, embedded partly in individual skills and partly in collaborative social arrangements. Where attention is called to the importance of tacit knowledge held by individuals (Nonaka & Takeuchi 1995), the community of practice concept helps us understand how tacit knowledge is created and shared within these bounded groups of people all involved in a shared practice. Hence, we can consider tacit knowledge acquisition and application, as *a function* of participation in communities of practice (Tschannen-Moran & Nestor-Baker 2004), *present* in the situation (Giroux & Taylor 2002) within a complex social process (Brown & Duguid 2001), and in the flow of practice (Duguid 2005). People in sharing a practice, will share know how, or tacit knowledge (Brown & Duguid 2001).

In acknowledging the importance of the structural dimension of the organisational process this research will add to it by emphasising the *relational social tacit dimension* provided by human social capital interacting with the same process. One should not look at process as a raw organisational tool for output alone but one should also include the social relational dimensions *surrounding* and *encircling* the process. It is the relational social tacit dimensions of knowledge, additional to the process that will be the focus of this research [see figure 2]. Understanding the relational processes and the properties of the relationship necessary to transfer knowledge is important in acquiring tacit knowledge (Collins & Hitt 2006). Kogut and Zander ( 1992; 1996) emphasize that firms are social communities that specialize in the transfer of tacit and idiosyncratic knowledge.

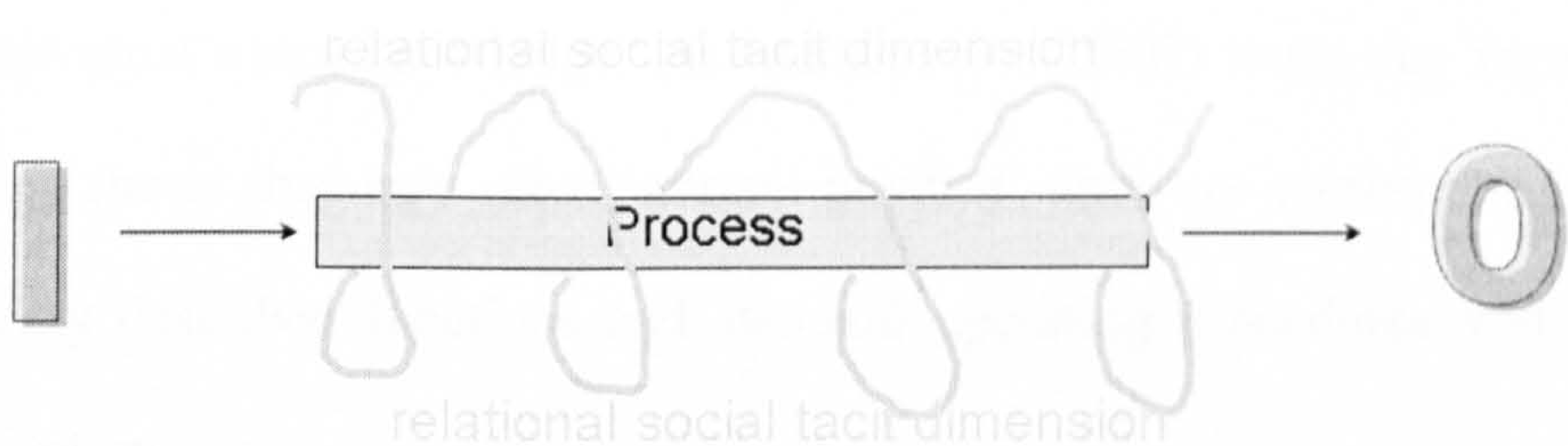



**Figure 2. The relational social tacit dimension of knowledge encircling the process of converting input to output (author).**

As opposed to a reductionist cognitivist view of organisations comprising discrete knowledge transactions, the organisation can be seen as a function of relationships between actors within a dynamic environment of social interaction. Trust, respect, friendship, identity and social norms are the kinds of personal relationships people have developed through a history of interactions, which have been discussed in the literature. Answering the call of researchers, for the empirical analysis of knowledge sharing practices using the relational thinking concept, this case study intends to discover more.

iv Requirement to examine TK in a quality managed organisation.

There is a lack of consideration of the interaction between the documented Quality Management System procedures and the human operator's needs which in some instances definitely require tacit dimensions. These considerations on all accounts have not been carried out before within the quality management movement. It is the procedural processes governed by the SOPs that are accredited, but not the way the practitioners in their own minds go about their work that is standardised. Tacit practitioner knowledge is effectively standards-free, whereas for organisational knowledge where standards do exist, they are not specifically related to knowledge. Polanyi (1966) was clear that there is no objective explicit knowledge independent of the individual's tacit knowledge. Assimakopoulos (2007) states that Wenger's analysis shows that very often 'normal practice' does not correspond to the explicitly described functions and standard operating procedures within an organisation.

This case study research intends to explore the concept that the higher tacit level processes employed by an experienced forensic scientist, such as case interpretation and judgement of the work required for the circumstances of the case, are not part of standard operating procedures (SOPs). It is intended that these research findings will enhance the understanding of the interaction of practitioners within a Quality Management System SOP environment.

# 3 METHODOLOGICAL FRAMEWORK

## *Epistemology of the methodology*

The methodology is the theory behind a certain research method and philosophical framework. The notion of method is couched in methodological considerations and has implications for a particular epistemological perspective. In framing the foundational epistemology of this research study affecting my research approach, I kept in mind that the purpose of this study was to understand the processes and conditions that lead to the exchange of tacit knowledge within/between communities of practice. In learning more about communities sharing knowledge a direct picture was taken followed by an indepth analysis of the actors/members of the communities. The picture, based on a positivist positional quantitative methodology, was taken to give a measured perspective on the actors within the communities. However this fixed reality does not allow one to address the dynamic, continuously evolving processes in which actors share tacit knowledge. In order to address this dynamism, I also used an interpretive qualitative approach where my intent was to understand the process of a phenomenon (Lincoln & Guba 1985), knowing that the qualitative method is a powerful tool for learning more about our lives in which we live (Merriam 2002), which locates the observer within an interpretive and naturalistic world of inquiry (Denzin & Lincoln 2000). Indeed the qualitative interpretive movement is built on a profound concern with understanding what other human beings are doing or saying (Schwandt 2000).

*Methodology*

On the general research questions having been addressed [see Research Questions in Chapter 1 Introduction] it is obviously necessary to decide on the kind of evidence to be collected and how it should be analysed. In this case the evidence comes from a multi-method approach, using both qualitative and quantitative methods. More and moreso in the business and management research community both evidence types are not mutually exclusive, and rather the qualitative and quantitative research techniques are sometimes viewed as the ends of a evidential continuum (Gable 1994 cited in Remenyi et al 1998). Importantly, the methodology should not, regardless of all other considerations, take away from the final analysis, that of the researcher's creativity and imagination that are of paramount importance. 'The research strategy and tactics are here to support rather the hinder the researcher's creative faculties (Remenyi et al. 1998: p. 43)'.

The research here can be classified under the empirical as opposed to the theoretical taxonomy, where the findings will be based on, or guided by the results of observation. As is in this research case, the empiricist goes out into the field and observes relatively passively what is happening, and by studying these observations and collecting related evidence, the empiricist will draw conclusions and make the claim that something of value has been added to the body of knowledge (Remenyi et al 1998: p. 31). Empirical research is often associated with a positivist view, but it can also be phenomenological in nature. Underlying positivism is the assumption that the researcher is independent and can make quantifiable observations. However such an approach especially in the social sciences such as management studies may not lead to interesting or profound insights into complex problems (*ibid*: p. 33). Phenomenology advocates the study of direct experience taken at face value, not in objective reality but instead through subjective consciousness whilst observing. The researcher constructs a meaning in terms of the situation being studied. Instead of making the choice between positivism and phenomenology, this research uses both approaches. A key tenet of positivism is that it takes a reductionist approach to exploring relationships between (*ibid*: p.35), in this case, actors. Suitably for this research, it leads to a simplification of the real world environment. This simple picture of, in this case, advice relationships, is a good footing for the phenomenological holistic approach to expand on the intricacies of such a relationship and other relationships once they have been simply envisaged.

The purpose of this case study is to understand the processes and conditions that lead to the sharing of relational tacit knowledge within/between communities of practice. In learning more about the way communities share tacit knowledge, a direct quantitative graphical picture was taken, followed by an indepth qualitative analysis of how the actors within the communities actually shared tacit knowledge. The quantitative picture, using social network analysis (Borgatti & Foster 2003) – a positivist graphical methodology, was used to give a measured perspective on the actors sharing tacit knowledge during advice seeking transactions within the communities. However this fixed reality does not allow one to address the dynamic, continuously evolving processes in which actors share relational tacit knowledge. In order to address this dynamism, an interpretive qualitative approach was used where the intent is to understand the relational dimensions of tacit knowledge being shared (Lincoln & Guba 1985).

The empirical findings were based on a case study of the FSL community where quantitative social network analysis and qualitative interviewing, ethnographic studies, and document review was carried out:

i Case Study

The use of a case study here is an appropriate approach to apply when a holistic, in-depth investigation of a bounded system is needed (Stake 1995), where ' "how" and "why" questions' can be asked (Yin 2003, p.22). As a means to frame the interpretive project, the case study can be considered to be an 'intensive description and analysis of a single unit or bounded system' (Merriam 1998, p.19), and 'is a particularly suitable design if one is interested in process (*ibid*: p. 33)'. The case study method 'allows investigators to retain the holistic and meaningful characteristics of real-life events – such as organizational and managerial processes' (Yin 2003, p.2). Indeed the rational for a single case study is 'in testing a well-formulated theory' where one can 'confirm, challenge, or extend the theory' (Yin 2003, p.40). On stressing the case as a 'bounded system', Stake informs us that the bounded entity lends itself to examination and understanding (Stake 2000, p.426).

The case study is a 'research tactic for the social scientist as experiments are a research strategy for the natural scientist' (Remenyi, Williams, Money, & Swartz 1998, p.50), where the case study 'requires the collection of empirical evidence' (*ibid*: p.169). Case study research often takes a constructivist approach where the intent is to provide insights into the human condition, in which 'case study researchers assist readers in the construction of knowledge' (Stake 2000, p.442). A case study is an analysis of a particular phenomenon such as an event, a program, person, process, institution, or social group (Merriam 1998), where the researcher 'seeks to uncover the interplay of significant factors that is characteristic of the phenomenon' founded on 'holistic description and interpretation' (Merriam & Simpson 1995, p.108). Importantly with regard to this research, case studies are useful for providing valid representation of social processes and for understanding social action by giving voice to participants (Manley 2000). The philosophy behind the case study is that 'only by looking carefully at a practical, real-life instance can a full picture be obtained of the actual interaction of variable or events' (Remenyi, Williams, Money, & Swartz 1998, p. 50). This research is what Stake refers to as an 'instrumental case study' in that 'a particular case is examined mainly to provide insight into an issue' or to refine theory (Stake 2000, p.437).

There are limitations of using the case study research approach, in that the representative data set may be limited and that the conclusions drawn from the data may be oversimplified. Indeed, its boundedness allows for focused analysis but limits comparison (Merriam 1998). Case studies are said to lack rigour and objectivity (McCutcheon & Meredith 1993) where they can be open to subjectivity and bias (Remenyi, Williams, Money, & Swartz 1998).

ii Social Network Analysis

The main goal of social network analysis is to detect and interpret patterns of social ties among actors (Borgatti, Everett, & Freeman 2002). Indeed the formation of a *network paradigm* as a result of the twenty five years of social network research in the organisational literature has been described and comprehensively reviewed by Borgatti and Foster ( 2003). They mention that the *network* study of communities of practice 'lacks rigorous empirical research (*ibid*: p.997)'.

Crucially, the unit of analysis is not the individual, but a collection of individuals and the set of advice seeking relationships among them. Fundamentally, the difference between a social network explanation and a non-network explanation is actual information on relationships among actors in a study (de Nooy et al 2005). Network research embraces a distinctive perspective that focuses on relations among actors, whether they are individuals, work units, or organisations. Here actors are *not* treated as isolates converse to the examinations carried out by the more traditional organisational studies (Brass et al. 2004).

Organisational network research has allowed a shift from statics to *dynamics*, where better evidence is offered by longitudinal and network change research (Brass, Galaskiewicz, Greve, & Wenpin 2004). For example, organisational structure provides some actors with access to different information than others have access to, thereby making some ties more valuable than others. Indeed the *centrality* of an actor in a network can positively correlate to that actor seeking others' expertise and thereby having a higher likelihood of obtaining relevant information to successfully solve a problem (Cross & Cummings 2004)

iii Interviewing

According to Seidman ( 1998) interviews yield to other people's stories which are a way of knowing, where the word *story* is the Greek word □*uspect* – meaning one who is "wise" and "learned". Interviewing is 'a basic mode of inquiry' where the interviewee selects 'details of their experience from their stream of consciousness' (Seidman 1998, p. 1).

According to Yin ( 2003: p. 89), one of the most important sources of case study is the interview(s), which should 'appear to be guided conversations rather than structured queries', where the 'actual stream of questions' are 'fluid rather than rigid. As a 'method of inquiry, interviewing is most consistent with people's ability to make meaning through language' (Seidman 1998, p.7).

iv Ethnography – Participant Observation

Ethnography, also known as 'field research' or 'participant-observation' is a form of research focusing on the sociology of meaning through close field observation of sociocultural phenomena (Lois 2003). In the past, the human sciences modelled themselves on the physical sciences, emphasizing the structures or reality outside the area of meaning, whereas ethnographers now pay careful attention to human beings who exist within the realm of meaning (Tedlock 2000). Ethnographic research is interpretivist, a tack taken in this research, and involves 'observing and participating in people's lives in a natural setting, as well as talking to them in depth about their experiences' (Lois 2003, p. 25), and is 'essentially phenomenological in nature' (Remenyi, Williams, Money, & Swartz 1998, p.51). Qualitative field study differs from other research methods in that it features researchers themselves as observers and participants in the lives of the people being studied in which the researcher strives to be a participant in and a witness to the lives of others (Lofland et al. 2006). The 'primary way a researcher can investigate an' 'organization or process is through the experience of the individual people' (Seidman 1998, p. 4). Typically, the ethnographer focuses on a community, selecting informants who are known to have an overview of the activities of the community. Ethnography is a traditional method of sociology and cultural anthropology. It involves the study of people performing activities and interacting in complex social settings in order to obtain a qualitative understanding of these interactions. Ethnographic methods have been used to study business settings (Orr 1996), and are a suitable method to study symbols, myths, and stories in organisations to capture the richness of the interaction among actors (Bate 1997), where the focus is on culture in informal or 'non-canonical' settings of the organisation (Brown & Duguid 1991). Among the qualitative methodologies currently in use, the ethnographic method has a long and distinguished history. Extended participant observation means that at least a year is devoted to the task such as the study of institutional settings within a culture (Sanday 1979).

As this research is based on a case study research it is prudent to know that it is often viewed to be a form of ethnographic research entailing the detailed research of one individual or group (Mertens 1998) where 'naturalistic, ethnographic case materials, to some extent, parallel actual experience', such that 'we come to know what has happened partly in terms of what others reveal as their experience' (Stake 2000, p.442).

'Participant observation refers to the process in which an investigator establishes and sustains a many-sided and situationally appropriate relationship with a human association in its natural setting for the purpose of developing a social scientific understanding of the association' (Lofland, Snow, Anderson, & Lofland 2006, p. 17). The participant observer becomes part of the group he or she is investigating by spending a great deal of time with members by participating in the activities the members engage in, whilst simultaneously observing. It has generally been assumed that naturalistic observation does not interfere with the people or activities under observation. The degree to which a qualitative researcher becomes involved in the activities under study can range in a continuum from that of observation only to complete active participation. Being over involved as a participant would mean that they had 'gone native' with their work consequently rendered suspect as a reliable data set (Angrosino & Mays de Perez 2000). Those researchers who have received permission to observe and record the events occurring within an organisation, as is in this case, can be best classified as 'privileged' observers as opposed to participant observers (Wolcott 1990). Nowadays, ethnographers accept participation as a legitimate base from which to conduct observation, where 'membership roles' have been designated (Adler & Adler 1987), such that the 'complete-member researcher' category, used in this research, describes those who study settings in which they are already members. This membership category has 'the advantage of the researcher already knowing the 'cast of characters' whereas the outside researcher must discover whom to ask' (Lofland, Snow, Anderson, & Lofland 2006, p. 41).

## *Collection of Empirical Data*

### i Case Study Data Set

In this case study on a forensic science community, the Forensic Science Laboratory (FSL) Ireland, the author examines empirically such tacit knowledge relations both at a local and at an inter-organisational collaborative level. The micro-level study provides an informative insight into the process of how tacit knowledge *flows* within and between collaborative networks, and how it is an integral factor in the workings of such networks.

As mentioned in the introduction, FSL is the Republic of Ireland's forensic examination and analysis service for all criminal casework encompassing drugs, arson, DNA, mobile phones, toolmarks, paint and glass, explosives, firearm residue, fibre transfer and other trace type cases. At the time this research was undertaken FSL employed over 43 forensic scientists at the one headquarters made up of four local collaborative communities of practice comprising forensic scientist specialists in the expert areas of: Biology, DNA, Chemistry and Drugs [see Results, Communities of Practice within FSL – a network map representation].

Outside of their own local communities, the forensic scientists gain access to new knowledge through their participation in professional associations and their respective conferences. The scientists at FSL are largely influenced by forensic scientists who practice in fifty three other forensic laboratories, distributed over thirty-one European countries under the European *Network* of Forensic Science Institutes (ENFSI). ENFSI was established in 1995 with the purpose of sharing knowledge, exchanging experiences and coming to mutual agreements in the field of forensic science. Within ENFSI there are sixteen Expert Working Groups including DNA, digital evidence, fingerprints, scene of crime, drugs, fibres, paint & glass, and fires which comprise the backbone of this pan-European forensic science collaborative network in terms of the scientific knowledge and interests. The digital evidence ENFSI working group is explored through participant observation, where the networking of an FSL member with the collaborative group has allowed a nascent digital mobile phone evidence service to be set up back at FSL. Another collaborative group is also viewed – IABPA.

### ii Quantitative network analysis of advice relations

By tracing the advice-seeking linkages within FSL and outside, this research aims to get an understanding of how these forensic scientists acquire and share intricate tacit process knowledge important in the very way that they carry out their casework. Tacit knowledge has a relational nature, embedded in social networks (Assimakopoulos & Yan 2006;Cross & Parker 2004), which are defined as a set of actors connected by a set of ties (Borgatti & Foster 2003), where a set of ties of a given type (such as *advice*) constitutes a binary dyadic social relation. In looking at how collaborations function, for the purposes of this thesis, informal internal networks are visualised (Doak & Assimakopoulos 2007a;Doak & Assimakopoulos 2007b) and external (Doak & Assimakopoulos 2006) networks of practicing forensic scientists. Social network analysis was used to uncover the structured connections shaping knowledge flows between key forensic scientist players within and between their communities of practice, and to outside forensic scientists in two network of practices.

- *within local organisation*

In endeavouring to show that social networks underpin the diffusion of tacit knowledge, the interrelatedness of forensic scientists at FSL was mapped and analysed, by visualising their social networks using Pajek (Batagelj & Mrvar 2005) and Ucinet (Borgatti, Everett, & Freeman 2002) software programs. Both programs represent network data in the form of a sociomatrix, ie, a set of actors (vertices) linked with one (or more) relation(s) / arcs. Such a one-mode sociomatrix was used to record the advice relations given by the full complement of FSL forensic science practitioners, 43 forensic scientists to each other over a three-day period at FSL in early 2005 [*see* Appendix: Sociomatrices]. The "advice seeking" relation was used to try to best capture the tacit element of knowledge being exchanged. The respondents were told not to record those instances where only functional communication or the mere exchange of information had occurred. For example, the tacit element of knowledge is deemed to be transferred in the case of an experienced scientist in the field of 'Blood Pattern Analysis', who provides a suggestion to a colleague on how to interpret a complex blood pattern distribution found at a crime scene. The tacit knowledge, as a result of the scientist's experience built up from practice, is transferred as advice given in response to a query on a specific scientific problem. Seventy percent of the full roster of scientists in FSL replied. In order to try to capture all the scientists, an additional sociomatrix of "advices received" was transposed. As a result all scientists were recorded as having given some form of "advice to". In order not to complicate the graph, this complete sociomatrix of the FSL was 'binarized' to reflect who simply gave advice to whom.

Network maps were produced using Ucinet as the software for social network analysis, and Pajek as the visualisation tool. The Pajek definitions are used in describing a *graph* (network) as a set of vertices (actors) and arcs (linkages, relations). The graph represents the structure of the CoP(s) network, where sets of scientists *(vertices)* are joined up by directional 'advice' relations *(arcs)* which point from a scientist giving advice *(sender)* to a scientist receiving advice *(receiver). Line values* in those extracted graphs are used to indicate the strength of a relation, that is the scientist gives advice a multiple of times (de Nooy, Mrvar, & Batagelj 2005: p.6-7). The graphs were *partitioned* according to how the laboratory is set up – scientists were designated their CoP member sections. This was to examine how close the section designation was when compared to his/her CoP membership. The vertices of the graph were assigned *vector* values which represented the length of service of each scientist within FSL. This was to try to relate the experience of a scientist to their centrality / peripherality, and prestige within their CoP.

Further analysis was carried out in order to categorise the groupings of scientists giving advice to their colleagues. In order to quantify CoPs, hierarchical clustering was performed by calculating the frequency of ties within the relational advice network within FSL.

In order to see if a CoP was closely knit, thereby getting a synopsis on the likelihood of scientist interactions, the cohesiveness of a subgroup was calculated using the *density* measure – the percentage of all possible lines (ties) that are present in a network (Wasserman & Faust 1994, 181). To discover those scientists who had relatively large tacit knowledge repositories, *prestige* was used as a proxy measure, by calculating the asymmetry of their advice giving over receiving. The prestige of scientists was compared to their centrality, as measured by their additive in and out degrees, to see if they were additionally crucial cogs in the relational information networks. Those scientists with high prestige measures were compared to their length of service, to identify any correlations. Betweeness, a measure of network centrality was used in establishing central knowledge actors, on a revised data set taken during the November 2005 advice survey.

- *outside of organisation*

In order to examine how tacit knowledge built from international best practice is subsumed into the localised CoPs, two Net work of Practices – ENFSI Digital Evidence and IABPA – were explored beyond the laboratory's organisational boundary, where the knowledge flows from the peripheral into the organisation were mapped. Using participant observation the reactions of members of the local CoP were recorded as new ideas and tacit knowledge are brought back from the NoPs.

- *mapping phenomenon of LPP*

To examine more fully the phenomenon of Legitimate Peripheral Participation (LPP) [*see* Sharing of tacit knowledge within a social environment], both from a novice and expert perspective, a CoP (Biology) sociomatrix was extracted from the complete FSL *advice* sociomatrix. The frequency of communication that occurred between Biology scientists over the three-day period was preserved in order that we could examine more fully the knowledge exchange between the scientists (i.e. the matrix was valued and asymmetrical, rather than binary), [*see* Appendix: Sociomatrices]. Another sociomatrix was used to record over a four-month period all instances of case *peer-review* on cases dispatched from the Biology CoP, [*see* Appendix: Sociomatrices]. This was used to capture the exchange of advice given by scientists with considerable experience to those scientists sending cases out of FSL.

iii Qualitative inquiry

The traditional qualitative school of inquiry was used where the 'primary way a researcher can investigate an organization or process is through the experience of the individual people' (Seidman 1998, p. 4). As well as participant observation, semi-structured interviews were carried out on forensic scientists within FSL who were selected through purposeful sampling, as identified through the network analysis above. In this research a picture of tacit knowledge exchange is elaborated in the ethnography of actors in the communities of practice. Although the interviews entailed some degree of variation, the interview questions were selected around elements of tacit knowledge exchange/reciprocation. The interviewee responses along with this researcher's comments are presented in the Results Chapters [NB. Only interviewee responses are presented that represent the subject matter argued. Those duplicitous responses are appendicised [see Appendix: Edited surplus Interviewee transcripts]. Access was achievable both to the SOPs and a wide range of official documentation, including strategy documents and internal memoranda, etc. The purpose of analysing the documents was to identify evidence of tacit knowledge exchange that supported the interview data.

To reduce the likelihood of misinterpretation or indeed the minimisation of bias, researchers employ various procedures such as 'redundancy of data gathering' and 'triangulation' – 'a process of using multiple perceptions to clarify meaning' (Stake 2000, p.443). Here in triangulating for this case study, 'a combination of observations, interviewing, and document analysis' were used as 'different data sources to validate and cross-check findings' (Patton 1990).

- *Interviews carried out*

Over the period December 2006 to April 2007 a series of half hour-long, semi-structured interviews were carried out with twenty-eight forensic scientists. The interviewees were all within the local inter-organisational collaborative network (FSL), who were selected through purposeful sampling, using knowledge giving capacities and network position criteria. Although the interviews entailed some degree of variation, the interview questions were selected around elements of tacit knowledge transfer/reciprocation covering the following topic areas: the learning of forensic science practice; the seeking/giving advice; establishment of how knowledge is gained/given; and the exploration of the concept of experience. The questions were developed to directly address the research proposition: that tacit knowledge, acquired through the relational mechanisms of social interaction, is a major contributor to the functioning of the processes within collaborative networks. [All interviewees signed a consent form, *see* Appendix: Interviewee Consent Form].

I gathered rich, thick descriptive data through the in-depth semi-structured interviews, where I took notes during the question and answer sessions, that I relied upon as pointers as to when I listened to the tape recordings. Transcription of the raw data comprising word-for-word quotations of both the participant's responses and interviewer's questions was carried out. [All twenty eight interview recordings and transcripts are available on request, digitally to the examiners].

The interviewees were treated as anonymous for the purposes of this research. All forensic scientists were designated a number [These number attributes stand in any of the network graphs]. Those selected for interview were assigned alpha symbols governed by their number previously assigned. Names were assigned on the basis that the alpha symbols had to be contained within the new name. The new names were plucked from a database in New Zealand (Statistics New Zealand 2007) and one from Ireland (Central Statistics Office Ireland 2007). [For the purposes of the examiners the names are included, *see* Appendix: Anonymous Code set]

- *Participant observation details*

Although employed in a full-time capacity as a forensic scientist at the Forensic Science Laboratory, Dublin, I actively became a participant observer of my forensic scientist colleagues in the workplace over a two-year period – 2005-2007. I kept a fieldwork diary throughout this research period, which, in an effort to limit organisational distrust, was added to at home after work.

In this research study, I was overt in my goal of finding out more about tacit knowledge. However, I did not advertise what I was doing – only to say that I was carrying out research on the organisation for my doctoral studies. Part of the reason for this was not to contaminate the field with prior discussion about tacit knowledge, since this can lead to questions about the researcher's definition of 'tacit knowledge' and how it works within the community, thus increasing the risk of the researcher imposing his/her ideas on the participants being observed. During my networking, I was able to comfortably engage the actors in conversation, where my presence as that of a researcher was largely non-apparent (Lofland, Snow, Anderson, & Lofland 2006).

- *Analysis of documents*

This researcher had access both to the Standard Operating Procedures (SOPs) and a wide range of official documentation, including strategy documents and internal memoranda, etc. The purpose of analysing the documents was to identify evidence of tacit knowledge exchange during process completion that supported the interview data.

The FSL SOPs were analysed for content that would be divergent to the actual processes detailed – that is a further tacit-type step outside of the protocol was required to continue on with the work detailed in the protocol. Using MAX qda ( 2007) keywords [~1,000] were generated automatically from the 198 SOPs and their frequencies calculated. The keywords were honed down to those that signified a tacit dimension and resulted in a divergence from the SOP, where extra work somewhat tangential to the protocol steps were required [eg., may, trainee, suggests, desirable, circumstance, feel, preferable, unsupervised, expertise, believe, depend, ideally, interpreting, advice, ascertain, familiarise, decisions, undertake, occasion, evaluate, peer review, suggests, assist, interpretations, conclusions, experience, consult, complex, suggested, knowledge, consideration, instances] [*see* Appendix: Keywords used to screen SOPs, for frequencies of the keywords]. A sub-search was carried out yielding segments of text throughout the SOPs containing these listed keywords along with the tacit dimension needed to continue with the protocol. These were carefully examined and coded for elements of tacit knowledge which required a divergence from the SOPs.

- *Questionnaire on Knowledge mix in day to day work of forensic scientists*

In looking at the interplay of tacit and explicit knowledge in the training process, a structured questionnaire was completed by a sample of forensic scientists from two CoPs at the FSL; one qualitative [Biology – 8 scientists] and the other quantitative [Drugs – 9 scientitstss] in the types of case reports that they outputted [*see* Appendix: Survey – the use of SOPs in practice].

# PART TWO

# 4 RESULTS – TACIT KNOWLEDGE WITHIN PROCESS

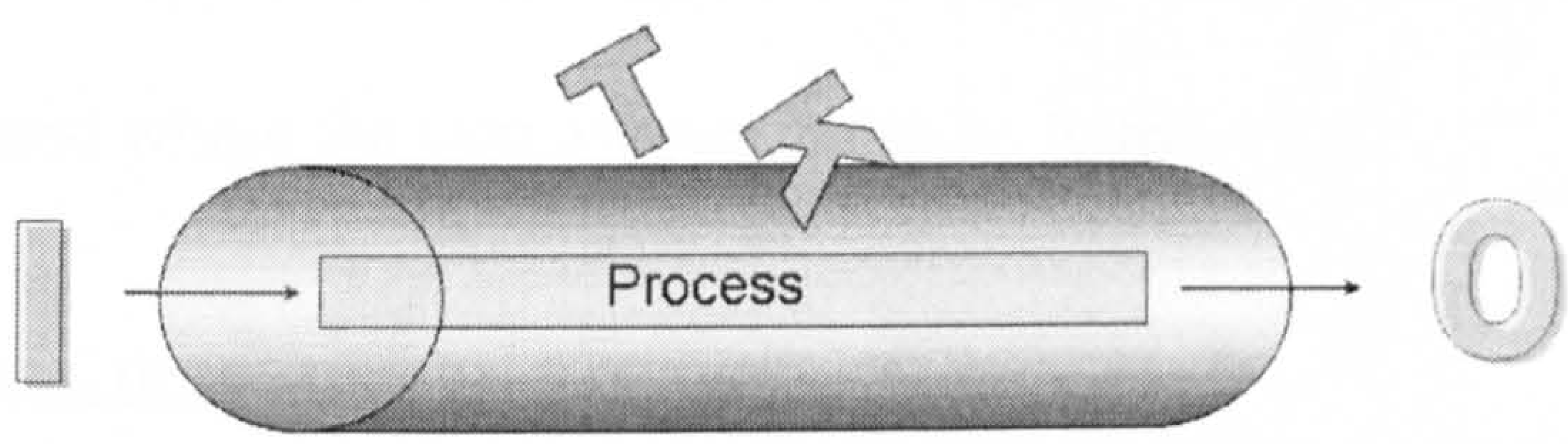



**Figure 3 Analysing the Tacit Dimensions within the process**

## *Introduction*

The above figure (Figure 3), a formative building block precursor to the relational model proposed in the thesis introduction, best describes how the results of the research are being interpreted for this particular chapter. Empirically the concept that, tacit knowledge can be looked at as being a major part of organisational process is examined. Eventhough processes are explicit by their nature; there is still a very much tacit element attached to the process which has been overlooked. In order to build upon the above figure, my interest here is what happens to the fully functioning practising expert, how does he/she gain or indeed give knowledge often of the tacit nature in the processes of their work. This empirical work intends to qualify the theoretical assumptions laid down within the community of practice literature, on how tacit knowledge evolves and is transferred amongst practitioners of a community. On making findings of how tacit knowledge interplays within the process, can I then explore the relational dimensions more fully.

***Background on FSL – focus of case study***

Before setting out to describe the tacit knowledge that is involved in the very processes of the organisation, it is prudent to describe the work and the set up of the laboratory.

I have set out below showing the actual processes of casework so as to fully understand where the tacit aspects are to be found.

i Formal organisational structure

The structure at the Forensic Science Laboratory (FSL), is a an office of the Department of Justice, Equality & Law Reform. The FSL is headed by the Director, who reports to a higher ranking official in the Department of Justice. Budget allocations, staff recruitment and major policy decisions 'come down' from Justice. The FSL is autonomous in all other areas of its operations. Within the FSL there are four departments: Biology, DNA, Chemistry, and Drugs.

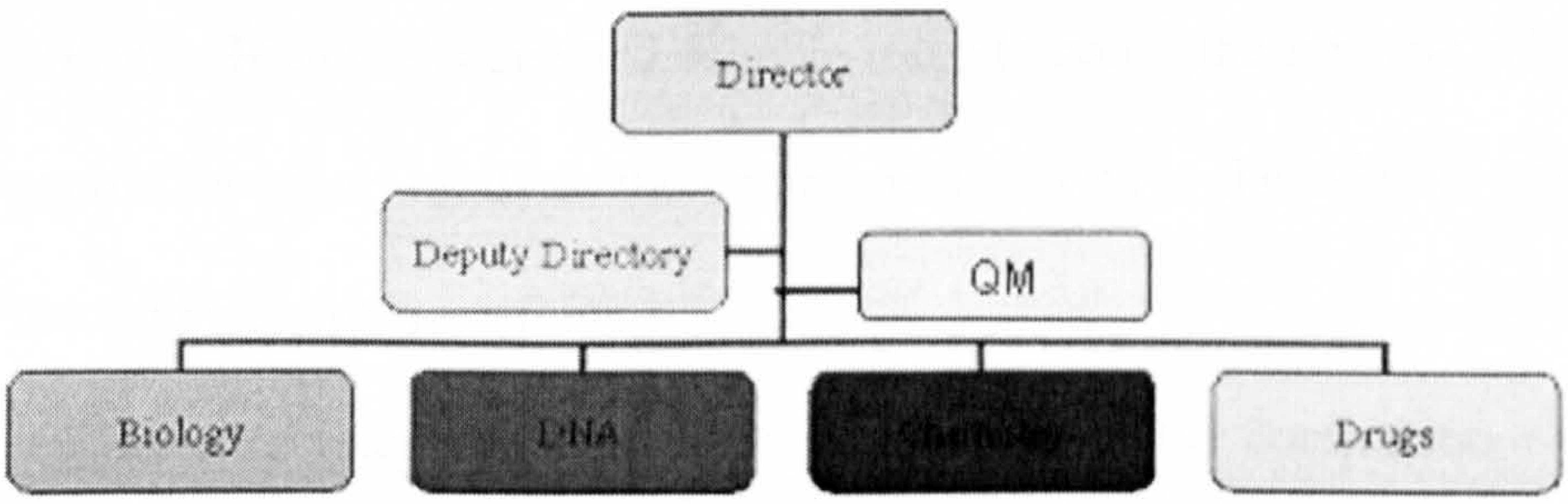



**Figure 4 The FSL formal organisational chart**

The management team of FSL is headed by the Director, along with a Deputy-Director, who are assisted by a organisational management team comprising of a Quality Manager, and four Heads of Section. The Quality Manager reports directly to the Director and is in charge of the integrity of the Standard Operating Procedures, and the quality of the work carried out within the organisation. Within each section there is nominal differentiation between forensic scientists who are split up based on a grading structure [Forensic Scientist I, II & III in descending order] largely related to pay scales and nascently related to micro-management responsibilities (as opposed to the strategic and policy management carried out by the holders of the management positions already identified). Up until recently, the promotion of forensic scientists from Grade III to Grade II and Grade II to Grade I were based on seniority – length of service within FSL as a scientist. Thereby there is a direct relationship between the grade of a forensic scientist and his/her length of service, and ultimately experience of the individual in the area of casework and amount of different types of cases that they have accomplished.

The FSL product is a forensic report written by the forensic scientist which is delivered to the Garda Siochana. The technicians assist the forensic scientist in all of the analytical procedures. The report is forwarded by the Gardai along with their completed Book of Evidence to the Director of Public Prosecutions. If a case is deemed suitable to go to court, the forensic scientist delivers his/her report orally in the witness box to a jury. The Gardai and the DPP are the FSL's only customers.

There are relatively few tasks for the successful completion of the whole task, the forensic report. The tasks include receipt of cases from Gardai, examination of exhibits, scientific analysis, reporting of results, and testimony in court. The FSL organisation is very uniform as opposed to differentiated when looking at each of the three sections. Each section is flat from a hierarchical point of view: a section head (the line manager), with scientists and technicians who report to the section head.

Each member of staff is highly qualified. Their work is specialised where each member of the section knows what work needs to be done, along a standard set of procedures set out in SOPs. Their tasks do not need constant supervision: the production of results which are codified in a forensic report is the executed task and it is this that gets seen by the section head. The section head reviews the final report before it is issued: at this stage the final product is assessed. Before submission to the section head, the report is peer-reviewed by a scientist colleague where any changes are made and formally recorded. The recurring task situations are programmed into the production of the forensic report. It is at these tasks in producing the report where tacit knowledge is found to interplay. Any infrequent situations, such as DPP queries and Defense examination, are referred to the Deputy-Director by the Head of Section.

The overall work in the FSL and within each section is routine. The mechanistic nature of the FSL is appropriate for the tasks it carries out. However, the organisation is inflexible to change. The length of service of a staff member is paramount, where decisions and promotions are the domain of the more senior staff members. New ideas can become submersed if suggested by the newer staff members.

ii Formal process of casework

From a bare process point of view, a single case travels through the following pathway documented as follows by a FSL CMS group of which I was part of:

i. A case is created when a member of the Gardai (or other agencies) calls to the Reception of the Forensic Science Laboratory with exhibits to be analysed. A case is allocated to a Garda (called the Member in Charge). All documentation relating to analysis will be sent to the Member in Charge.

ii. There are a small number of cases that are created in response to requests from other agencies such as the Department of Agriculture or the Military Police. These are processed in the same way as Garda cases.

iii. An Administration person (receptionist) will either log the case and related exhibit details directly or will call a scientist from a section to review the case material with the Garda. Scientists belong to sections within the Laboratory. (Biology, DNA, Chemistry or Drugs).

iv. A case always has one or more exhibits/items. Additional exhibits can be delivered at any stage relating to an existing case.

v. The Administration person inputs the case details into the case database file, where each new case gets a unique case number along with the year of receipt, on a desktop PC at the reception desk. This is a transcription from the C56 Garda paper form.

vi. The case is then either transferred to the Central Intake Store or if in very urgent cases is assigned to the scientist who met with the Garda.

vii. Normally a scientist is assigned a case by the Head of Section, who distributes cases from the Central Intake Store. The CMS software allows this allocation to be logged. The scientist is given a balanced portfolio of a designated number of cases, with new cases being assigned as the current cases are reported and leave the Laboratory.

viii. When a scientist starts working on a case, he/she updates its status to Work in Progress.

ix. The forensic scientist on reading the background details supplied in the file or ascertained through additional phonecalls with the Garda member in charge of the case carries out analysis on selected items that have been submitted to the laboratory.

x. Of items that are examined the forensic scientist writes details of the examinations of each on separate case examination sheets and then selects sub-samples for any analysis or assays. Results of such analysis are introduced by paper into the file.

xi. The forensic scientist then combines both his/her own examinations and the analysis results to write the case report.

xii. The forensic scientist works along the steps identified in the standard operating procedures.

xiii. Some of the examinations or analyses require a second person to sign-off, or witness certain procedures.

xiv. The forensic scientist may delegate the item examinations or some of the analytical processes to a technician. The results provided by the technician are incorporated in the forensic report without overt indication of the work being carried out by the technician.

xv. The case report details the items received and the results of the analysis and findings from the item examinations. Details of any further analysis required inform the reader, where further work such as DNA profiling or fingerprint analysis are required.

xvi. A case can be assigned to more than one section. These are called shared cases.

xvii. The scientist to whom the case has been assigned generates a draft report when the analysis of the case exhibits has been completed.

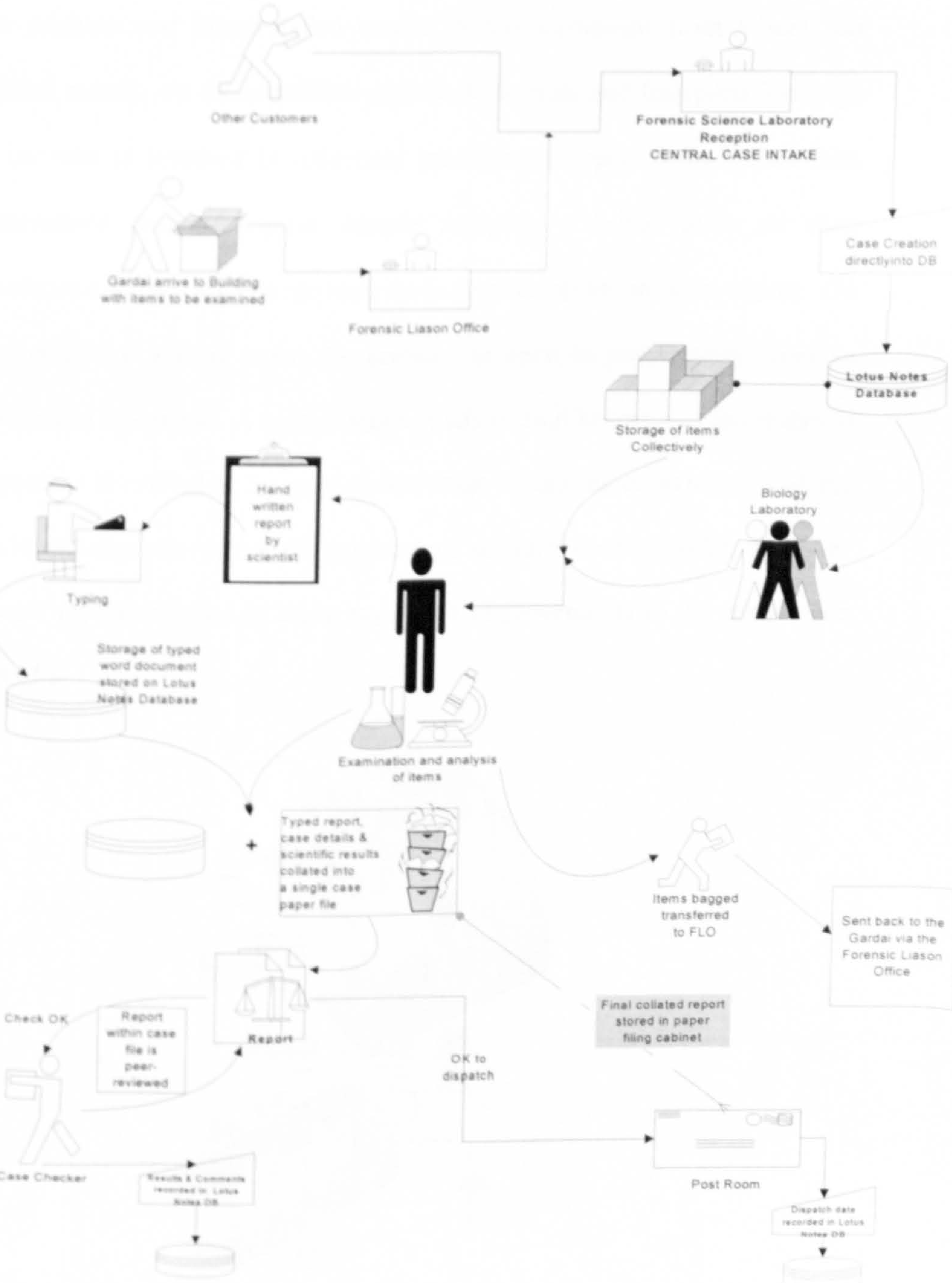
xviii. The scientist either types the draft report or sends the report to the Administration section for typing on a word processor. The electronic typed report is attached to the CMS case file on the database.

xix. When the draft report is available, it is returned to the scientist. The scientist then passes it to the Head of Section who allocates another scientist to perform a peer review of the report.

xx. The report may be changed during the peer review process. The peer review comments and changes are recorded on the database.

xxi. When a final report is available, it is sent to the Administration section for posting to the Garda. The post date is recorded to the database.

A diagrammatic representation of the process involved in a Biology case follows:




*courtesy and © Declan O'Connell, FSLab Dublin*

**Figure 5 FSL Biology Section Process Workflow**

iii <u>Actual process under the lens of the researcher</u>

Where the forensic scientist is intricately involved in process, that is at the case analysis and interpretation stages, is the viewpoint from where this research stands. At the immediate casework analysis and interpretation stage the scientist is involved in ultimately producing a report from his/her item examinations and subsequent sample analysis. He/she pulls all their experience and tacit knowledge reserves in final compilation of the report. On completing the written report the scientist is open to peer review from an experienced colleague. A second stage of where tacit knowledge interplays in the process is evident at the peer review stage where the experiences and the tacit knowledge reserves of the experienced scientist casting his/her eye over the case report are used to make suggested improvements to the report [see Figure 6].

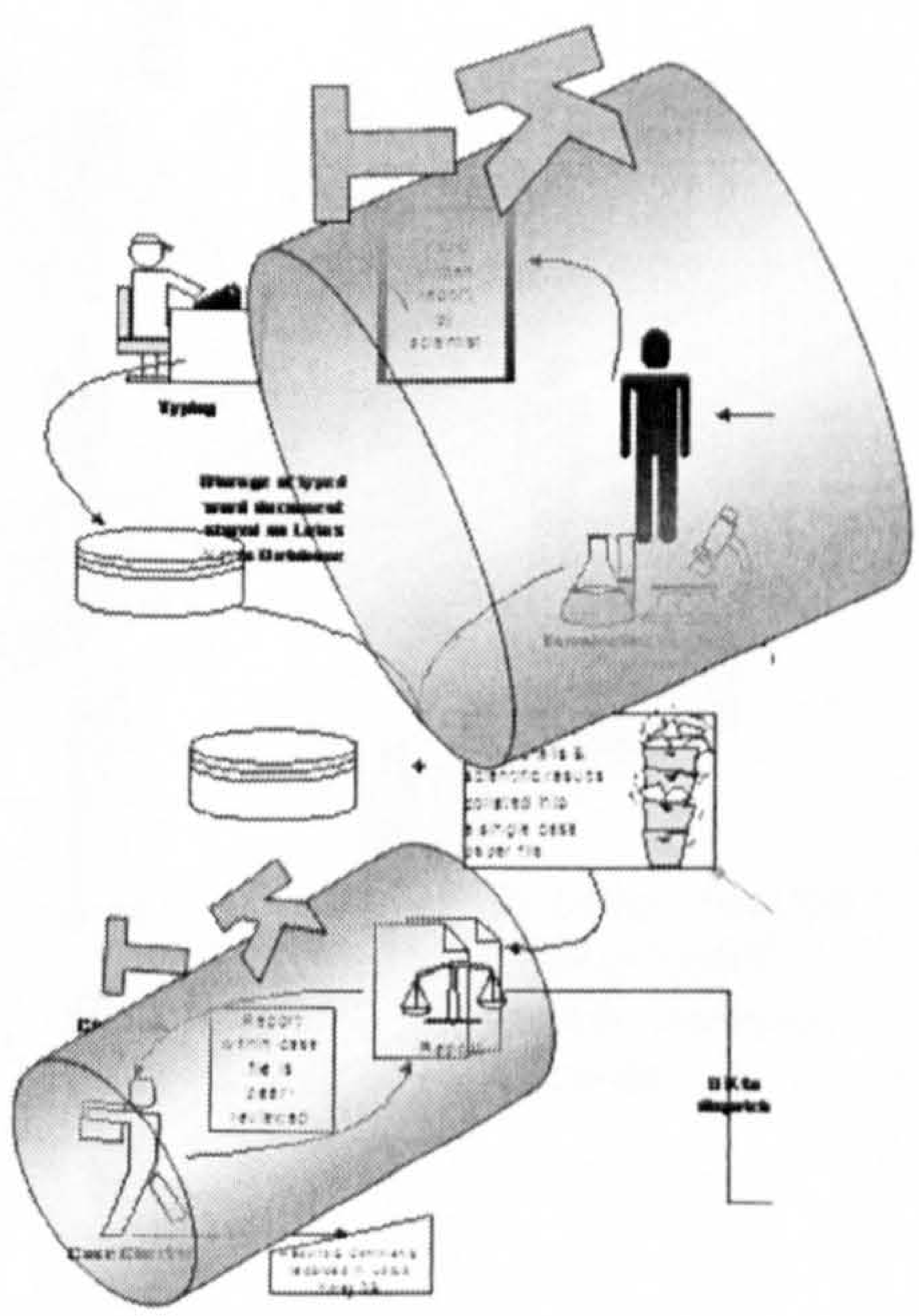


**Figure 6 The processes where tacit knowledge (TK) interplays for the forensic scientist – at the case analysis and peer review stages. An excerpt from laboratory flow chart**

iv The process as a result of knowledge sharing

Viewed in terms of the organisational workplace practice, the forensic scientist works on a case on an individual basis where their results are evidenced as reports, classified as 'statements of evidence' authored by one forensic scientist for the exclusive perusal by the Director of Public Prosecutions. However, the individualism of a report as seen by an outsider to the organisation is actually the opposite in real terms where the report is a result of a collaborative exercise – an amalgam of knowledge from many social actors. It is this perceptive direction that the research has taken – the holistic view of the way processes as those carried out by individual scientists are integrated with the other social actors within the organisation [see Figure 7].

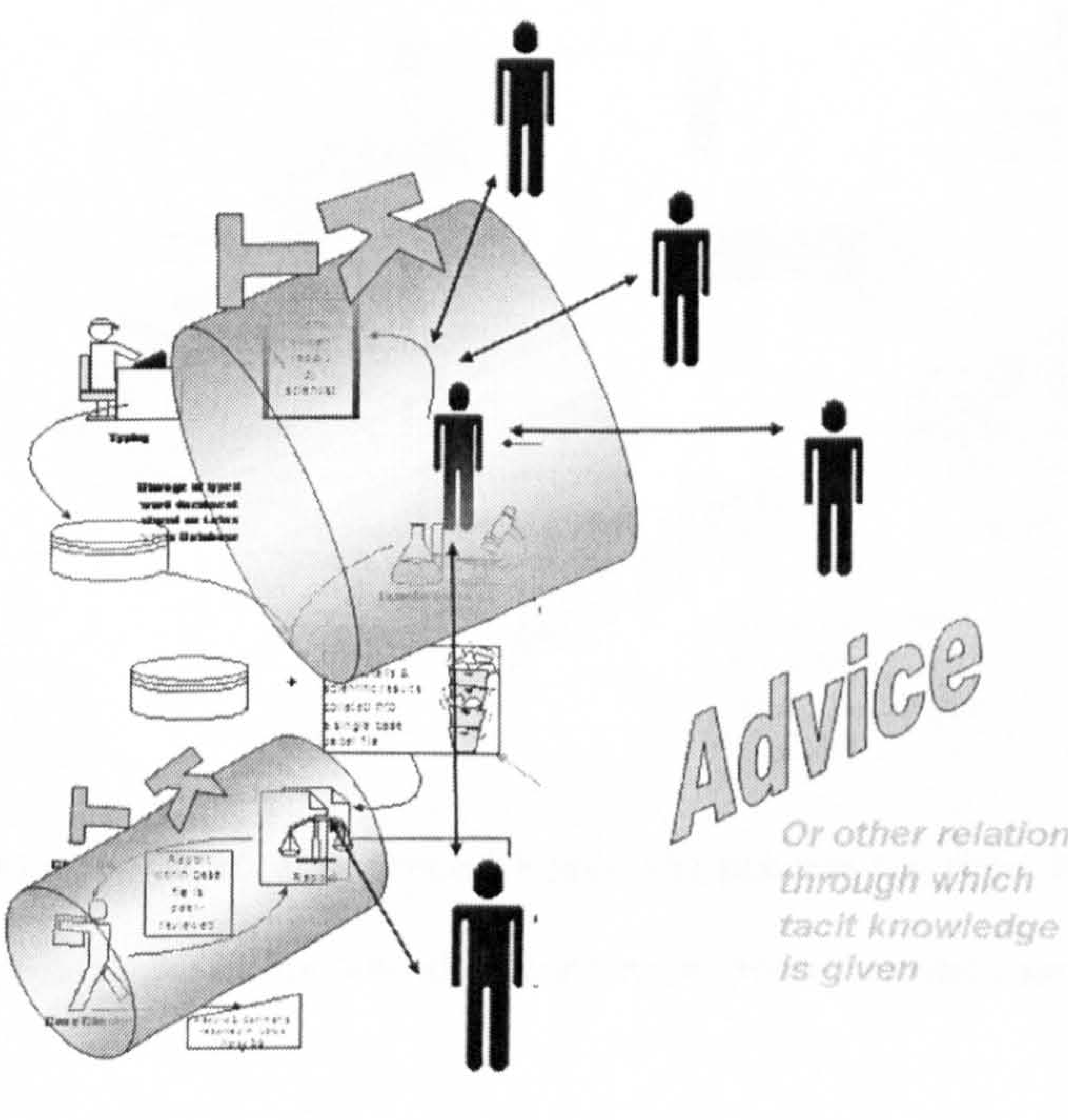



**Figure 7. Advice or other relation through which tacit knowledge is transferred from/to other practitioners**

v Diagrammatic representation of advice

Throughout the remainder of the results in this thesis various assumptions are undertaken with regard to the line diagrams showing the sharing of advice or other relations mediating the transfer of tacit knowledge amongst social actors in networks of advice. Any discussions on process should be couched in what this research takes as *the* process. The detailed steps on the left side of the figure below [see Figure 8] have been reduced to two blue process boxes as seen on the right of the figure: the process required for case analysis and subsequent report generation, and the peer review process of the case report. At both tacit knowledge stage gates other individual actors are involved.

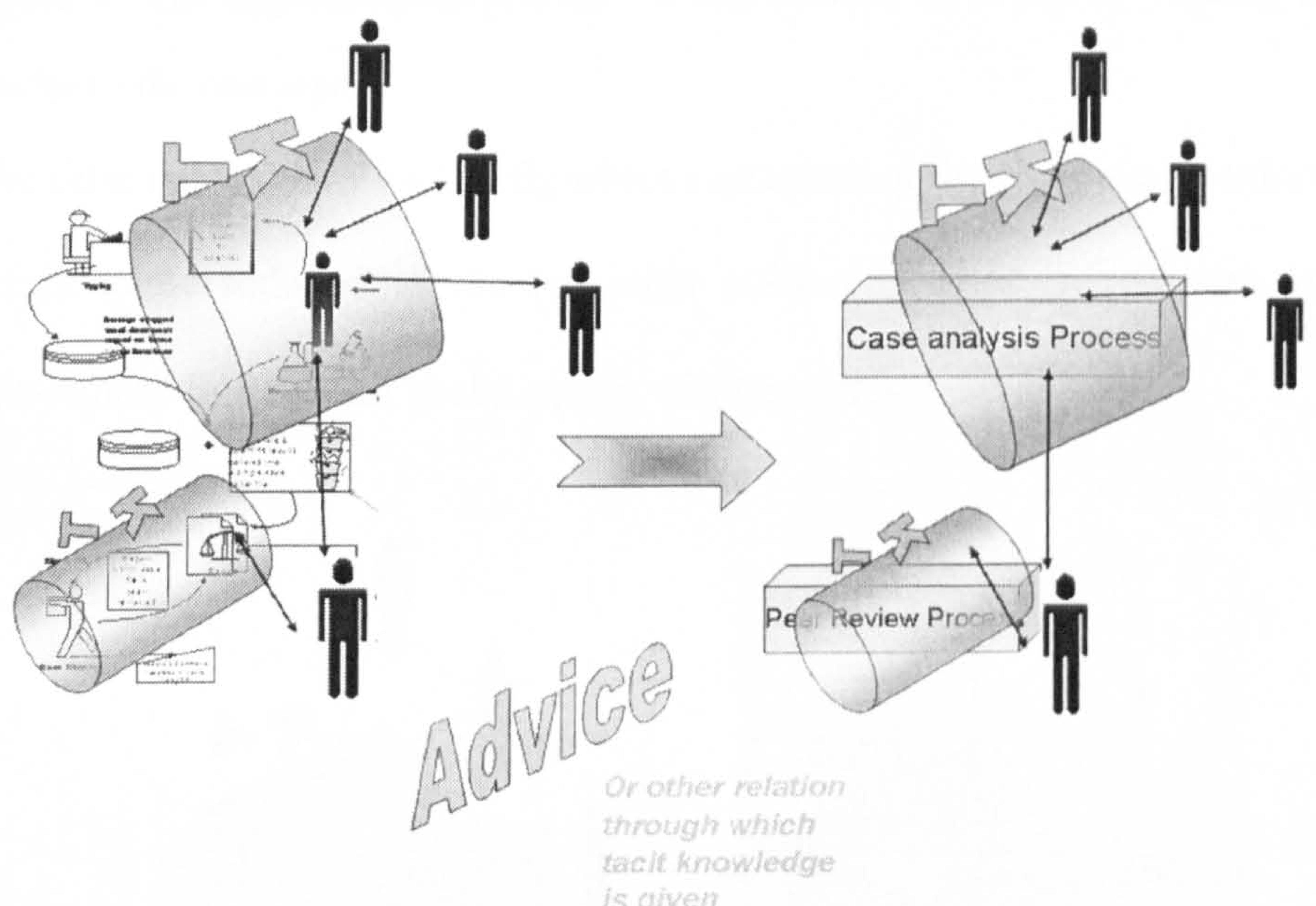



**Figure 8 Two blue process boxes: the process required for case analysis and subsequent report generation, and the peer review process of the case report**

The next figure [see Figure 9] combines the two processes as one – however, importantly in any discussions in the future the one process should actually be thought of as being a representative device: intending to encompass those organizational processes that ultimately yield the final product – the case report.

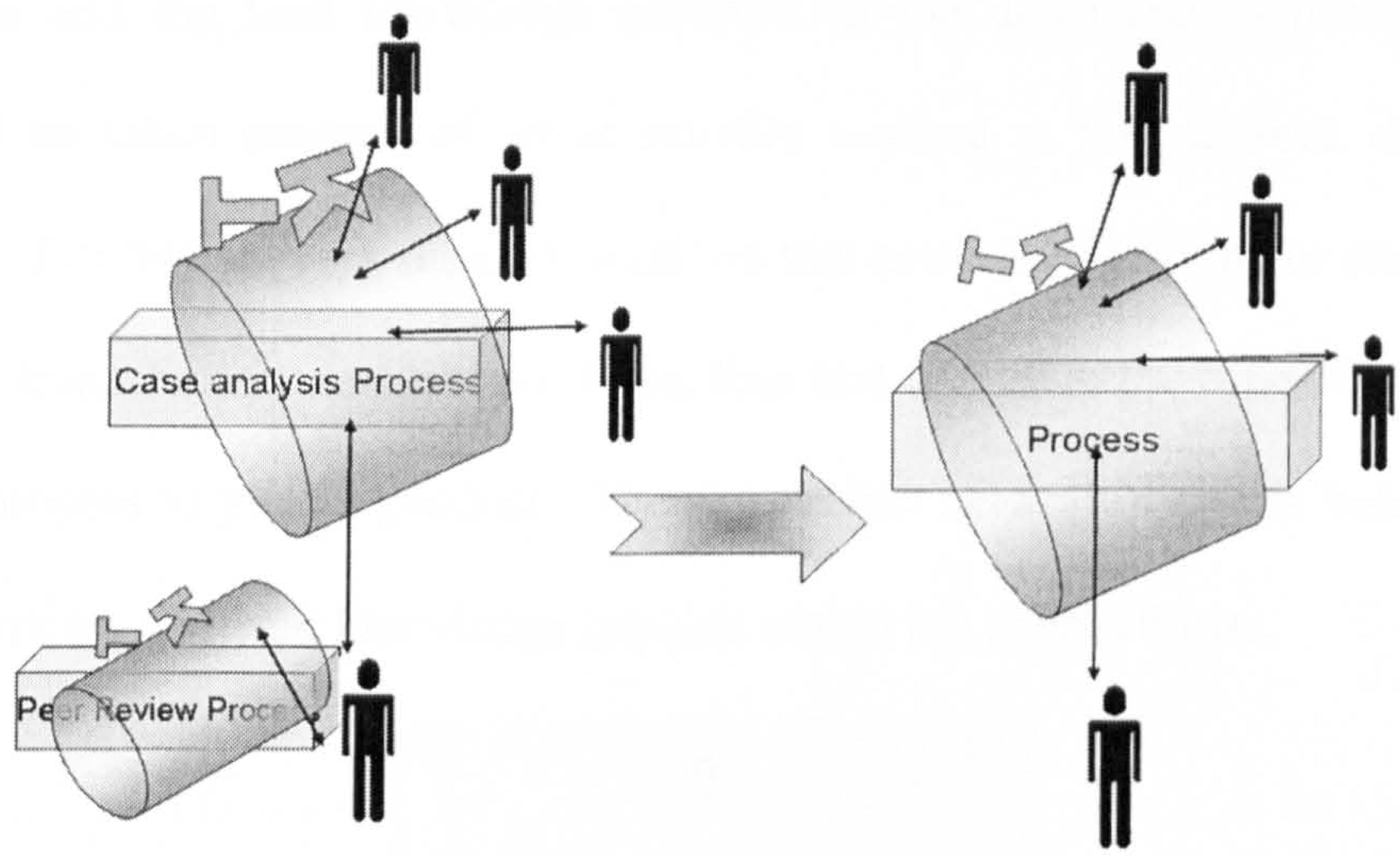



**Figure 9 The organisational process – a compendium of processes yielding the final product – the case report**

The time comes then for the figurines representing the forensic scientist social actors to be reduced to red (or other coloured) discs [see Figure 10]. In subsequent findings all social actors will be represented as such.

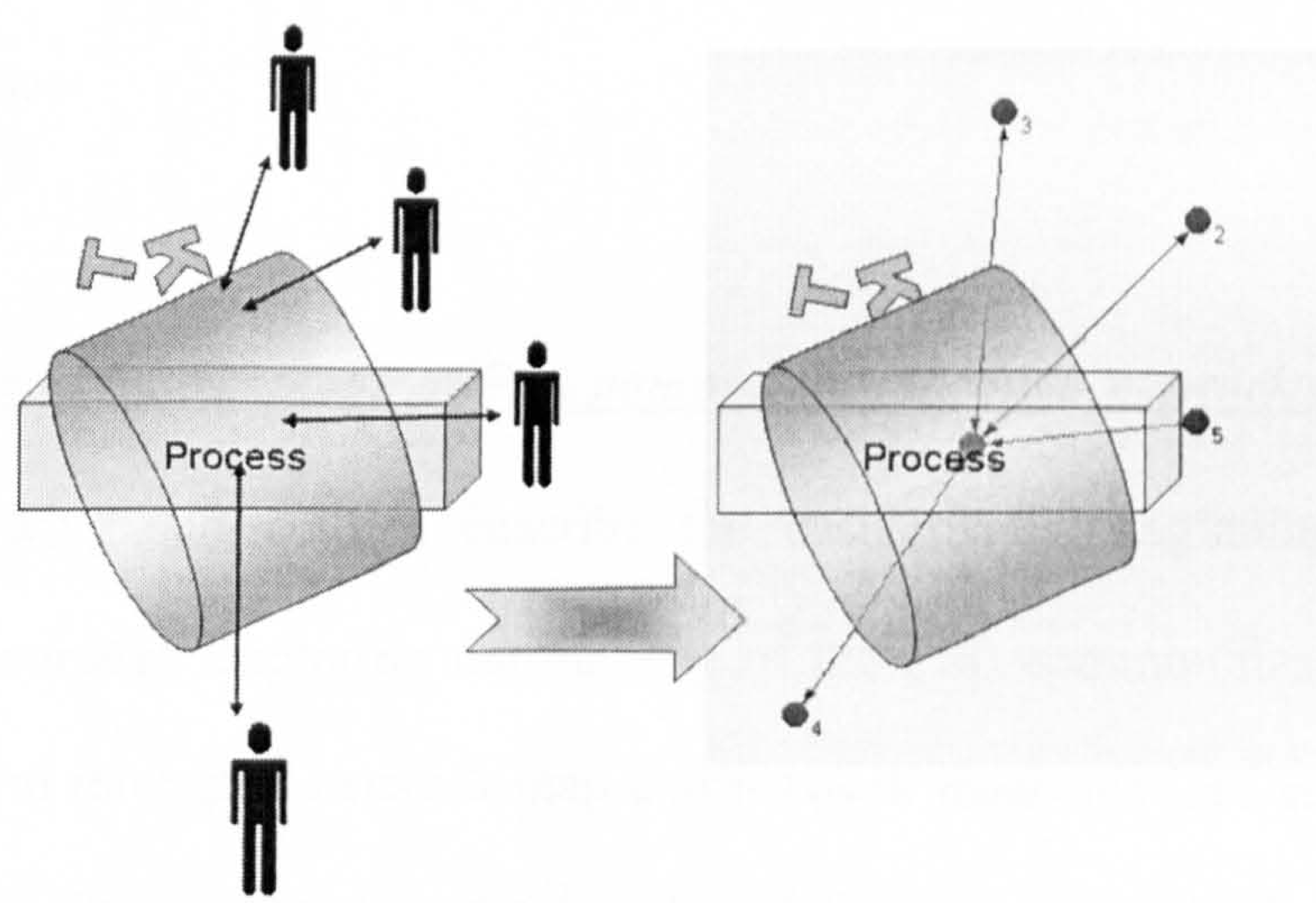



**Figure 10 Figurines representing the forensic scientist social actors are reduced to red (or other coloured) discs**

The nude network line diagram below contains no process box or indeed the tacit knowledge ether cylinder [see Figure 11]. However, both the concept of process and the tacit knowledge involved in the discharge of the process should be taken account of when actually looking at the network diagram below. For this network diagram signifies that actor one is giving or receiving advice from the other actors two, three, four and five all at the time of carrying out a process to yield a product. The simple line network diagram below has both process and tacit knowledge implicit within the connections.

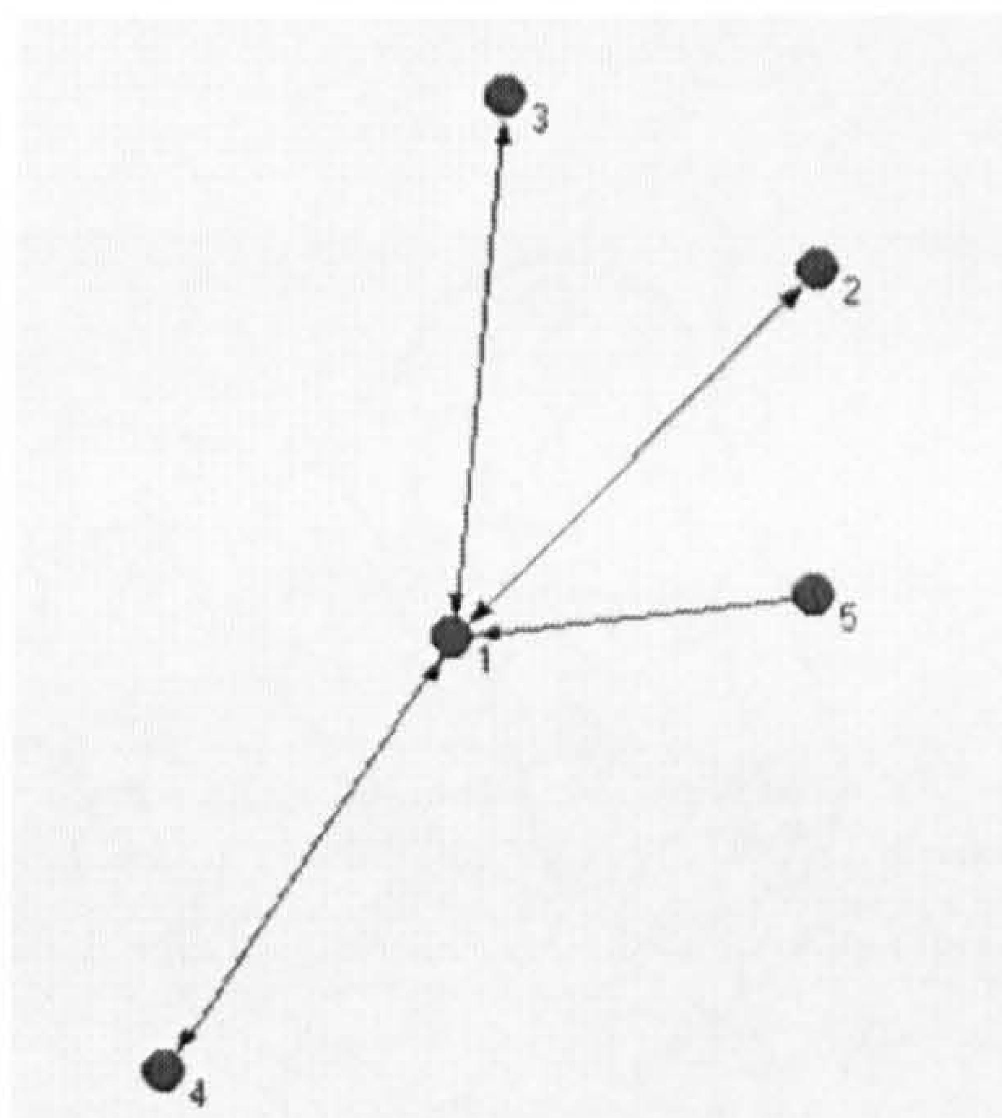



**Figure 11 Nude network line diagram, both process and tacit knowledge implicit within the connections**

***<u>Exploration of the makeup of FSL communities through network analysis.</u>***

The following sub-sections describe the basis of the beginnings of this research journey: exploring the makeup of the FSL communities within its organisation through a network map and network measures [see sub-sections of below]. The structural survey is a foundation in making findings of how tacit knowledge interplays within the process.

i Communities of Practice within FSL – a network map representation

Here shown is a resultant snapshot of tacit knowledge exchange mediated by the advice relation over a three-day period, taken from the Spring 2005 advice survey (see Figure 12). Relational tacit knowledge exchanges are seen to radiate amongst forensic scientists within/between intra-organisational communities of practice at FSL. When compared to the formal organisational chart (see Figure 4), the network map is highly informative, yielding details of how the forensic scientist practitioners actually work in carrying out their process.

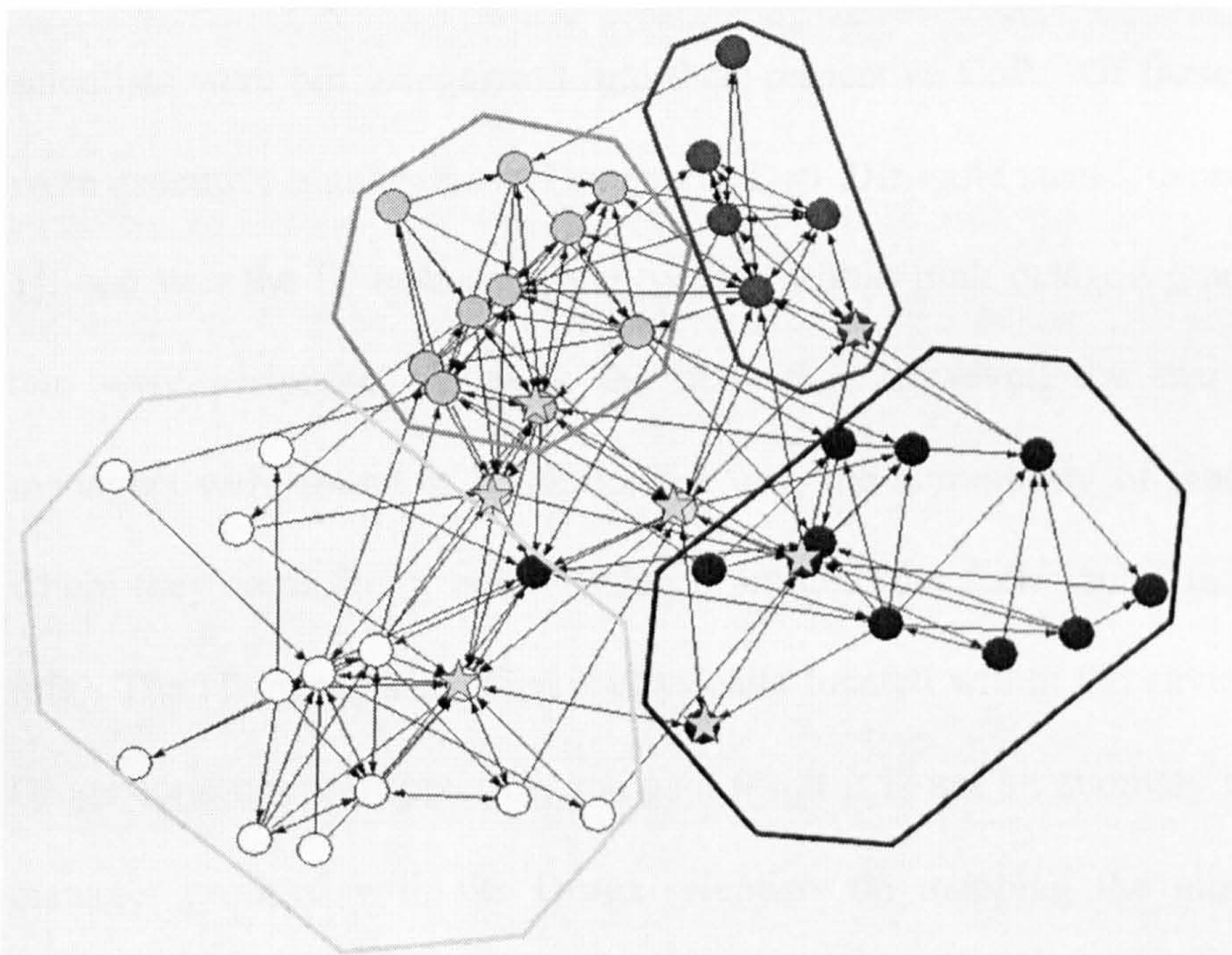


**Figure 12. Network map of FSL, recording advices yielding tacit knowledge transfer between forensic scientists over a three-day period within/between four CoPs[collection of vertices of one colour] largely within the section boundaries of the organisation[coloured octagons]. Biology (green), Chemistry (blue), DNA (red), Drugs (pink), Executive management (yellow). Management (gold stars).**

The analysis took place at the micro-level, treating the forensic scientist and his/her network of *advice relations* as the unit of analysis indicative of tacit knowledge exchange.

ii Hierarchical clustering identifying cohesive sub-groups.

In further empirical analysis of such communities, hierarchical clustering was used allowing cohesive sub-groups to be identified – CoPs of actors at FSL (See Figure 13). The exercise subdivided scientists with relational advice ties into increasingly more homogenous subsets of cliques, thereby partitioning scientists into their respective community of practice subgroups. Five scientists were not categorized into their respective CoP. Of these five, two were executive management [Director & Dep. Dir.-gold stars □uspec of graph 1], one was the IT manager [blue vertice within pink octagon-graph 1], and two were peripheral actors in the network. However, the two executive managers were found to be associated with the community of practice from where they came from, before being promoted into their senior management role. The IT manager's office is physically located within the environs of the Drugs community of practice, and as a result it is not an anomaly to find the manager grouped with the Drugs scientists on mapping the clusters. The closeness of the scientist's relationship between the section classification and his/her CoP is to be expected, as the work in each section is very specialized and appears idiosyncratic to members of the other sections. Except for the IT manager, one sees that the scientists work within their community of practice boundary. As FSL evolved over its circa twenty-five year history, recruitment was via three sections: Biology, Chemistry and Drugs. Only one year ago (since this network survey), for logistical reasons, the DNA section was formed, splitting away from the Biology section. The DNA section has literally taken all the processes of DNA profiling away from Biology, allowing the scientists in Biology to concentrate on harvesting evidence from the physical exhibits received into the laboratory. Biology operates as a separate community of practice to DNA but still works very closely with them as it can be seen in Figure 12.

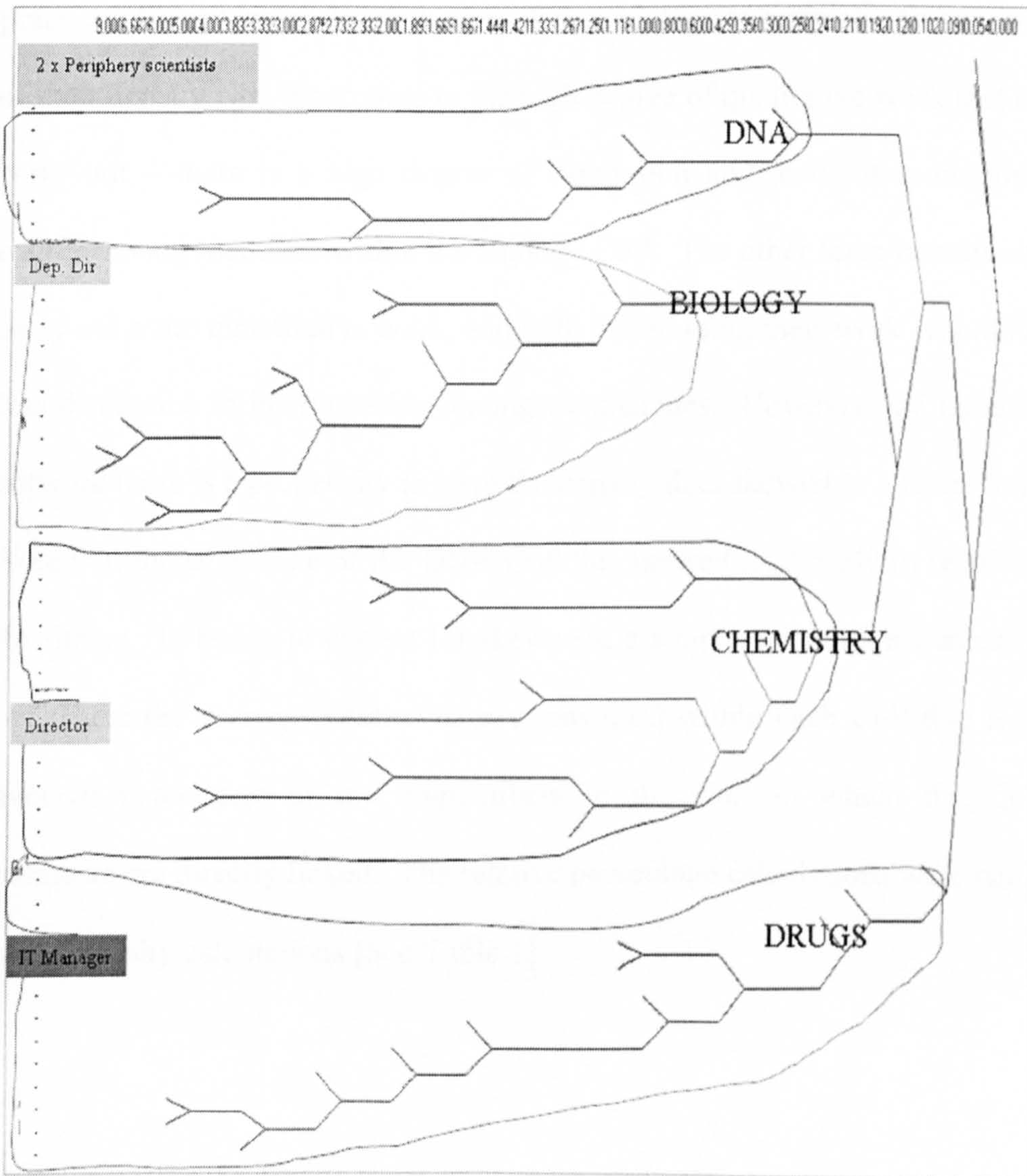



**Figure 13. Hierarchical Clustering of Cliques at FSL. Frequency of ties among scientists measured allowing scientists to fall into their respective CoPs[coloured contours].**

iii Cohesiveness of subgroups – density measure

In further elucidation of the CoPs within the laboratory, *density* measures were used on the Spring 2005 advice survey, attributing a value to the cohesiveness of a subgroup [see Table 1]. In determining how closed-knit the empirical sub-groups are, values between 0 (empty graph) and 1 (complete graph) were calculated. I found that the Biology CoP was quite dense in their communications, when compared to two of the other three communities of practice. In looking at the type of work that biologists carry out, this measure of their density would correlate to the high degree of qualitative work that they carry out – there is a high degree of discussion and tacit interpretation of results among members within the Biology CoP. The other three communities carry out more quantitative work, and with this in mind their work would need less discussion in interpretation amongst colleagues. However, the larger the network there is a propensity to have the density data skewed to a lesser value. Note that the small size of the DNA CoP has skewed its density in relation to the others. In trying to correct for skewness, a simple calculation was carried out where the *average relative degree* was used within each CoP that is, the average percentage of the co-members in the CoP to which the CoP's members are directly linked. The relative percentage calculations were similar to the density calculations [See Table 1].

| Network | Density | Std.Dev. | t-test | Ave % |
|---|---|---|---|---|
| DNA | 0.6 | 0.4899 | 0.005533 | 55.5 |
| Biology | 0.4667 | 0.4989 | 0.001711 | 42 |
| Drugs | 0.2051 | 0.4038 | 0.025971 | 18.9 |
| Chemistry | 0.1894 | 0.3918 | 0.036861 | 17.3 |
| Management | 0.5 | 0.5 | 0.015 | |
| All | 0.1058 | 0.3075 | | |

**Table 1. Density of selected networks**

iv Prominence – a quantitative marker for Tacit Knowledge levels

On trying to establish those scientists in the network who have a large/small tacit knowledge repository, the prominence of actors was measured as a marker to begin my tacit knowledge investigations. However, some scientists may have an abundance of practical tacit knowledge built up over years of experience, and may be still peripheral in the network. Hence both centrality and prestige indices, two classes of prominence, were used to measure the importance of those scientist actors within the network. In looking at the network, an actor is deemed prominent/central if the ties of the actor make the actor particularly visible to other actors in the network (Wasserman & Faust 1994: p.173). The simplest measure of structural prominence is popularity, which is measured by the number of requests for advice a scientist receives (indegree). A scientist with a large indegree becomes close to all other actors. The centrality measure combined with the prestige measure of an actor allows those scientists to be empirically identified, who become central cogs in the tacit knowledge exchange network, and are recognised by their colleagues as major knowledge channels for seeking advice. As a corollary, those scientists with a low indegree are peripheral in the network, and seldom get asked to give any advice.

On closer examination of the density of arrow heads in Figure 14, in conjunction with the indegree findings (see Table 2), one finds that there are seventeen scientists (approx. a third) who give advice to upwards of five other scientists.

| Indegree [no. of requests for advice rec.] | Frequency of Scientists |
|---|---|
| 0 | 4 |
| 1 | 8 |
| 2 | 3 |
| 3 | 5 |
| 4 | 6 |
| 5 | 3 |
| 6 | 4 |
| 8 | 2 |
| 9 | 3 |
| 10 | 2 |
| 11 | 2 |
| 14 | 1 |
| | 43 |

17 scientists each gave advice to five or more scientists

**Table 2. Indegree Analysis**

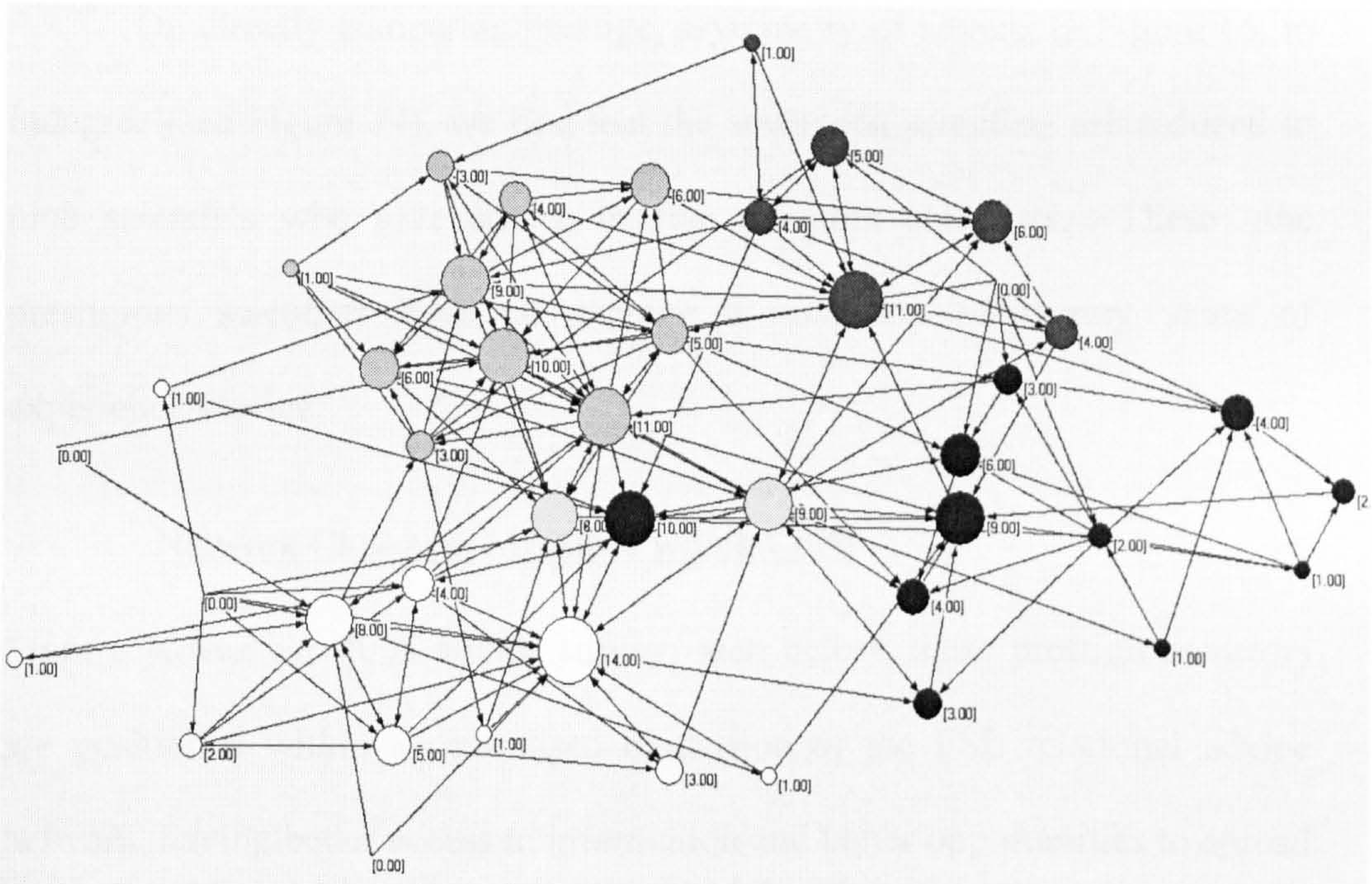



**Figure 14. Density of arrow heads[no. of requests for advice rec.(n)] and size of vertices (indegree) related to prominence/centrality of a scientist.**

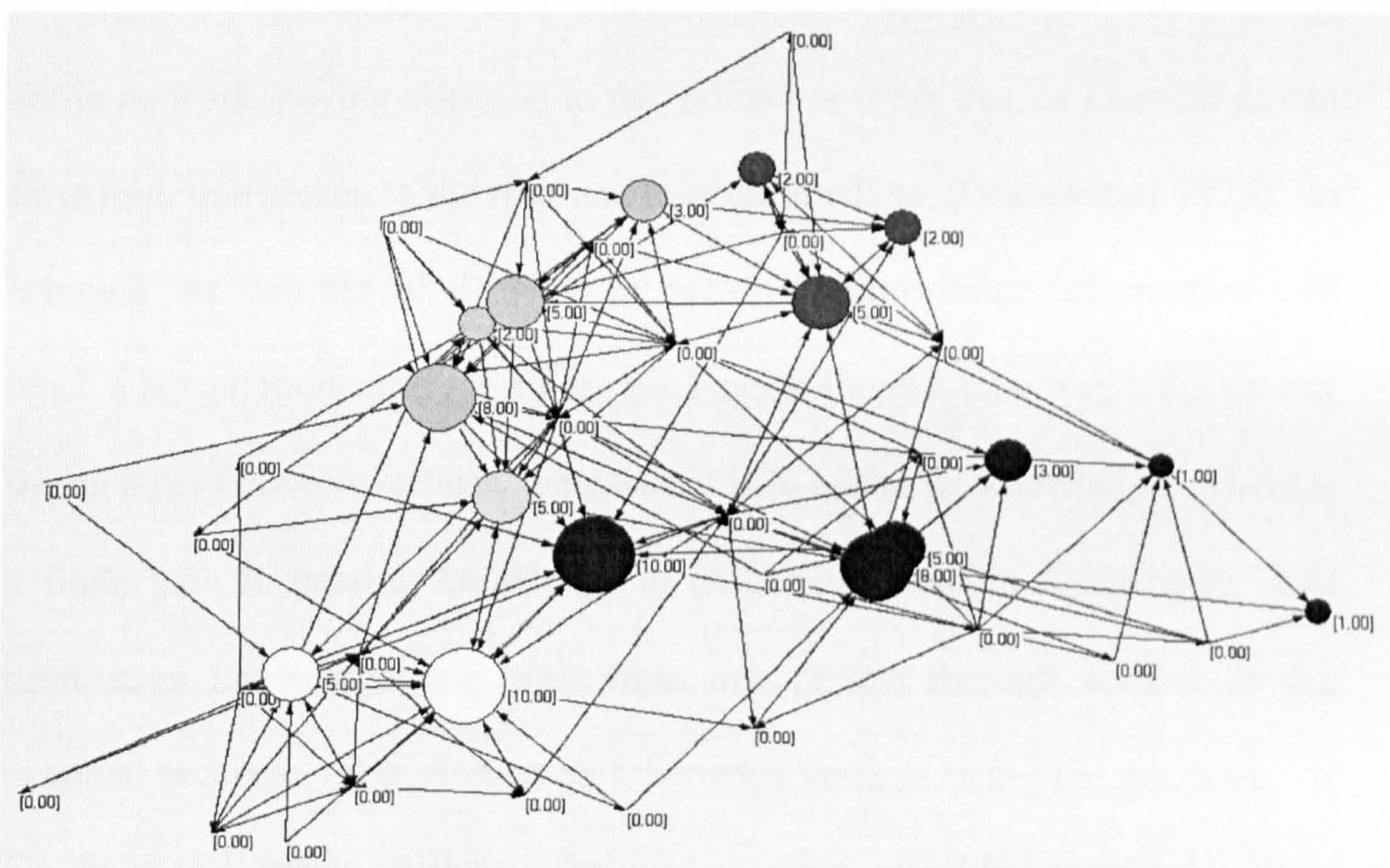



**Figure 15. Prestige of a scientist. Assymetry of advice. 9 scientists give five (net) or more advices.**

On directly comparing prestige, asymmetry of advice, in Figure 15, to indegree (see Figure 14), we find that the seventeen scientists are reduced to nine scientists who give advice to five or more scientists. These nine prestigious scientists have on average a minimum of twenty years of experience/service.

v Network Closeness Measures within CoPs

From a November 2005 advice survey, seen below, these prestigious actors are positioned within a centralised dimension of the FSL relational advice network, having better access to information and better opportunities to spread knowledge, often of the tacit type.

Already shown above, degree centrality is just the number of neighbours of a vertex. However in analysing the communication structure of the network, one needs to concentrate on who is connected to whom in the entire network, paying attention to the indirect or weak ties, as knowledge can flow from one person to the next and then on to others (Granovetter 1973). In bringing the concept of distance in networks, knowledge information will reach a person more easily if it does not have to travel a long way – the shorter the distance between vertices, the easier it is to exchange knowledge. There is a finite path in passing knowledge to neighbours, and in reaching its final destination knowledge may pass from one person through another to the eventual receiver – the shortest path between vertices being the geodesic. If the distance between vertices is below two steps, communication is accurate and fast, whereas if there are three or more steps knowledge exchange is not accurate (Cross & Cummings 2004). With the concept of distance, closeness centrality can be used to predict the information flow from one vertex to another, based on the total distance between one vertex and all other vertices, where larger distances yield lower closeness scores. The closer a vertex is to all other vertices, the easier knowledge may reach it, the higher its centrality (de Nooy, Mrvar, & Batagelj 2005). FSL is moderately centralised with a Network Closeness Centralization score of 0.43448 where 1.00 signifies the maximum centralisation of a network. Taking a score of above 0.5 as those scientists who are central, approximately two thirds of all the scientists are within a centralised communicative grouping [within line-circle see Figure 16]. Within this centralised grouping, the director is most centralised and indeed is evidenced as being head of the structured management group comprising head of sections and the quality manager [yellow spheres, see Figure 17].

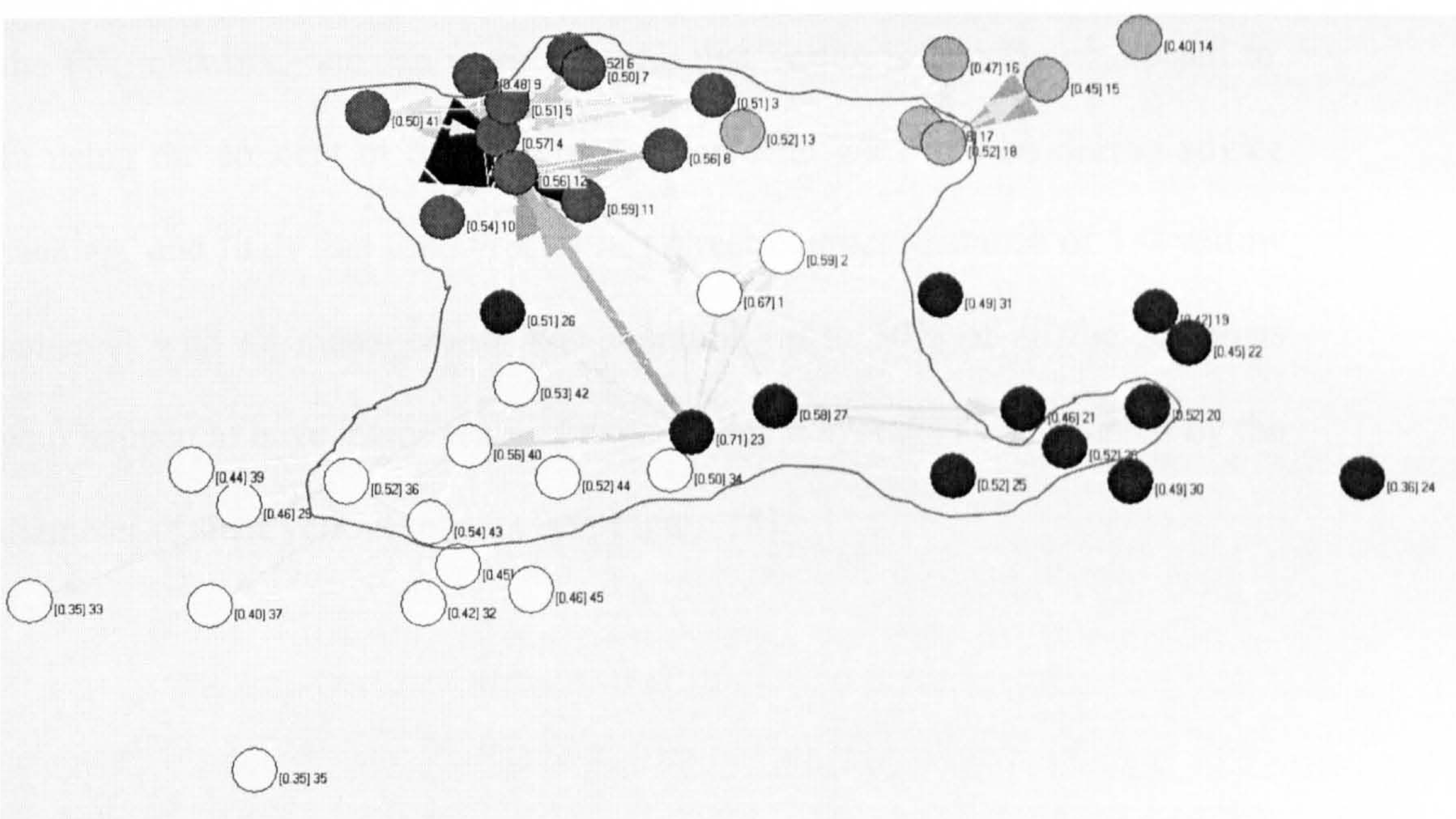


**Figure 16. Closeness Centrality of FSL actors within COPs. Approx 2/3rds within centralised communicative network**

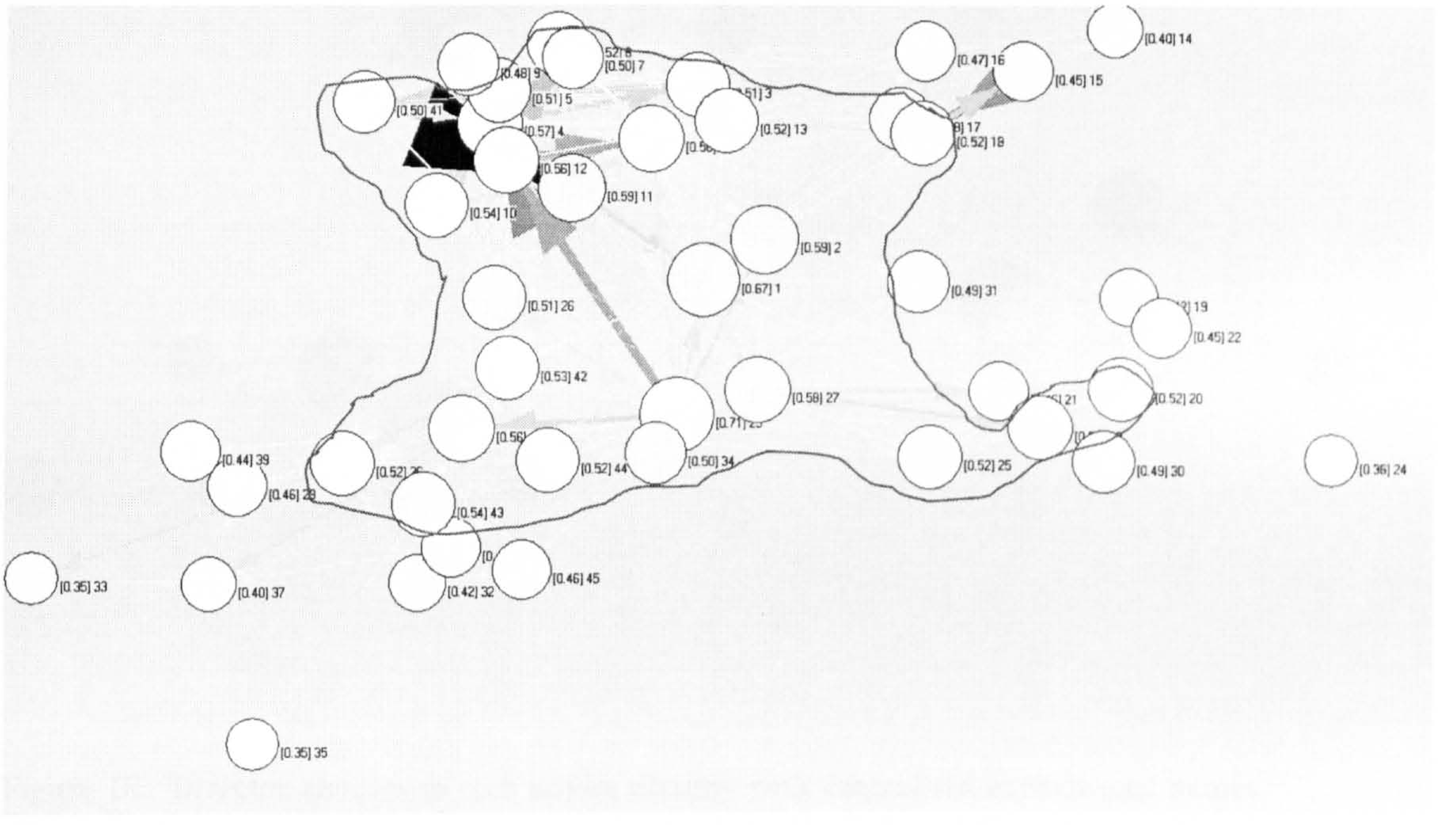


**Figure 17. Director structurally close to HOSs and QM**

In looking at the distance between one vertex and all other vertices in the FSL network, one can work out who that vertex is directly connected to. In using the concept of distance to find out who goes to who during advice seeking, one finds that the Director has direct contact [distance of 1 – yellow spheres] with all management and including up to 50% of all the scientists who happen to have many years of experience on average as designated by the diameter of their yellow spheres [see Figure 18].

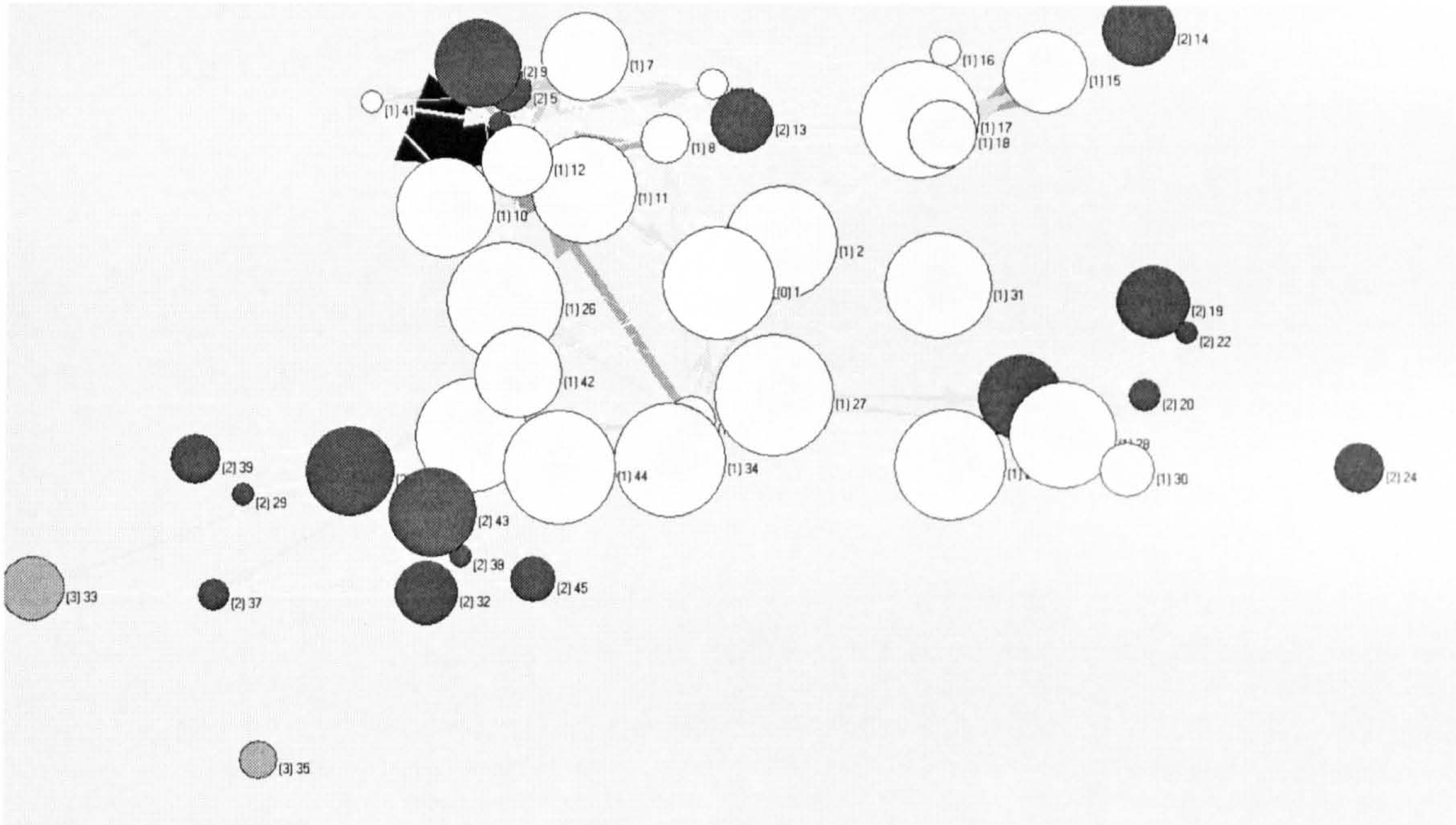


**Figure 18. Director chooses to seek advice directly with centralised experienced actors including all senior management.**

Contrasting with the structural managerial dimensions, Georgina [actor 7] shows that as a member of a particular community of practice, she shares knowledge directly with only those colleagues within her own Biology community and an individual in DNA, and does not have direct contact with her Drugs colleagues [see Figure 19]. It is obvious that she is bounded within her particular community [line circle]. The Director and the Deputy Director also appear within her direct contacts as a result of her function as a senior member of staff.

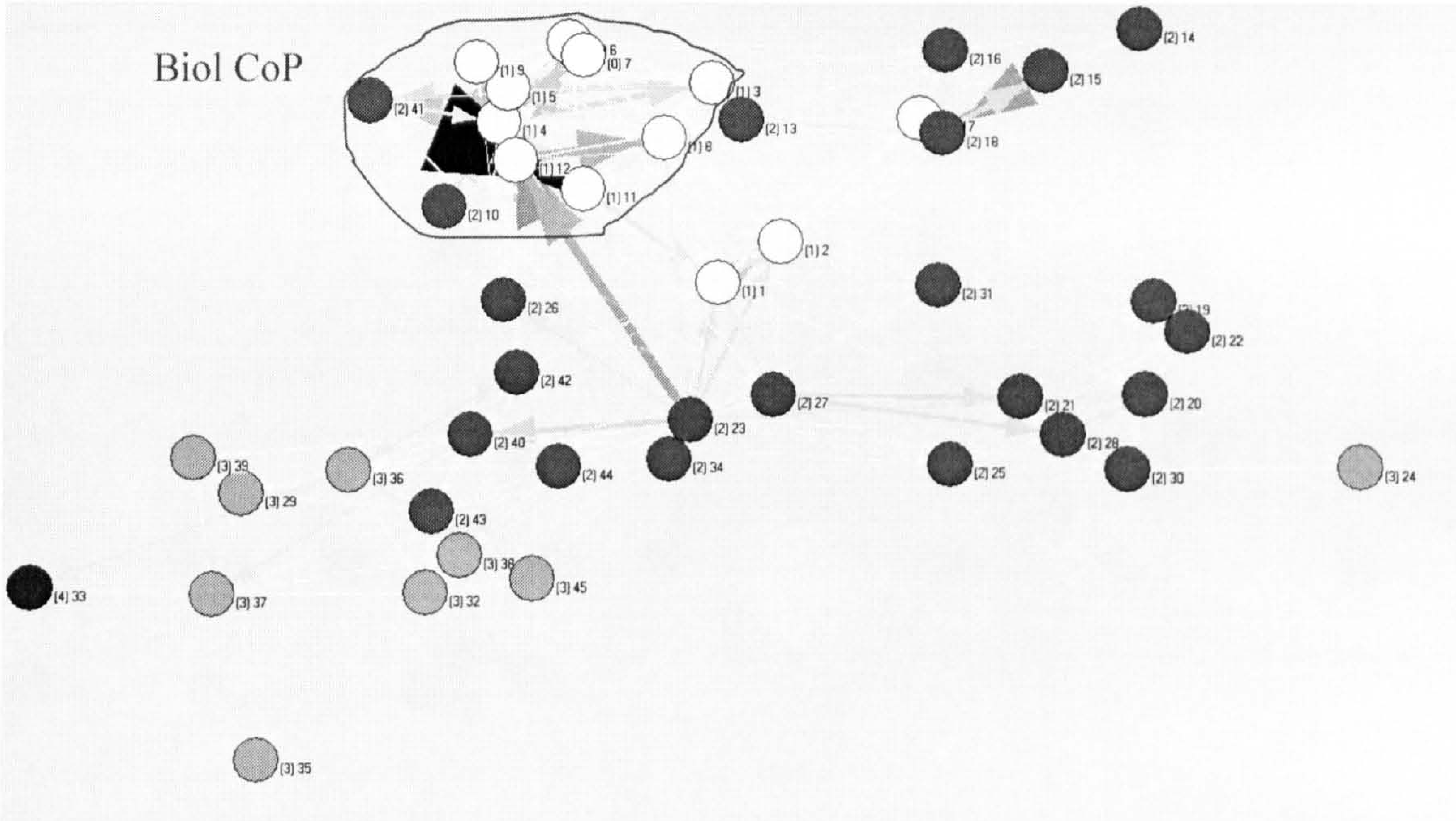



**Figure 19. Actor bounded within a COP community.**

A good managing head of section would have direct contact exchanging tacit knowledge through advice contacts with his/her colleagues as is the case with Keiran [actor 11] who has direct contact with all the actors in the Biology community of practice he manages [see Figure 20], as opposed to the Chemistry head of section [actor 26] who has direct contact with none but two of the Chemistry community he is in charge of [see Figure 21] – showing the evident difference between being structurally directly connected because of his head of section office [see Figure 17], but not directly connected with his community through relational advice networks.

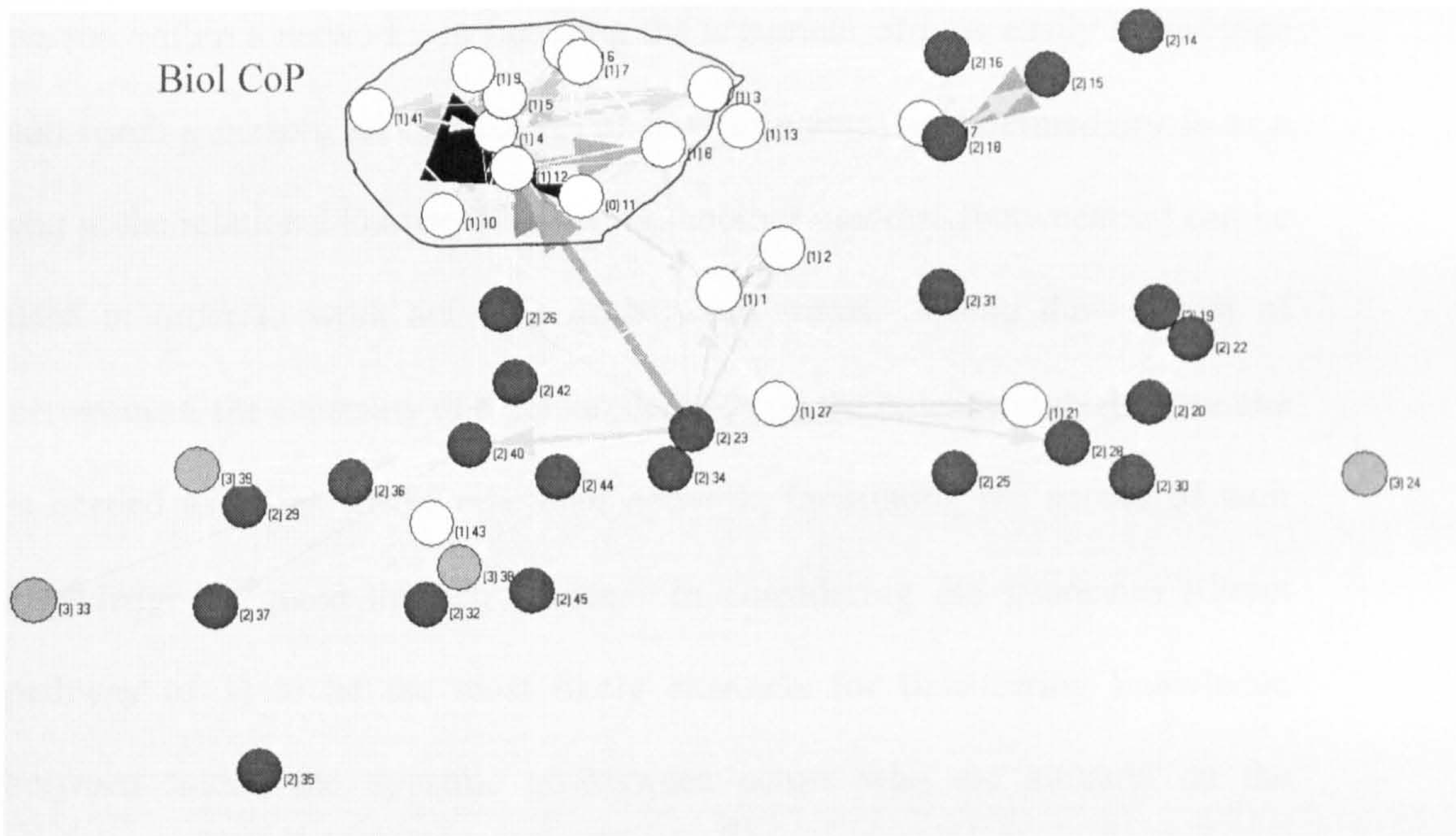



**Figure 20. Far reaching effective manger of a COP**

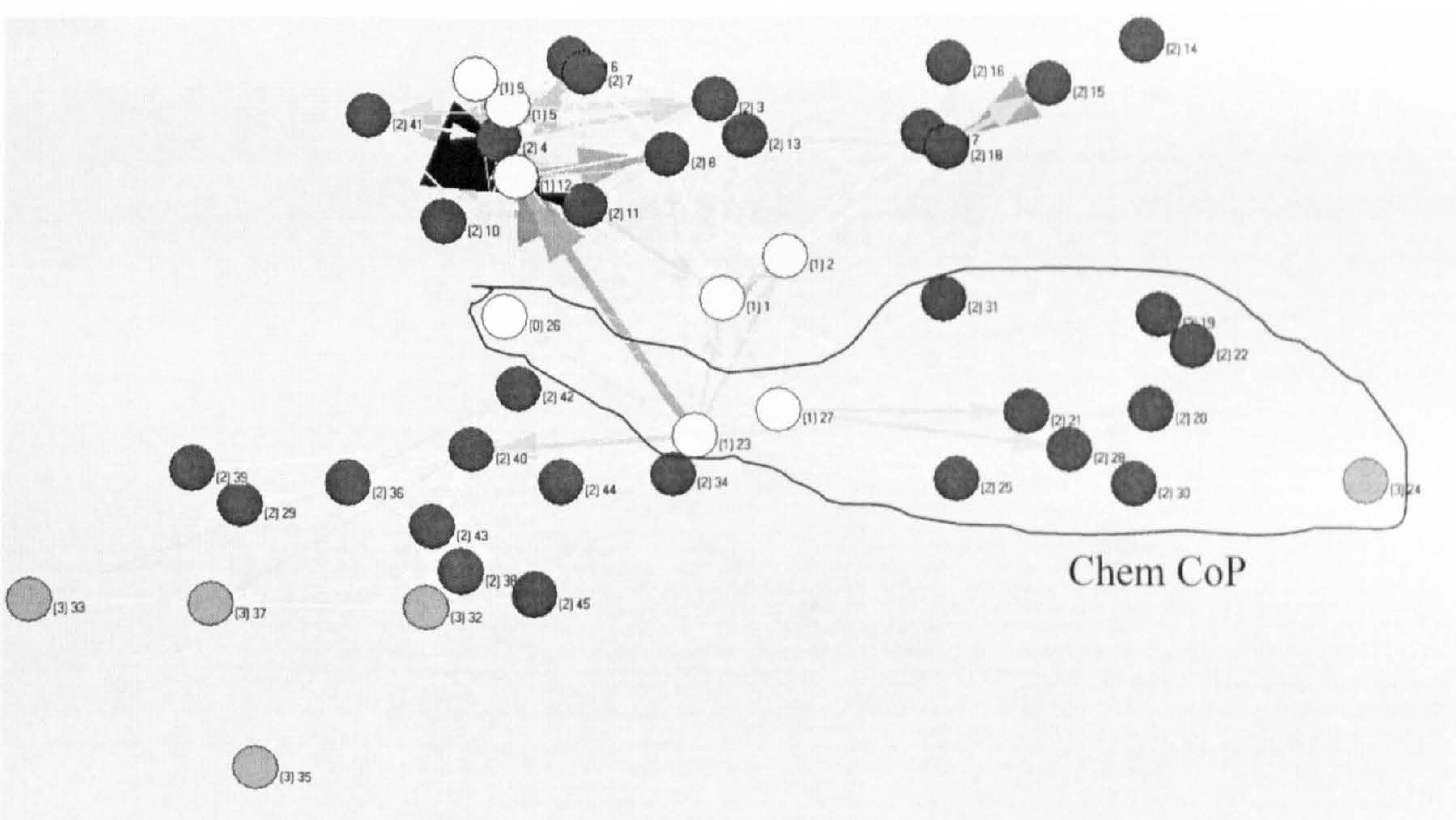



**Figure 21. Manager needing improvement in direct contact with target COP**

As already shown, degree and closeness are based on the reachability of a person within a network. In finessing the argument of how easily knowledge can reach a person, taking account of how important an intermediary is as a cog in the relational knowledge network, another measure [betweeness] can be used in order to work out their go-between status. Using the concept of betweeness, the centrality of a person depends on the extent to which he or she is needed as a link in the relational network, facilitating the spread of tacit knowledge as given through advice. In considering the geodesics (direct pathway of 1) to be the most likely channels for transferring knowledge between actors, the dynamic go-between actors who are situated on the geodesics are very important in the flow of knowledge (de Nooy, Mrvar, & Batagelj 2005). The betweeness centrality of a vertex [actor] is simply the proportion of □uspect□s between pairs of other vertices that include the vertex.

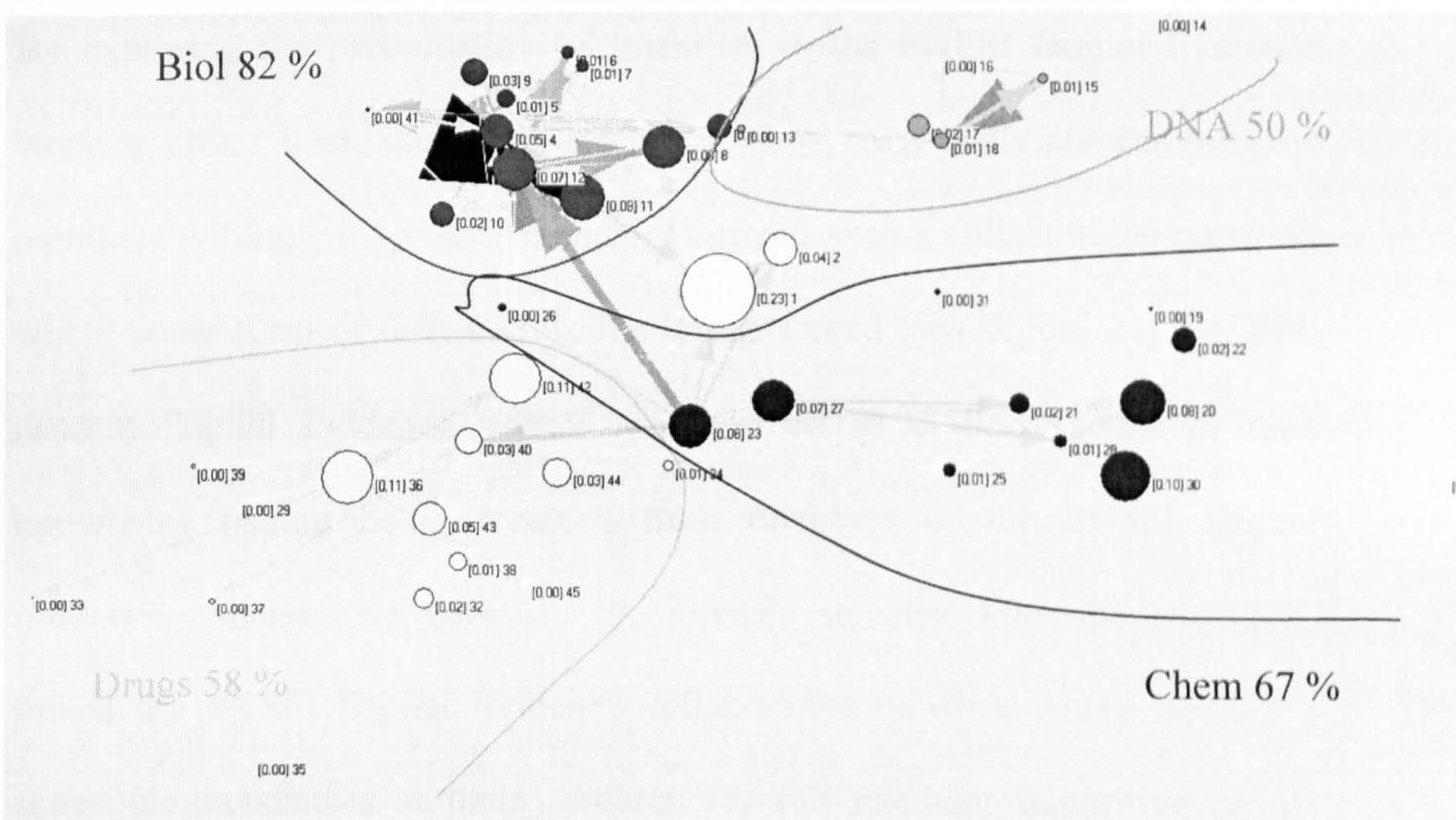



**Figure 22. Betweeness scores within whole FSL network**

The actors within Biology and Chemistry have relatively high betweeness scores where 82% of the Biology scientists and 67% of the Chemistry scientists score in the positive. This would be expected because of their more qualitative work requiring them as links in their knowledge referral advice networks, whereas with Drugs [58%] and DNA [50%] scientists, their work comprises more quantitative analytical work, requiring less advice seeking where their processes can be carried out in stand alone fashion.

***Collaborative Networks of Practice***

Outside of their own local communities, shown here is how forensic scientists gain access to new tacit insights through their participation in professional associations and their respective conferences.

i a quantitative network view

By exploring the participation of scientists in the ENFSI Digital Evidence working group, using quantitative network maps, empirically one can see how members willingly help other members through such a collaborative network, where some form of tacit knowledge is exchanged [see Figure 23]. A FSL nascent Digital Evidence service was formed as a direct result of tacit knowledge having being received from members of the ENSFI Digital Evidence collaborative network. A forensic scientist from the Irish FSL joined the ENSFI Digital Evidence collaborative network where through a series of attendances at their conferences, and resultant inquiritive emails began to receive tacit knowledge from contacts within. From participant observations it was found that the majority of knowledge that was required to be able to set up the FSL's digital evidence service was of a tacit face to face nature. A proper functioning laboratory would not have been set up were it not for the attendance of the forensic scientist for a full week at a laboratory in France [FR (1-4), Figure 23] and a full day at a laboratory in the UK [UK5]. At both laboratories there was extensive tacit knowledge captured through intense one is to one face contact. Likewise tacit knowledge from a highly experienced forensic scientist in the UK [UK 2] allowed robust quality assurance attributes to be added to the laboratory protocols, from face to face meetings at the network conferences [UK2a(way)] and through direct contact from a visit by the UK scientist to the local FSL community [UK2h(ome)]. Figure 23 shows the FSL forensic scientist [FSL a(way)] gaining tacit knowledge from members of the collaborative network [country code(n)]. The FSL forensic scientist [FSL h(ome)] brings back the tacit knowledge to set up a nascent digital evidence

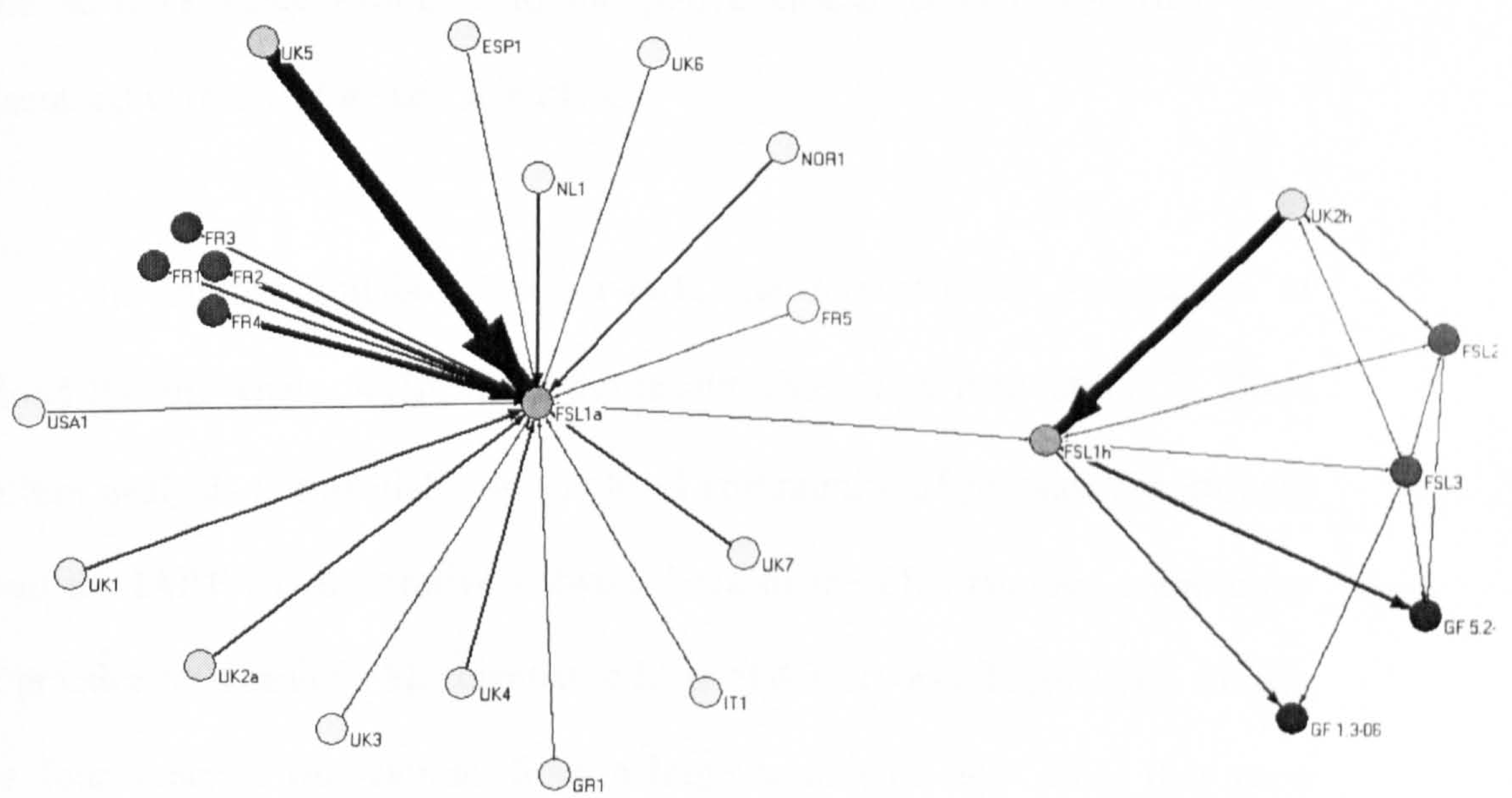



**Figure 23. ENFSI Digital Evidence collaborative network [left] – bringing back tacit**

**knowledge to the local FSL nascent digital evidence community [right].**

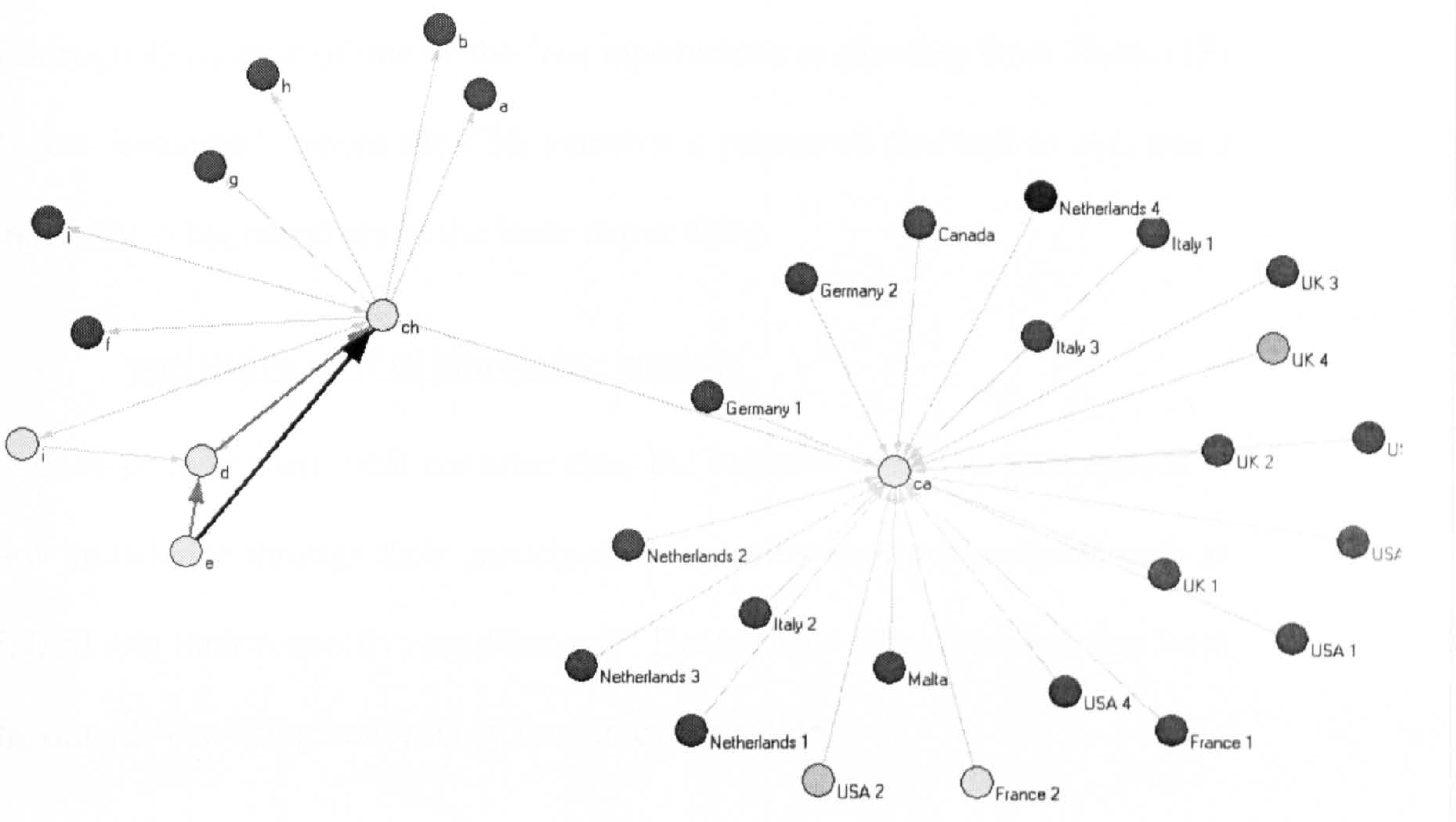



**Figure 24. IABPA collaborative network [right] – bringing back tacit knowledge to the local FSL biology community [left].**

Service and shares this knowledge locally with two colleagues [FSL 2&3]. The services made available to the police G(arda S(iochana)] 1&2 were discussed with FSL forensic scientists.

In another collaborative network, the International Association of Blood Pattern Analysis (IABPA), the results show how innovations in blood pattern analysis not available in the local community of practice are brought from the IABPA collaborative network back to the FSL Biology community of practice by a senior FSL scientist [c h(ome) & c a(way), Figure 24]. Shown are four separate innovations from a large wealth of new ideas that were chosen to be brought back [blue, green, turquoise, yellow discs]. Captured is the interaction of tacit knowledge exchange back at the local community as the new innovations are being brought back. Through participant observation a thorough discussion of one of the four innovations originating from France [Fr 2] was witnessed, where the FSL scientist *c* presented findings to *d,e*, and *I* and to the other members of the local community.

ii qualitative view of knowledge outside

Outside of their own local communities, the forensic scientists gain access to new knowledge through their participation in professional associations such as ENFSI and their respective conferences. The transfer of tacit knowledge from the outside can bring new energy into an organisation.

Nathan a senior grade scientist discusses the advantages of outside contacts from whom his can gain extra knowledge:

> Its good because you get an overview of what's happening around Europe, plus there's networking involved then...that you have a couple of contacts...even if you don't learn the stuff there, you learn of it from somebody that knows about it so that if you do need it further down the road, its just a matter of contacting them.

Troy one of those senior scientists that represents FSL on an ENFSI working group speaks of his own experience and his awareness of other colleagues who have attended such outside meetings. However, he is aware that it might be very beneficial for the individual involved but there needs to be a mechanism to pass it own to their colleagues back at FSL:

> Well I would say people acquire quite a lot of knowledge in terms of attending conferences and various things, particular ENFSI type stuff but to what extent that knowledge is subsequently passed on without you going and kind of querying a person, I'm not sure.

> In addition Troy would 'be more than likely to go to other

organisations' for the extra knowledge he seeks as the scope is beyond the repository of knowledge held at FSL. He expands:

> Certainly if I'd thought anybody in the lab had the information that I wanted then I'd have had no problem going to them, but I suppose because I've been here a comparatively long time, I tend to be mainly a donor rather than a receiver within lab knowledge and, therefore, the longer you're here the more likely you are to have to go outside to get the extra bit because you've supposedly haven't got [the knowledge yourself].

Isabella, who serves on a UK/Ireland collaborative network, is happy with the standards of knowledge that she can get from her own FSL colleagues but she does recognise that knowledge from the outside is trickling in:

> I think a lot of it is within the section but certainly there is a lot more recently from outside the section. Like the Body Fluids forum is a great way of gaining knowledge and hearing about situations that other people have been in and how they have dealt with them. So I think increasingly we're looking outside.

Georgina has experience of knowledge flowing back into the organisation from the outside:

> I think we get a lot of information from meetings and things like that and that advanced BPA courses I think has been very useful.

Dylan taps the outside knowledge available to him for any innovative developments back at FSL:

> In some instances I would call upon my colleagues in the academic world in relation to certain questions I would have, certain possible new technologies that might be used or people who are experts in certain fields that we are only beginning to look into in the laboratory.

He also speaks of learning from the neighbouring country forensic scientists:

> I think also what has really helped that whole idea of learning in the laboratory has been the changes taking place in the UK in relation to report writing and actually forming opinions prior to that and the new technologies added to that immensely

Brianna an executive manager speaks of the early days at FSL where individuals depended on help from the outside:

> I go outside the organisation for forensic, yes, very much so. No, I mean we started with very little knowledge here. When I started in the early days so we were constantly looking out and trying to get information from anybody we could. We built up a lot of contacts in other organisations...

These insights demonstrate how tacit knowledge is brought from the outside back to within the organisation and as visualised in the network analysis of the IABPA [Figure 24]. The advantage in having been involved in such collaborations is that the forensic scientist feels that they are working on a par with the best practice in Europe, stating:

> ...now we are as experienced as they are ...

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Qualitative view of knowledge outside]

iii <u>yielding gatekeepers</u>

Gatekeepers to the outside world are valuable assets to an organisation that is continuously innovating and updating their technologies for efficiencies in their operations:

Adam reflects the role of gatekeepers with regard to the knowledge that they possess:

> There tends to be people who are acknowledged as having a deeper breadth of knowledge in the section in certain areas but they would generally fall into the people of are on the ENFSI Working Group Committee in that they have [come back with a knowledge] outside the laboratory in what the wider world is doing in the area and should feed that back, I suppose, at section meetings.

Troy as a gatekeeper outlines the steps he takes when he seeks to bring in new knowledge to FSL:

> There are cases crop up where you need to use researchers or contact colleagues in other countries sometimes to see if they've experienced a particular situation and can they give you any diagrams for it or shortcuts, I suppose, rather than us they may have experience on that kind of case or some type of material before, which would allow you to piggyback on their knowledge, their experience.

Again Troy gives a good example of a gatekeeper in action, being able to coordinate new knowledge streams and importantly helping to solve problems at the local level from knowledge gleaned from outside:

> A lot of them I would have come across in various ENFSI groups or at meetings like that. It happened in a case in point last week. The document section brought over some stuff here for examination that they were having difficulty in analysing and because I'd dealt with inks and things in the past, they came to me specifically. I took the case and it was a case of fraud involving post office documents and I tried a couple of things here which didn't work and then I thought maybe they've encountered this because the suspects they think might be Eastern European. I contacted a few people that I'd came across in the ENFSI documents group – one in the Netherlands and one in the UK to see if they'd come across a process like this before because I know the documents people...I got some help from them.

Monique a gatekeeper in the molecular biology area uses her contacts outside to be able to screen out companies who are offering new production technologies that are complex and need users' testimonials to help wade through the commercial claims:

> Because I want to talk to people who are using it, the companies are telling me the good points but you need to know is it user friendly, what is the down side of it etc.

Alice an executive manager and senior gatekeeper sees the need for outside knowledge to invigorate the organisation and reflects why she seeks it from outside:

> I'd say as time goes on I'd probably go out more, not to the exclusion of internal checks but I'd probably seek information more outside the

> organisation...In terms of pure forensic science, traditionally I'd have gotten quite a bit of that outside the organisation as well. I noticed, whether it's arrogance on my part or a reflection of age and god knows what, there are fewer people who's opinion influences me as much as they used to.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Yielding gatekeepers]

# 5 RESULTS – TACIT KNOWLEDGE RELATIONAL DIMENSIONS

## *Relational environment in which tacit knowledge is transferred – a quantitative graphical view*

On interviewing the twenty-eight forensic scientists [see 3iii Interviewing], the following graphs represent a compendium of the egocentric view of the advice capabilities of each of the interviewees. Each drew on a blank canvas where they placed themselves in the organisation when they gave or were in receipt of advice. The majority of the individual egocentric graphs drawn by each interviewee gave a localised view of themselves within their respective communities. They put themselves in a natural pecking order where in the main those more experienced than themselves gave advice and those less experienced than themselves were in receipt of advice from them. This can be seen clearly in the organisational graphs of combined egocentric advice networks [see Figure 25-Figure 28]. The different shades of green are representative of the scientists' grades where clearly it is seen that advice is not mediated by the organisation's structural bureaucratic order but by the relationship of experience. If it was based on a structural dimension, each grade would only seek advice from others within the same hierarchical grouping, such as grade Iis with grade Iis.

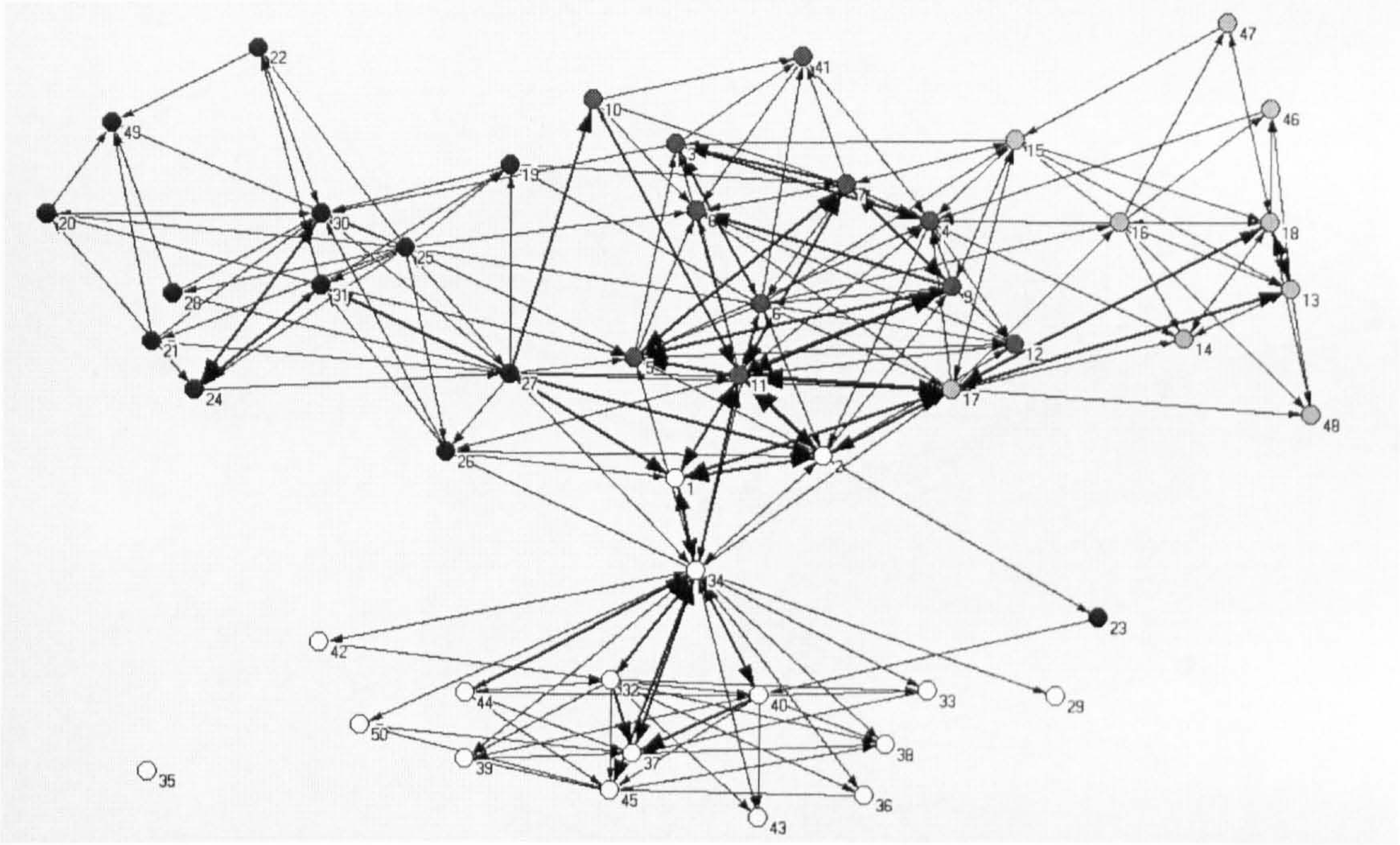



**Figure 25. Advice relations based within a relational network mediating tacit knowledge transfer Spring 2007. Blue (Chemistry), Red (Biology), Turquoise (DNA), Pink (Drugs).**

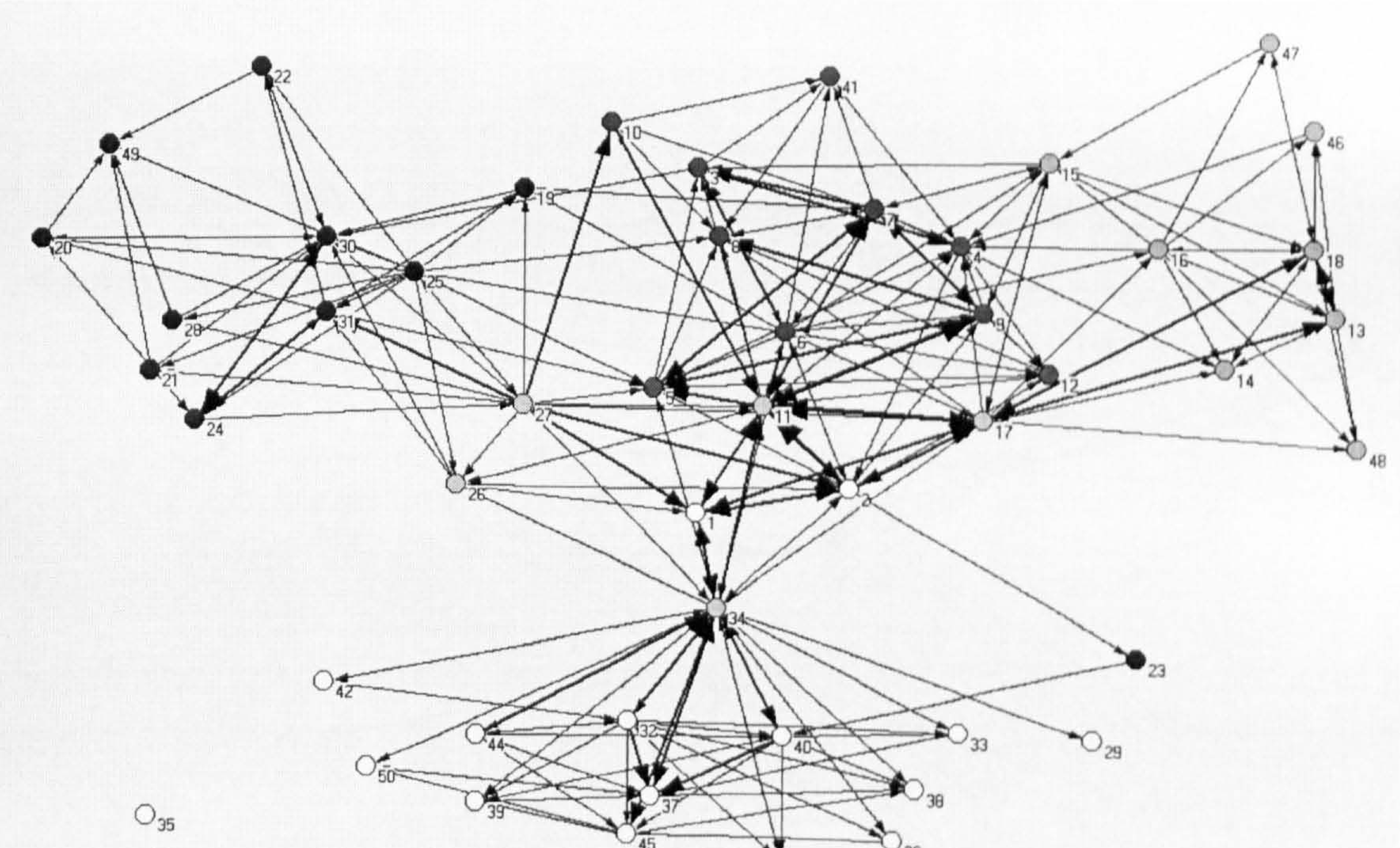



**Figure 26. Advice relations based within a relational network mediating tacit knowledge transfer Spring 2007. HOSs**

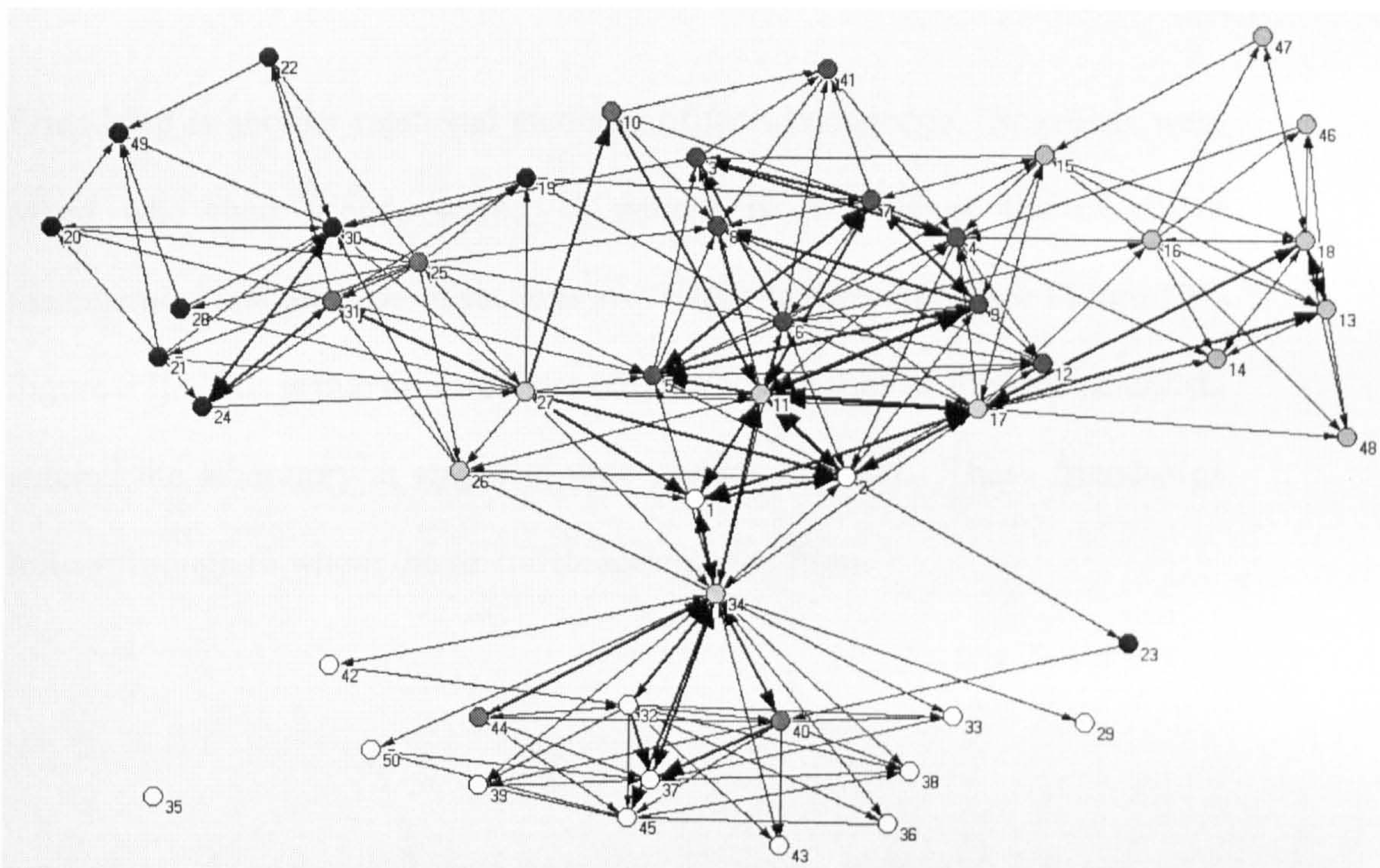



**Figure 27. Advice relations based within a relational network mediating tacit knowledge transfer Spring 2007. HOS & G1s**

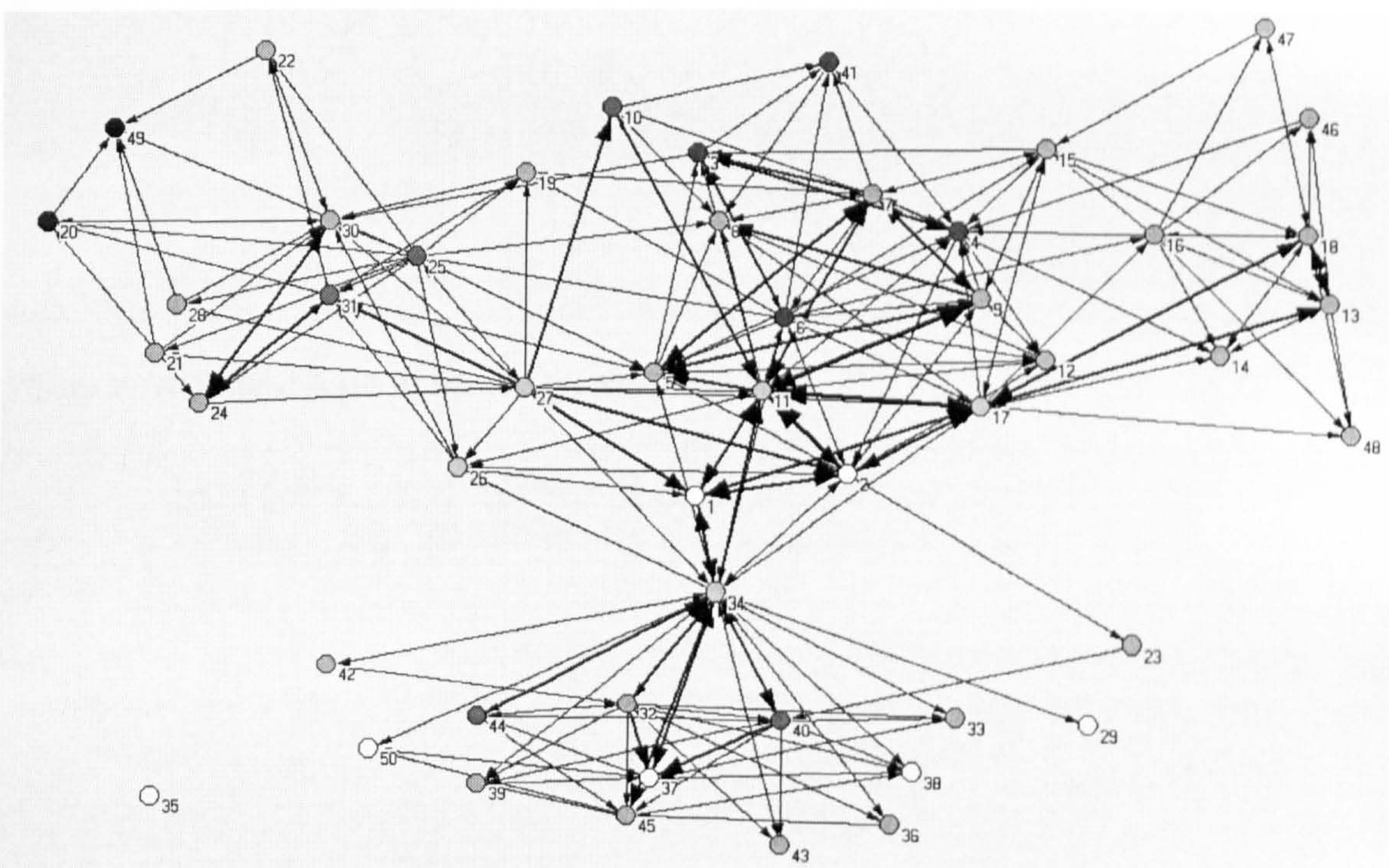



**Figure 28. Advice relations based within a relational network mediating tacit knowledge transfer Spring 2007. HOS & G1s & G2s**

Friendship is another relational mediator of tacit knowledge. Scientists were asked who their friends were. A pattern is seen where the executive management and the head of sections are friends to each other [see Figure 29 – Figure 32]. This is due to the cohort effect where groups of forensic scientists entered the laboratory at stages in time periods together. These friendships follow through to whom the scientists seek advice from.

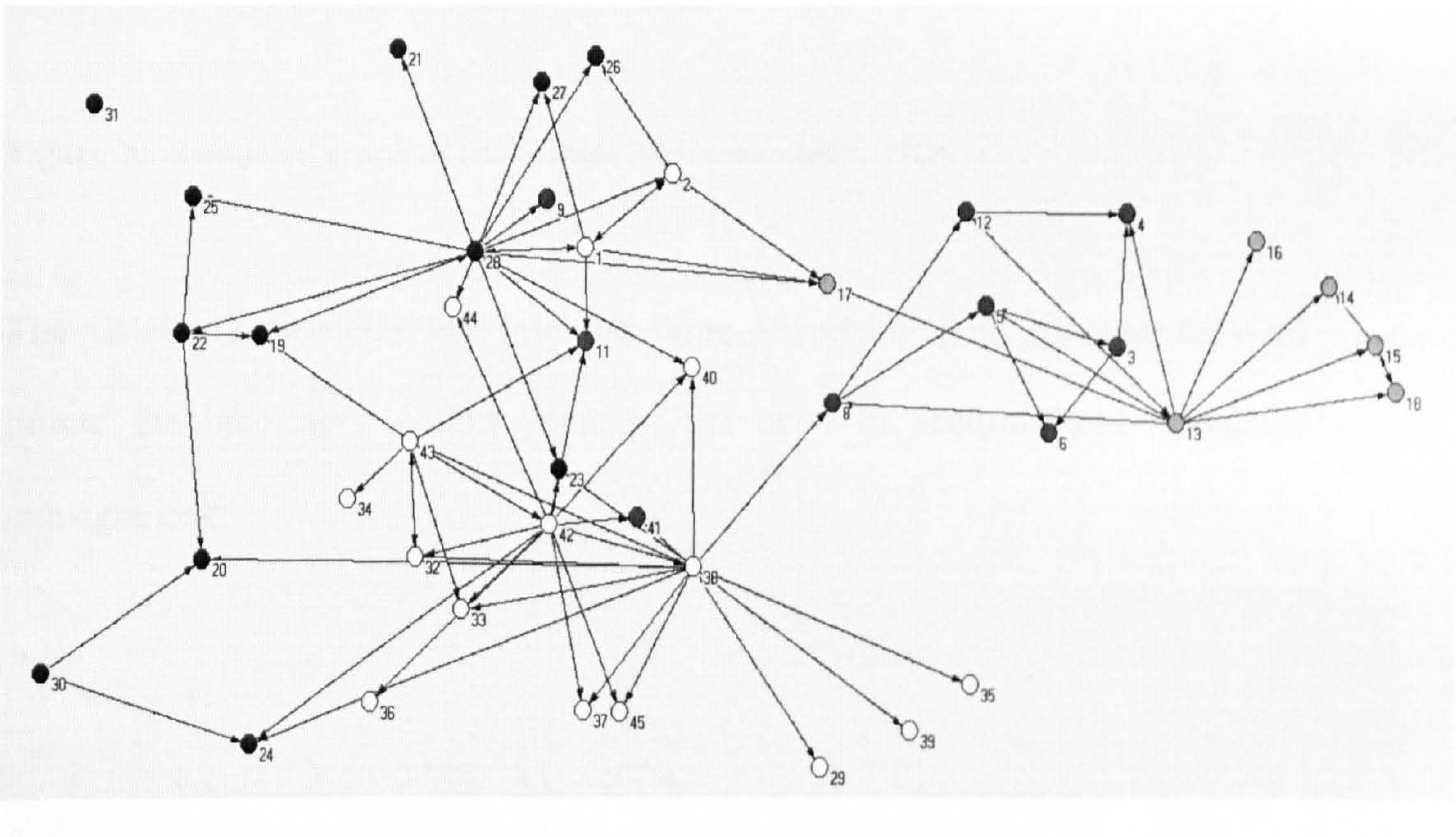



**Figure 29. Relational graph of friendships November 2005.**

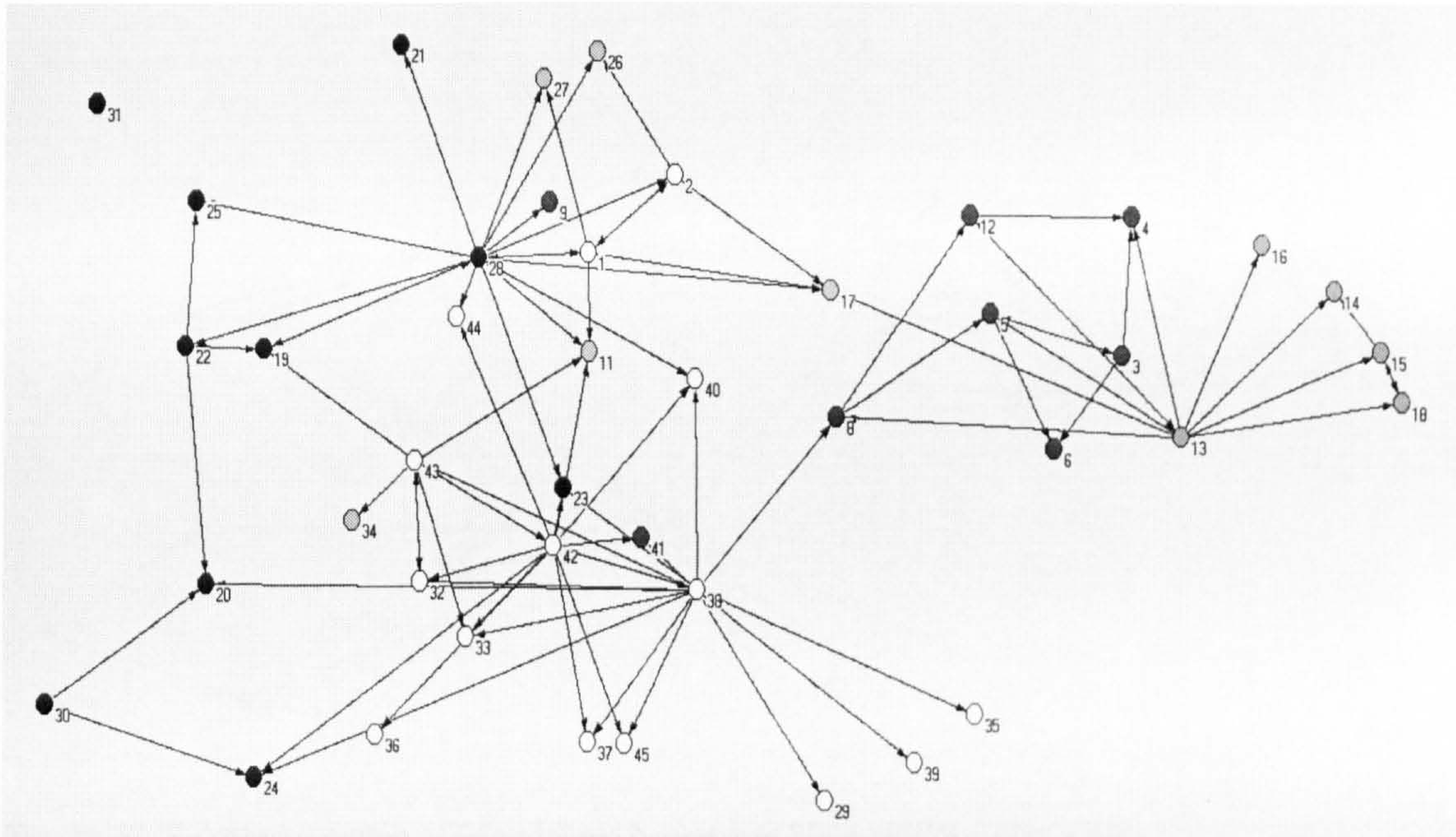



**Figure 30. Relational graph of friendships November 2005. HOS**

The Grade 1s similarly fall into the same friendship pool because they all joined the laboratory within years of the head of sections and executive management.

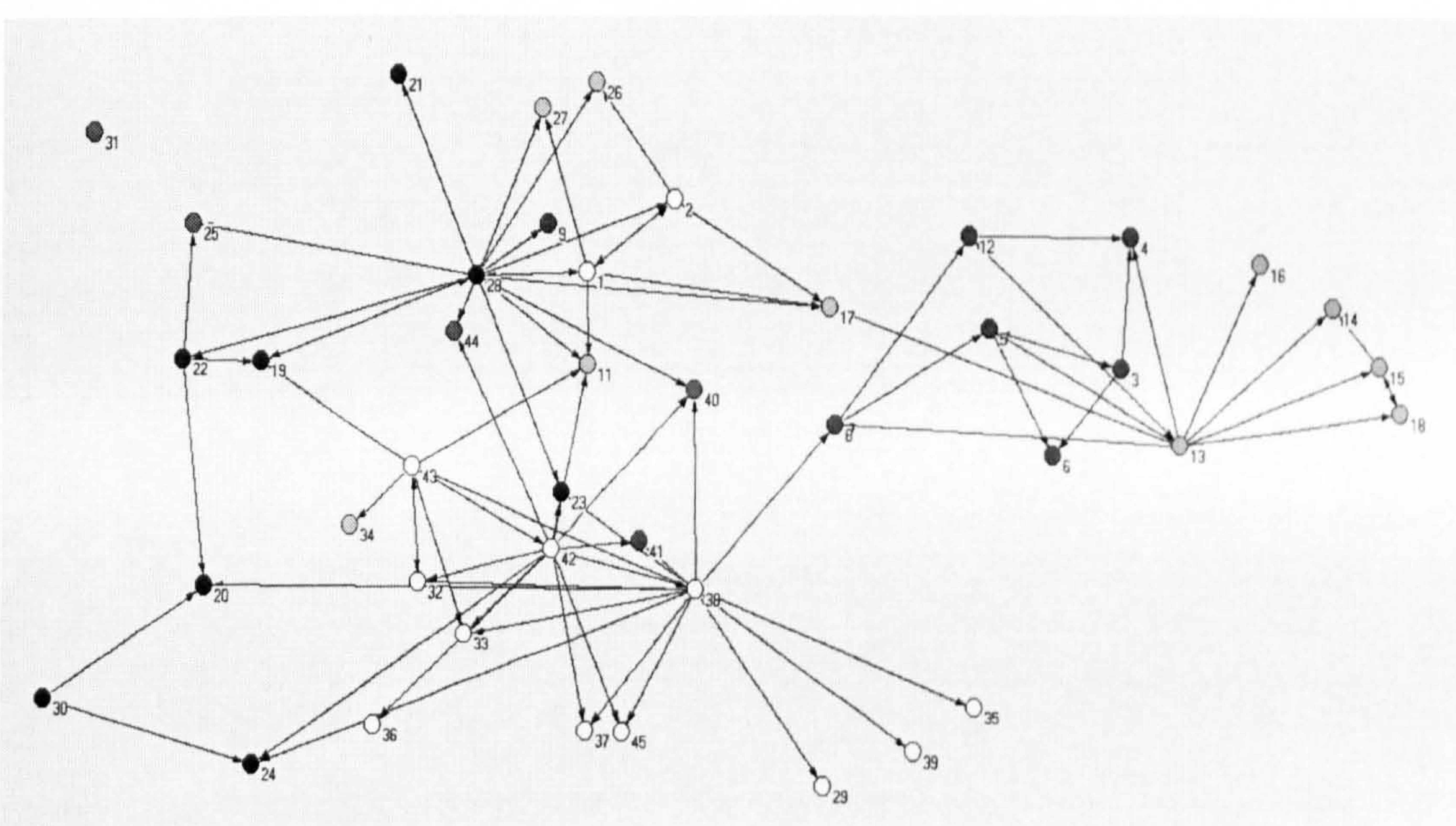



**Figure 31. Relational graph of friendships November 2005. HOS + G1s.**

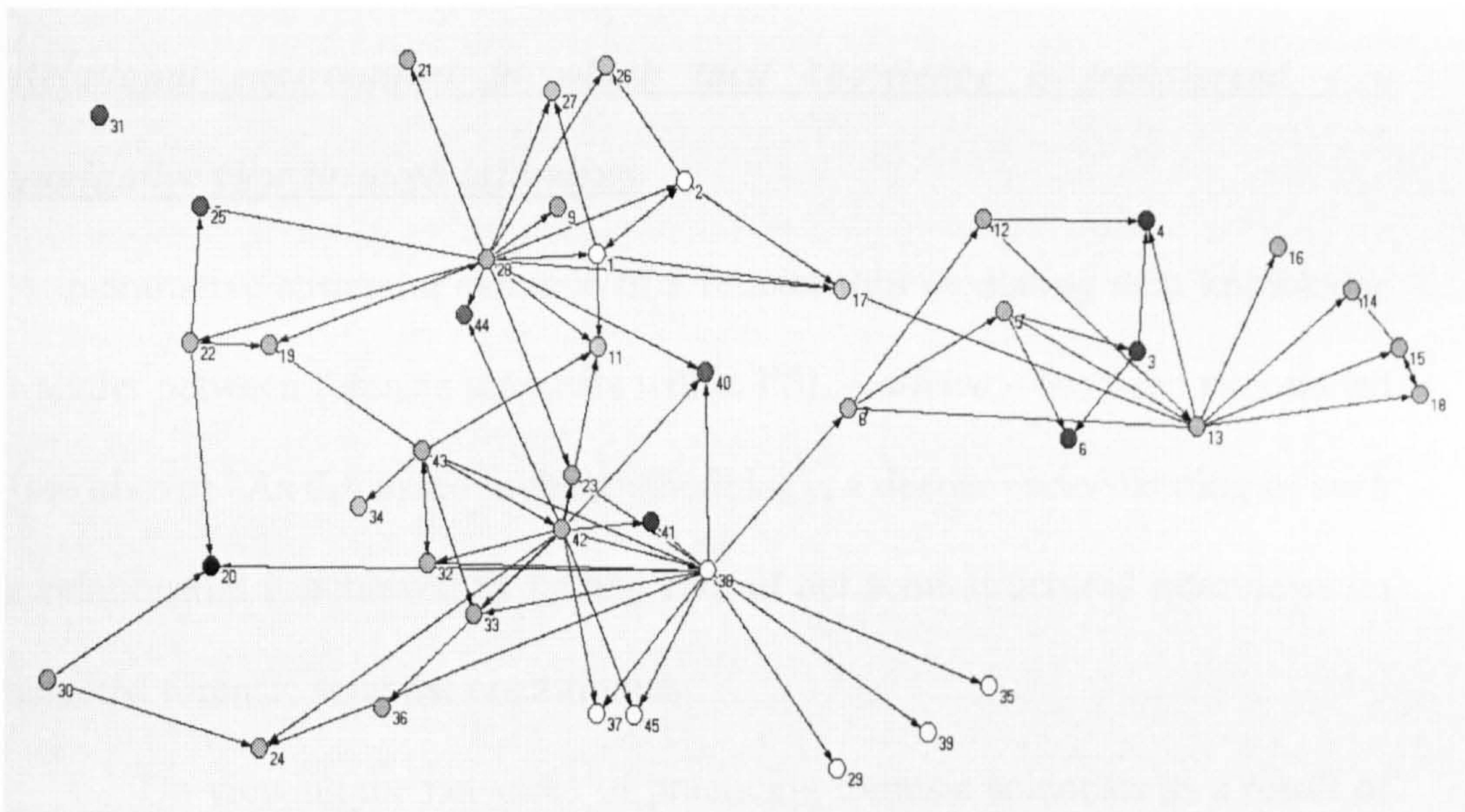



**Figure 32. Relational graph of friendships November 2005. HOS + G1s + G2s**

The Grade 2s are a different cohort to the grade 1s and managent as seen by their friendships more between themselves than with the others.

***Relational environment in which tacit knowledge is transferred – a qualitative view through interviews***

A quantitative structural example of a relationship mediating tacit knowledge transfer between forensic scientists within FSL – *advice* – has been expounded [see above]. As discussed in the methodology, a deeper understanding of such a relationship is achieved by having carried out semi-structured interviews on selected forensic scientist practitioners.

On viewing the networks of practicing forensic scientists as a result of their carrying out the production process of ultimately yielding the case report, I now set out to understand the means of how and why such processes require the functioning of such relational tacit dimensions of knowledge in the local collaborative community of practice networks. I intend to explore the relational dimensions mediating tacit knowledge exchange. Typical of communities of practice, Wenger informs us that it is practice that is the source of its own boundary, where participants form close relationships and develop idiosyncratic ways of engaging with one another (Wenger 1998).

A unifying concept of the knowledge and learning gained through participant practice, is its construction from 'relations among people engaged in an activity' (Osterlund & Carlile 2005). From practice to participation brings about the concept of relationships (Handley et al. 2006). The social actors within such communities of practice rely very heavily on their network of relationships to find information and solve problems (Cross, Borgatti, & Parker 2002). These crosscutting personal relationships develop over time and provide the basis for trust, cooperation, and collective action in such communities. The nature of the relationships in the social structure leads to certain benefits for the participant actors. Understanding the relational processes and the properties of the relationship necessary to transfer knowledge is important in acquiring tacit knowledge (Collins & Hitt 2006). This relational thinking concept falls well into the already discussed theory of Lave and Wenger's (1991) situated knowledge in communities of practice, where knowing and learning are constructed by relations among actors engaged in an activity.

As mentioned in the introduction there is still a very much tacit element attached to the process which has been overlooked. In the section ahead, I intend to show what happens to the fully functioning practising expert: how does he/she gain or indeed give knowledge often of the tacit nature during the course of their relationships with each other; and what are these relationships when they carry out the processes of their work.

### i Processual relationship amongst actors

At first sight the standard operating procedures can seem quite complex, primarily due to the fullness of explicit details pertaining to each individual step within the overall procedure governing a particular process. Supposedly the SOP should be read in its entirety allowing the resultant carrying out of the process without the need of seeking clarification or advice from fellow scientists who have already practically accomplished, sometimes over years of practice, the carrying out of the steps detailed. As work within this organisation cannot be carried out without the completion of the standardised processes, the significant dealings around the carrying out of the process ensures that process in itself becomes a relationship between the forensic scientist practitioners in this case study.

Georgina who always without fail frames her work to reach the stage of whole case completion, recognises that she should seek advice from others in order to put the finishing touches to a process that is out of the scope of her own expertise:

> If it's technique, normally where I would seek advice, I would be "I really haven't a clue" you know, it might be procedure or something that is out of my scope. I might feel that paint might be important here but I don't have the standard procedures to do the analysis, so I need to go and talk to an expert, this is out of my scope completely.

Dylan, a recently recruited forensic scientist whose innovative ideas and refreshing process views of casework have been a valuable addition to FSL would seek advice with relation to process, but tells us that there is more than process advice to take from members of FSL.

> What triggers me to go and seek advice? Naturally it would be if I didn't know how to proceed with a certain thing within the laboratory or if I felt that I needed to do something other than what's in the standard operational protocols but I don't tend to see it as seeking advice, I tend to see it as forming, getting other people's opinions and then developing what I feel would be best practice and that might not necessarily be in the standard operating procedures, and it would be for me from getting people's opinions in relation to seeking advice.

Nathan comments on why advice is sought by those who during the carrying out of a procedure may come across something that needs clarification:

> Well usually if they come up with something unusual that's not covered by the SOP, that would be the most common reason they'd come asking you, or it could be just out of...I won't say laziness is the word...rather than go through the hassle of having to thumb through the SOPs...if the person standing beside you is more experienced – just ask them – they might be able to tell you straightaway. It's probably more efficient to sometimes do it that way, you know.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Processual relationship amongst actors] ii Experiential relationship amongst actors

A forensic scientist's need is to collaboratively confer with a fellow forensic scientist who is higher in the pecking order, who has already experienced through their own years of practice, the answer to the question that they seek. In pulling from another's experience, an individual is tapping their tacit knowledge housed in their brain, such as expertise or professional insight formed as a result of experience (Woo et al. 2004). Hence, as seen from the following interview excerpts because experience itself is treated with deference becoming a reified trait or as a measure of an individual's ability, experience is chosen in this research as a relation between actors.

Jake chooses individuals based on what they have previously worked on:

> 'I would be looking at the more experienced people in the lab and what they were working on', and would select the person he asks by establishing that 'this person has probably worked on something similar'.

Francis likes to hear of others' experiences, soaking up their advice:

> You would definitely be interested and listening and using other people's experiences as well because obviously working on casework for a number of years and things cropping up or coming up and things you mightn't have thought of, so it would definitely be interested if somebody's talking about their case or whatever

Julia, a senior grade forensic scientist does seek advice from those who have the most experience but differentiates that from the length of service that a scientist has spent at FSL:

> Go to people with most experience, not necessarily choose somebody with fifteen years over ten years.

Nathan, a senior forensic scientist recognises that advice is sought for:

> reassurance sometimes, especially with the junior people. They're probably doing the right thing but they just want somebody to put their mind at ease that – yes – that is the right thing to do.

The relative inexperience of a scientist is not directly related to that person seeking advice to help assist with the carrying out of the process. Highly experienced forensic scientists also seek advice but for more robust reasons – that of checking the integrity of the outcome of one's thoughts as opposed to a simple process addendum. Isabella, a very experienced and one of the most senior scientists in her section explains:

> When I have a conflict in my head I suppose is the main thing when I think, Oh it could be this, and that might be the easy one, and that might be the road I would be tempted to go down, but maybe it would be something else, so I really should get somebody else's opinion on it.

Importantly, Ella clarifies what she means by experienced as it different to the length of time somebody has served.

> If I was so less experienced it would have been the most experienced I would have asked but not the person here the longest. I want to make that distinction. There is a distinction from being here a long time and the way a person works and being most experienced. So that person is here and has done the most amount of cases, they're here the longest, but they're not as experienced in certain aspects of work. So I wouldn't ask them.

Aoife, an experienced forensic scientist appreciates the need to confer and seek advice during the stages of her carrying out her analytical processes:

> There might be little nuances in cases that you might have a doubt over and you'd like another person to have a look at it, as a second opinion, just to see are they thinking the same way you're thinking and, if not, why not, and what validity their opinion might hold.

Troy mentions that length of service could be looked upon as a proxy for experience:

> There is a relationship of sorts there, in that I suppose particularly in the kind of cases where people will come and look for advice, there might be the more unusual ones where something has cropped that

> might come in only once every couple of years and the longer somebody is here the greater the chances are that they would have encountered that one or more times already, and therefore its not particularly a thing to do with kind of longevity or anything like that, but its just that because they've been here longer, their more likely to have encountered this before.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Experiential relationship amongst actors]

### iii Capability relationship amongst actors

Individuals go to those recognised as being capable, where they have the ability necessary to do something or have a particular talent or acquired skill. Such capabilities are also known as competencies, a measure FSL uses in judging whether scientists are able and fully trained to carry out a predefined set of procedures set out in standard operating procedures.

Capability is slightly removed from experience which is related to time – the knowledge of and skill in something gained through being involved in it or exposed to it over a period of time. Capability has more practical undertones.

Set out in the selected interview excerpts below, one sees that competency capabilities feature prominently in an individual's judgement of others and as a result capability/competency is chosen as a relation that mediates between actors.

Nathan would be aware of the individuals who possess the knowledge needed to help for his particular query:

> I'd probably seek out the one I think knows most about it. I'd be aware that there are certain people...that there's different levels of

> knowledge in different areas – like if I need to know something legal I'd probably go to herself, or something about quality assurance, I'd go straight to her.

Monique would know of someone's abilities and then ask them if deemed that they can be of assistance to her:

> But if I know that somebody has an expertise in an area I think they might have, I certainly will go and ask them. I think some people have strengths in different areas. Yes I think people have different strengths and I am not sure why. You know, I don't know whether it was an affinity for a particular area or that they maybe developed a particular area, you know brought something on stream and therefore obviously had to deal with all the pitfalls along the way.

Georgina, who herself is very confident would not approach an individual who is not able to help her:

> I'm not gonna ask a person who isn't competent to do something

Francis shows the judgement process she makes in deciding who to seek advice from when the knowledge she needs is not as straight forward:

> you perceive...their...expertise and experiences in the area and approachability and I suppose it would depend on how complicated a query you had. Maybe if it was something more straightforward you'd be quite happy to consult [anybody], but if it was something that was really complicated you'd go to somebody else [with that specialism].

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Capability relationship amongst actors]

### iv Mentoring relationship amongst actors

As newly qualified novices enter their profession they need to consolidate their competencies under a mentoring system. Indeed the mentor relationship shared amongst forensic scientist is very apparent and is the crux of how new entrants who may be academically highly qualified become practically functioning forensic scientists. A sample of excerpts is presented, but the mentoring relationship is dealt with elsewhere [see LPP – a qualitative insight].

Brianna is a member of the executive management team having previously served as a head of section and a forensic scientist who has had the experience of completing the most serious of cases. She very much invokes the idea of scientists to actually seek advice in the process of them finally out putting their case reports – after all that is what they have been trained to do:

> I think the fact that you know ultimately when a scientist hands in their report for checking they are saying this is my opinion, I am prepared to stand over that. So you have to make sure that you've got all the information you need to know what are the limits that you put on the information that you are giving out to the customer. And it is the ability to know what those limits are I think is what we are training people towards, is to know when they can, how far they can go with something, or what extra information they need to get to be able to say, to go further perhaps than we would normally in a case, or they would normally in a case, and to know which people to consult and where to get the information from

Francis, having built up a professional relationship with Georgina through the successful training regime in turn still seeks advice from her:

> I felt there was a good kind of mentoring system and Georgina being my trainer, she'd be the point person I'd go to and I think there was a bit of that, the person who trained you is the person you kind of go and bug, that's the wrong word to use but you go and ask their advice.

### v Casual relationship amongst actors

As discussed in the literature review casual renewal of acquaintances at coffee or at the water cooler are well known sites of informal but highly important for knowledge diffusion. The sharing of tacit knowledge requires such interaction and informal learning surroundings typically found in a community of practice setting [see yielding a community of practice concept]. Hence this type of setting can be attributed as an informal casual relationship mediating between individuals the business proceedings of the organisation.

Aaron has a knack for gaining knowledge of the tacit nature by keeping his ear to the ground:

> you would find like say if you're passing down the lab, two or three people sitting around and I'd be looking at a file or something or it could be something that maybe would be useful to you so you kind of earwig if you think.... It's casual, some people like talking to you... yeah, when people come across something new or different they tend to [mingle].

However he finds that finding those instances of knowledge pick-up are just sometimes difficult to come across:

> That's the problem though...I say it flows freely but just to have to seek it out like.

Nathan picks up knowledge from his chats with his colleagues:

> Usually from informal discussions...you'd ask them, how did you get on with the course and if there was something on the top of their mind or the tip of their tongue, you'd pick it up that way.

Because of his specialty field, Adam in the course of his casework would go to court more often than his colleagues to present his evidence in the witness box, sometimes spending hours being subjected to belligerent cross examinations. He has developed a nose to pick up valuable tacit knowledge which he gains from finding out what his DNA colleagues were subjected in their court cases:

> I suppose particularly in relation to Court probably in an informal setting you're going to hear it all...particular barristers' foibles, or particular judges' foibles...how somebody dealt with them, the kind of questions that were asked...it's transmitted on some level...so if you're going up before this judge, you might actually query the person – you

> know – you had a case there six month's ago, what kind of questions arose in connection with it?

Georgina who as a very experienced and most revered forensic science practitioner always sees the benefit of the collegiate atmosphere she tends to relay when her working practices are observed. She mentions instances of valuable learning for all:

> you know someone has a strange damage case or I had.....we've done it where you had a really good case, remember the BPA and I said to you "Jesus..., show that to people" and we all went....that type of thing, you can recognise something different, unusual.

Georgina continues, renowned for her insightfulness captures exactly what an informal environment does for the gaining of knowledge contrasting it with one that is more structured. It is never formally recorded – 'just casual':

> And it's informal because it's very important because when it's informal it actually will capture really important situations that aren't usual whereas if you have a structured environment, those situations are gone because you have to wait for it to happen at a particular time or a particular day and on top of that people are much more open to learn because it's pure system as opposed to....you know.

[For other similar subject responses, *See* Appendix: Edited sur plus Interviewee transcripts ; Casual relationship amongst actors]

vi Helping relationship amongst actors

Because of the helping culture that predominates where the reciprocity of such a noble nature is evident, the relationship of helping is deserved of its nomination as a relational transaction medium within process.

It is in Jason's own interests to be helpful because he relies on the return help from his colleagues. In itself the help offered allows for a gainful knowledge transaction:

> I'd be quite happy because I know that it could be me on the other end of the stick tomorrow and I'd like...it would be nice for somebody to stop what they're doing and say – oh, actually I can help you there...just simply do that and there you go...save you wondering about it for the next half hour.

Jake also speaks of the helpful culture that exists at FSL and has a grasp for how important such an atmosphere is for passing knowledge about:

> you feel, yeah, you've been helpful and letting them kind of progress as well. I same with myself, you know, you feel that everybody else has been very helpful to me, why shouldn't I be helpful to people who are coming up as well who are learning.

Aoife regards her section as one where forensic scientists can ask each other for advice with ease because of the helping culture that predominates:

> The Drugs section was very good at 'everybody helps everybody else out' so you would feel that you could go and ask anybody.

Troy does point out that there is a scale as to how individuals help each other, some not as free with their time as others:

> No, it is just human nature. Some people are more helpful and approachable than others.

Georgina being ever so practical thinks highly of the two way street:

> I'm just happy to help people and in the same way...but it works both ways, I have a strong expectation that if I go to someone for help I'm given it.

Francis describes vividly the helpful culture at FSL, painting a picture of the way individuals seek advice:

> it's quite easy to pop down the corridor and ask somebody for advice and everybody has been very helpful in that, there's never been an occasion that I can think of that somebody has told me to go away, usually people are very amenable to helping and are interested in your case and what you're doing and very helpful.

Brianna in her mould as a senior manager responsible for the organisation reflects why it is so important for a helpful culture to predominate at FSL:

> So if there isn't a willingness to share in the first place you have got a problem

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Helping relationship amongst actors]

vii Openness/Sharing relationship amongst actors

One is dependent on the open and sharing environment at FSL for any knowledge especially of the tacit type to be transferred.

Francis is practical in stating how she gains knowledge through the active communication with others:

> knowledge is given, if you ask you'll get it and I think a lot of the time it's on you to go and seek out a colleague.

Ella finds the use of email to be an effective way of seeking knowledge of the tacit dimensions:

> I like to use the email system to ask people for their advice or to say, I'm thinking about doing this or here a BPA description about going to Court, what do you think? I use email to do things or ask whatever, to try and gain a tenable group discussion. More often than not, most people come back to you.

Dylan illustrates how he is comfortable questioning opinions proffered which is culturally allowable in the open environment at FSL:

> If I didn't necessarily agree with the mentor and I thought maybe there was another way to do it, I would ask second opinions. I would definitely get more than one opinions in relation to a question I had on a case and I believe that's fundamental to building up experience yourself and getting to think through other people's opinions in order to develop your own and hopefully come to a good conclusion in relation to your question.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Openness/Sharing relationship amongst actors] viii Approachability relationship amongst actors

Approachability is a strong relational complement to the work of a forensic scientist. Because many of the processes involve the scientists to seek advice, the people who are sought for advice must be numerous in numbers and accessible in their demeanour. The advice system would fall if there was nobody prepared to give the valuable tacit dimensions in knowledge extracted from advice.

Shane even after his long service at FSL still seeks those that are more approachable:

> somebody that you find approachable...somebody that you know doesn't mind dealing with queries and is willing to put down whatever they're doing to talk to you.

Troy, who has served the organisation for a long length of time, still seeks those who are more approachable, putting it down to disposition of the individual:

> It is just human nature. Some people are more helpful and approachable than others. Its comes back to approachability I think, in that some people are very free with knowledge and, you know, actually without the knowledge even having been sought often are prepared to dissipate as much as they can.

Kieran, a senior manager thinks that approachability is a major contributor for positive person to person interactions:

> Whether we like it or not approachability is one major factor, irrespective of knowledge. There's some people, no matter what they have, you would be reluctant to...that's the nature of human interactions but I think you would say I need to know this, who would I go to.

Isabella, through her years of experience as a revered forensic scientist to her close knit colleagues has worked out for herself those who are not actually akin to the spirit of knowledge giving:

> Well, I think some people make themselves more approachable than others. I think there are people who will go into their office and close the door and you know don't go near them or if you ask them to do something they'll say – well I can't do it now but I'll make an appointment for next week and we can do it then.

Chloe, makes light of herself and tells us who she is really comfortable to go and seek knowledge from:

> This is terrible; I actually go to the people who are nice. Do you know, then I won't feel awkward asking or being made to feel stupid.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Approachability relationship amongst actors]

ix Respectful relationship amongst actors

A strong community fosters interactions and relationships based on mutual respect and trust (Wenger, McDermott, & Snyder 2002). In relying on advice that can be quite complex, it is evident here that a respectful trust mediates the decision as to whether a scientist seeks advice from another or not.

Shane lists attributes of respect that contribute to his decision to whom he is to seek advice from:

> You're talking about somebody who has quite a number of years experience...a senior scientist...somebody who is credible in your eyes.

Adam himself viewed by others as a sage also gives credence to those who are on the ENFSI working groups in deference to their knowledge of their specialist areas:

> There tends to be people who are acknowledged as having a deeper breadth of knowledge in the section in certain areas but they would generally fall into the people of are on the ENFSI Working Group Committee.

Holly has her own measure suggesting she uses respect to choose who she turns too for advice:

> Their credibility for starting and the way that they inform you and also thrash out the various other ideas that you may not have thought of, their experience, their wealth of experience.

Georgina does use her sense of respect for others as a factor in who she seeks advice from but warns of those who keep their knowledge to themselves, something that she does not respect:

> So I have to respect them in terms of being able to solve problems and interact, all these type of things, they'd have to be people I believe are happy to share knowledge, I really do not like going to people who have the knowledge and I know they have the knowledge and they have this thing about "I'm not going to tell everybody cause it's power type thing". They're really bad for an organisation I think.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Respectful relationship amongst actors]

x Proximal relationship amongst actors

The community of practice is not just a place to exchange knowledge, but it is a place where the tacitness of practice can become assimilated by actors working in close proximity to each other, which in itself is a necessary requirement for such work to be successfully carried out. The exchange of knowledge through physical proximity may allow for knowledge to move from tacit to tacit (Nonaka & Konno 1998). A strong tie between two social actors can form because they are in close proximity in relation to each other, which can be instrumental in providing knowledge of a tacit nature (Levin & Cross 2004). Hence being proximal, already found as a relational condition of communication between engineers (Allen 1970), is also chosen here as a relationship mediating the advice transaction.

Laura does defer to the colleague closest to her for advice:

> go to whoever was nearest

Jason too finds himself to approach individuals who are near to him:

> but then it could easily be just the first person who walks past.

Sophie finds it suitable to choose proximity as a factor when she goes to seek advice from fellow forensic scientists:

> Generally whoever is around when I want to ask a question.

The above respondents are all relatively new to the organisation and consequently they may seek new knowledge through advice receiving at the first port of call as opposed to having the experience of knowing who to go and seek knowledge from based on other relational criteria. Kieran, a senior forensic scientist and section head suggests that the more experienced scientists use other selective criteria.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Proximal relationship amongst actors]

xi Cohort /Cliquish relationship amongst actors

Because of the sharing of the same practices daily within the same group of individuals, symptomatic of communities of practice, cliques have formed at FSL. They have formed in part due to the cohort effect where groups of forensic scientists entered FSL during time periods together, as a result of national recruitment competitions.

On noting the cliques within the organisation, Danielle observes the ramifications of the cohort effect:

> I think there's a lot of times when people come into the organisation you can see...I think any of the groupings within the organisation are very much based on when you came in and I know, myself, I tend to – I'll say, socialise on the level of going to lunch and coffee with the people who joined the organisation in and around the same time...particularly in the Chemistry section, because there are a lot more people who were here a lot longer, they tend to stay together and that's why I'm saying that the knowledge isn't really dissipated down much – they stay together, they tell each other everything and then people like me, who don't actually go to lunch with them, who go with other people, miss out on all that. That was always my impression.

Monique thinking from a managerial perspective recognises the cohort office collectives:

> It is an interesting problem really from management point of view as to how you situate people in offices, because people are more comfortable sharing offices with their own cohort but it's not necessarily the best way to go for the job.

Dylan gives an insight into his refreshing way of doing business by differentiating between the expected behaviours of the different grades of forensic scientists:

> I think there was such a gap between the employment of the senior forensic scientists, the grade 2's and then all the new grade 3's which is maybe a ten or fifteen year gap that they felt more insular and new people came along and they were questioning everything and the people who were here prior to that for ten or fifteen years had already done their questioning but forgotten about it and already had this information, so sort of a natural thing, well why are you questioning forgetting that at one stage they were in our position and that they were questioning. Anybody whose come from academia recently I would imagine was always questioned day in day out be it under grads or post-grads or their own colleagues then things were just so set in the laboratory in relation to how cases are approached and also I think it's the way our thoughts have changed has allowed people the freedom to express opinions more easily and not feel that they would be hammered if they have a different opinion.

Alice with her senior management hat on is very disturbed by the obvious collections of different staff members:

> I think a disturbing amount happens in casual conversations. I say a disturbing amount because it is almost whimsical as to who talks to who and it means that I am slightly concerned about the transfer of knowledge from one generation to the next and by generation I am talking about layers of people who have come in at different times and who, when they need advice will go to their own peer level as opposed to maybe people ahead of them who have more experience, and that's a concern for me. So that there's lots of knowledge transferred right through the organisation but often times it is at the expense of experience gained by a different group.

Alice touches on the fact that although the scientist within FSL may not be thought of highly, when the same scientist goes outside and presents to an international conference, the reviews that come back suggest that that scientist is in fact very good but has been mis-judged at home. This is a sure sign of the negative effects of home grown cliques:

> I think there's been a tendency within the laboratory, of people not to stand up and be counted, by which I mean if somebody's knowledge about a particular area, that it's more difficult for them to stand up in front of their peers to give that knowledge in a formal way. Therefore knowledge transfer is dependant on the small group of people that they may be regularly in contact with. Whereas when you go to a meeting and somebody else stands they confirm the expert status that appears to be over and above what we have here.

[For other similar subject responses, *See* Appendix: Edite d sur plus I nterviewee transcripts ; Cohort /Cliquish relationship amongst actors]

### xii Interpretative relationship amongst actor colleagues

On carrying out a series of SOPs to completion, the forensic scientist is then confronted to work with the results pertaining from such processes. Such compilation of results needs to be interpreted with respect to the whole case in the custody of the report-writing forensic scientist. This skill is learned from the experience of completing many cases and not covered in SOPs. Interpretation and judgement go hand in hand and are the points of much discussion during peer review which is designed to ensure that case reports despatched from FSL entail the full complement of work that has to be fit for purpose.

The official objective of peer review is to ensure that reports leaving the laboratory are correct with respect to the administrative, technical and interpretative norms of the laboratory. The individual carrying out the review is a second competent scientist who reviews each report and associated file independently of the scientist who has completed the case report. Any changes that are made are based on the reviewer's suggestions.

The experience of the case reviewer is critical in that they must make a judgement that the findings are appropriately interpreted and are expressed in a way that is understandable to the recipient without compromising the content of the report. In addition the work needs to be fit for purpose – that is that all work to address the case scenario has been carried out and also to ensure that no extraneous work has been carried out.

Hence interpretation raised during peer review, becomes a nominated relationship mediating much of the operations at FSL.

Adam the senior scientist who is very much involved in the quality end of the management structure speaks of how the peer review system can involve learning by individuals:

> And then case review and comments coming from people doing peer reviews are a learning process for new people as well. Well, not just for new people but all the people.

Monique in her comments on how did she think the gaining of knowledge took place at FSL proffered peer review as a major contributor. However she does warn of variances in the judgements of the actual reviewers:

> I think peer review has a huge role to play in it although I also feel that it is very difficult to get consistent peer review and I think it's a bit confusing sometimes for our new people because something that's acceptable to one peer reviewer is not acceptable to another.

Melissa herself experienced found peer review or colloquially known as case checking to be a valuable learning tool for her:

> Well initially I learned a lot in case checking. I mean it can be very frustrating but that's peer review and I think you learn a lot initially then. I think after a while you are more confident – if you write something you're more confident to be able to defend what you've written to your peer reviewer.

Ella captures the sense that when one has come off training from cases that they are on their own and that the peer review process is like a life-line, before the case report finally departs from FSL:

> You're sent out into doing your own cases and then you learn by peer review.

Adam, the esteemed and longest serving member of FSL, not needing now to ask of the process steps because he knows of them intimately, would always think of the bigger picture with regard to what to include in the final report:

> Its probably more on the interpretation side...I have this material and I've done this on it...maybe the question would arise – well, what more do you think I can do or should do. Equally then I can say, what do you think that it means or what do you think it means. The advice would probably be in those areas. And people would come to me to seek it

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Interpretative relationship amongst actor colleagues]

### xiii Adversarial relationship protectively instilled amongst actors

Unique to forensic scientists their work can be contested by legal counsel – adding an additional dimension not normally experienced by other professionals who only have to worry about the final product or service they have just completed. At the end of the production and final despatch of the case report the work of the forensic scientist is not finished. The case reports are transcribed by the police into Books of Evidence where the other evidence gathered by the police sits. When a case goes to trial in the courts, it is the book of evidence that is proffered by the prosecution barrister on behalf of the State and interrogated by the □uspect's defence barrister. The court room event really does focus the forensic scientist as not only is their work questioned but they are subject to questions on the surrounding theories and principles that are the foundation of the FSL procedures that ultimately yield the case results. The personal character of the forensic scientist is on the line as any mistakes made by him/her whilst in the witness box have repercussions both personally and for the organisation. The defence barrister is known sometimes to confront the forensic scientist with a whole new set of questions that have never been asked for a similar case before, striking a professional surprise upon the scientist. The environment in the court room can be quite attritious. As a result when work is being carried out at the bench in the FSL laboratory, it is often that the forensic scientist carrying out that analysis has an imaginary thorough cross-examination going on in the back of his/her head, readying themselves for that eventual dreaded court case. Advice from colleagues at this juncture takes place numerous times and is of the utmost importance.

The real need of a forensic scientist is that they are comfortable with their decision, in having made the correct judgement or having expressed fairly an opinion, because their subjectivity will only be tested in the loneliness of the witness box, within the courtroom. Isabella whose years of experience show through, speaks of the journey. Her focus on the what to expect when in court is revealing:

> I think because of the adversarial system in the Courts, you really need to be bouncing your ideas and your opinions and your decisions off somebody else, because they're always going to be challenged in the long run by somebody else, either by a defence scientist or by a defence barrister, so you really need to be making sure that your opinions are sound all the time.

The adversarial system frames the way Georgina guards herself, a scientist with many years of gritty experience who is looked upon as been the most experienced and approachable forensic practitioner within FSL:

> ...I seek advice...if I'm working in an area and a case that I've had to think out of the box and I want it challenged to check its robustness – then I will go – I will actually pick people that I know will be awkward and difficult and I'd go to them and say right this is how I'm thinking, now, I want you to beat it down.

Aoife is worried that some of her colleagues may not be as well prepared with the knowledge required for such cases as others for when their cases go to court:

> That is a very worrying aspect because I think when you go to Court you really do need to be able to fully stand over and be convincing to a jury as to what you've done and why you've done it.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Adversarial relationship protectively instilled amongst actors]

xiv <u>Structural relationship amongst actors</u>

As well as the above relational mechanisms that mediate the course of action of knowledge being transferred between forensic scientists, there is also the official structure that interconnects individuals, such as differing forensic scientist grades or seniority. Because FSL is designed along the lines of a functional bureaucracy because of its civil service origins, structure in this case study very much mediates the pathways of advice seekers, and consequently the structured bureaucracy is proposed as a relationship.

Laura a recent entrant to FSL feels strongly about the structure that is based on a seniority based pecking order:

> In here its very much power play. It's very structured and its very – you know – Victorian, and the higher up the food chain you are, the more you're allowed to voice your opinion.

Jason who may have more than one way of carrying out a particular case would use the safety valve of being deferent to the senior's opinion recognising that such a seniority structure is in operation:

> There could be three ways of doing something. You've decided on a certain way of doing it. If you say it to a certain person who's senior, well if its questioned later you can say, well, one of the most senior people in the section agreed with me that this was the way to do it. So in that case I may go to someone quite senior.

Georgina is nonplussed with a formal structural system of advice giving/receiving:

> If you have a structured environment, those situations are gone because you have to wait for it to happen at a particular time or a particular day and on top of that people are much more open to learn because it's pure system as opposed to....you know.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Structural relationship amongst actors]

***<u>Tacit knowledge gained – as result of advice given</u>***

As discussed in the literature reveiw tacit knowledge is embedded in holistic work processes, where it is implicitly gained – it is an integral part in the accomplishment of working tasks. As a result, tacit knowledge is submersed and consequently it is difficult to quantify or indeed qualify.

Indeed the term tacit knowledge is only mentioned by two interviewee candidates: by Alice a senior executive who has had significant management training; and by Melissa who once shared an office with this researcher. This goes to show that the concept of tacit knowledge is foreign to the scientists at FSL who are obviously very familiar with the practice of tacit knowledge exchange as seen in the outcomes of the interviews but have not formally labelled the concept as a term in their vocabularly.

Hence it is difficult to qualify that tacit knowledge is actually appearing through advices – it is up to this researcher to identify such tacit knowledge gaining or giving incidences during advices being made to show that it is the exchange of tacit knowledge that is being practiced.

Melissa does speak of tacit knowledge in the correct context, on the subject of some of her colleagues who have had opportunities such as attending outside working groups of European forensic scientists:

> I think here people do try to share their information but I suppose I am a bit envious sometimes of the people that are going to, let's say, the ENFSI and the EDNAP meetings because I feel they have gained and over the years I same people, year in – year out, and I feel they have gained so much more information and I suppose through *tacit knowledge* and speaking to people, you know, at dinners and things like that, and I feel that they have learned far more than I would and they, because it not in a very structured form, they might hear it over coffee – whatever – they have all this extra information.

Alice, in her executive management capacity is very aware of the problem of scientitsts not aware of the work that they do involves the exchange of tacit knowledge:

> I think people are generous in their knowledge exchange but I think that people are unclear about the level of *tacit knowledge* that they have

Alice continues by expanding her concept that tacit knowledge is embedded into the very steps that scientists carry out in their interpretation of results, extra to the steps detailed in standard operating procedures. Her worry that there is a danger developing in forensic science practice outside of Ireland that the standardised tests are enough. However at FSL there has been an equal if not more concentration on the interpretation and consequences of results in a case. If there is something that is not quite right are indeed is niggling at the forensic scientist's conscience then the chances are that he or she is correct in their assumptions:

> SOPs per say are not a bad thing, but we can't afford to fall into the trap that it's the only way. I mean if the SOP is all that was needed, well then we could take the lowest common denominator and just set people to work, that's not my vision. It never has been ...*tacit knowledge* as a scientist is an expected result, if the result doesn't conform with that, and whether that be that the circumstances of a case would say if this story is right we'd expect to find semen on these swabs and if they don't find it they go back and re-test or think through what they've done to make sure that everything is boxed off or whether it is a sample of a drug that, in this form you'd expect maybe you should do an extraction before you check, so it's not confined to any aspect of the lab, but it is around what you expect and whether or not you just accept the result.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Tacit knowledge gained – as result of advice given]

### *Why forensic scientists seek advice from their colleagues*

The "advice seeking" relation that was mapped [see Figure 12] was used to try to best capture the *tacit* element of knowledge being exchanged. For example, the *tacit* element of knowledge is deemed to be transferred in the case of an experienced scientist in the field of 'Blood Pattern Analysis', who provides a suggestion to a colleague on how to interpret a complex blood pattern distribution found at a crime scene. The tacit knowledge, as a result of the scientist's experience built up from practice, is transferred as advice given in response to a query on a specific scientific problem.

Advice-seeking linkages most often take place in the local workspace of the community of practice. Scientists usually gain contact with a colleague either by beckoning them by a holler down the corridor or by a telephone initial contact and then ask their questions directly, face to face. The discussion usually takes a few minutes, and if need a second or third colleague is sought to come to some form of agreement in interpretation. In a few cases, a discussion may attract more attention and become a group discussion, either on the spot or through a quickly convened meeting arrangement.

It was found that all the interviewees, who were asked what was the major contributor as to why they would collaborate with colleagues inter-organisationally, mentioned that there was a need to acquire through advice the tacit dimensions of how to proceed within a certain amount of their processes.

Jake, who is relatively new to FSL informs one that:

> you are often seeking advice on particular cases as to how you might approach it if I complicated case or, say, in interpreting some of the SOPs, or a sampling policy – something like that. The case comes in and in the usual fashion is broken up in different pieces and it may not be obvious from, say, a sampling policy as to what you should do here and then you would seek advice from somebody more experienced who's dealt with more complex cases or something similar, say, something like that and say – well, how did you approach this and have a look at what their advice would be.

Troy a senior scientist prominent in advice giving, understands what scientists seek in advice:

> I remember seeing something she had on one of these page-a-day desktop calendars which was 'Advice is what you look for when you know the answer but wish you didn't'. So very often people come to me and say look I have this situation here where such and such, do you think I should do this? Almost certainly the answer is, yes – I think you should. And they know damn well that but they're hoping against hope that somebody will say – no, I think you've done enough. But I think quite often it is that rather than approaching something new, they just wanted to feel for, you know, do you think I've done enough or should I go and look at this as well. That's the kind of advice I get asked for very often.

He adds by alluding to the self-criticism that the experienced scientist puts upon themselves:

> I suppose in some cases its reassurance that perhaps they've already done enough or that they've done something the right way or whether...they just want confirmation perhaps before a case goes for checking to see whether somebody else would agree with their conclusion or their methodology or the extent to which they've gone in a particular investigation – should I do more/have I done too much – rather than have it come back at the checking stage and have to do more.

Robert, a very experienced forensic scientist in the micro-biology field who has seen many novices pass through his section makes an important observation as to why advice is sought by individuals:

> I would say there is no substitute for seeing something done. I mean, no matter how well it may be described in literature, I don't think you get a proper concept of what's going on until you actually see it done in front of you.

Melissa, a very experienced scientist still seeks the comfort of peer opinion as a reason for her to take advice:

> Well, maybe its a poor reflection on me, but a lot of the time I would have an opinion formed and I suppose its just reinforcing my opinion. It's good to hear – if you have an opinion – that somebody else is coming up with the same opinion as you. And it's just to reinforce it, to make you feel more confident in the decision you are making or, on

> the other hand, if somebody disagrees with it, maybe you might go back and you haven't seen another angle that they might see.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Why forensic scientists seek advice from their colleagues]

# 6 RESULTS – TACIT KNOWLEDGE IN STANDARDISED PRACTICE

## *Knowledge Exchange*

Communities of practice play a role in enabling tacit knowledge creation and exchange. Knowledge workers in local communities operate together within a network dimension sharing a common language and technical background boosting the processes of knowledge exchange and generation (Giuliani & Bell 2005). Knowledge of the tacit version is both exchanged between actors at a bounded local Community of Practice level and is transferred to actors who share a common interest externally outside of an organisation.

Harry as a manager paints a picture of the demographics of those seeking knowledge within FSL:

> Younger people seek knowledge moreso than the older people. All the time on going every day discussing something. Mostly newer people going to older people.

Shane feels as one who gives knowledge many times reflects that those who seek the knowledge to help themselves need to be proactive in getting it:

> I think knowledge is available. I mean you can't go around sort of pushing knowledge onto people – they have to want it.
>
> One of the reasons Shane gives the knowledge is to pass it on:
>
> its part of what I'd normally do. I mean as you go on you tend to sort of...you can't do everything yourself so you have to rely on other people to do things and that means passing on knowledge to them.

Shane gives a clear example of the different islands of knowledge within the one organisation:

> Well, I would think there is a fair exchange of information within the sections but I wouldn't think there's much exchange of information between the sections...people sort of identify with their sections and they're organised on a sectional basis. I mean I think you have to seek it out basically, if you want information on something relevant to another section.

Monique as a manager has tried to ensure the exchange of knowledge by planning for it so that it does not become encumbered with operational issues:

> We've tried to, I suppose get more knowledge transfer and not just business done at the meetings. So what we've done this year in fact is to have, or what we hope to have is every quarter a designated technical and literature meeting as opposed to trying to mix it in with the business meetings, because there's too much, there's a lot of business.

Francis as well feels it is expected to give knowledge which in her opinion is always through a face to face medium:

> I think if you don't give it you're not doing your job

> She feels she also gains personally when she herself gives advice:

> Well I suppose you gain from hearing more about different cases and get the person who's asking your view to get their view and knowledge and have a bit of a discussion and back and forth. You usually feel glad that you've been asked and happy to give it. If you feel comfortable and you know what you're talking about you should be happy enough.

In order to break down some of the boundaries and be able to access the organisational islands of knowledge, Francis has some suggestions:

> I think it [knowledge] flows quite freely but maybe could be better...Maybe if you have some type of lunchtime presentations, there's a lot of knowledge in the organisation but it's kind of in pockets and people kind of work in their own kind of area and other people might not even realise like what expectations there are, so I suppose maybe there could be some type of better...but I'm not saying I know how to do that without wasting people's time or whether it would be taken up, so I think it flows quite well and it's up to you if

> you're not working on an island you go out and ask people and you know, it's freely given.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Knowledge Exchange]

## *Knowledge Databases*

There is now the realisation that knowledge lies less in its databases than in its people, hence promoting the importance of people as creators and carriers of knowledge (Brown and Duguid 2000a). As mentioned in the literature review, individuals rather than turning to databases and procedure manuals to obtain information, seek knowledge in a tacit form from trusted and capable colleagues (Koskinen, Pihlanto, & Vanharanta 2003).

Laura sees that there is a variance in the information available in the data forms:

> I've read through them for information…and from reading the ones on there, there are individuals who fill them out more completely than others, so they would have differing values.

Adam sees the database as a prelude to a personal encounter with the individual who had written the original entry. The fact that there was mention of the incident in question would allow the scientist to make the decision should he/she go further:

> I think...people tend to keep their comments brief. The best way of getting the knowledge is probably to go and contact the person. It gives you a feel of something...it gives you an indication that there might be something useful that you could from gain from talking to the individual.

Troy reflects that for knowledge transfer to occur that face to face contact is the ideal way:

> That knowledge is subsequently passed on without you going and kind of querying a person, I'm not sure. You know, I'm not sure there is an easy mechanism for that. I mean people put things like PowerPoint presentations on the intranet and so on but it's not the same. Probably the best way would be to have some kind of a debriefing on a face-to-face basis or to the section or the team or the group, whatever it is that's involved.

Monique being a section head is very cognisant of time resources and as a result is positive about having a knowledge database such as the court reports database that gives a summary of the questions asked of the scientist whilst in the witness box.

> So I think the intranet is really useful because you can't have meetings after every court case so what I would see, the reports with one person who goes through them and kind of compiles what's in there and then if the reports from our section then obviously the person concerned would be at the meeting. The database entries act as reminder headlines for when the scientist presents his court appearances to the group.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Knowledge Databases]

***<u>Expert</u>***

Finding out about how forensic scientists think what makes a fully trained expert gives a window to peer through of the type of individuals that the scientists actually seek advice from. Some have found that the difference between experts and novices is related to their inventory of tacit knowledge (Sternberg 2000), where the tacit knowledge consists of embodied expertise (Wenger 2002). There are those that have formed the opinion that expertise requires practical skills (Sternberg 2000).

Wanda a relatively new forensic scientist who is undergoing training herself thinks of competencies when asked, what makes a fully trained expert:

> I think the competencies are important to be able to do the practical side of the work but then there's the interpretation side of it as well and to actually be able to interpret what you find from doing your cases.

Kieran, in his practical thought processes thinks being fully expert is based on the net advices one gives:

> It should be demonstrated by you being less of a consulting and more consulted.

Julia a senior scientist gives a clear list of what is expected:

> Technically competent. Also be competent to interpret and decide on work to be carried out. Be objective in analysis and open minded. Take a holistic view.

Georgina the well respected forensic scientist speaks of being able to think outside the box:

> A fully trained forensic scientist is somebody who knows protocols, you talked about protocols earlier, and I would say that that's the baseline, so no matter how brilliant you are, if you don't know them you're not gonna be brilliant. There's a certain level of skill base stuff if you like, that you must reach, that's the first thing and then after that a really good forensic scientist in my mind is a person who can think outside the box, the scientist who goes by rote, you know, [this case] I do X, Y and Z, that's the person who is not going to be the really good forensic scientist because they'll be alright for ninety percent of the cases but for the ones that you need to take out of the box they can't do it.

Alice expands on the concept of experts having well thought out processes that they should mull in his/her mind when working on a case:

> I think...having the expected results in your head for a particular situation, and you might think that that's something that's not possible, but if a scientist is coming to any examination they should have some clarity around what method would progress this because the test or the method would give them a result either for or against the proposition

> of the test. And if that's not covered by the SOP or more particularly if the result is not expected, they might have to go back.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Expert]

### *Experience –View held by Individuals*

Here in this research, one finds how knowledge workers themselves define experience. Formed as a result of experience, tacit knowledge is knowledge housed in the human brain, such as expertise or professional insight (Woo et al. 2004). Grounded in experience, tacit knowledge is a personal knowledge which because of its intricacies cannot be fully expressed (Horvath et al. 1999). However, Wagner (1987) argues that whilst tacit knowledge increases with job experience, he believes that it is not a direct function of that experience, postulating that there are those with long years of service who do not evidence higher levels of tacit knowledge.

Jake sees that an experienced forensic scientist is one that has dealt with a wide scope of activities instrumental in carrying out their function:

> I think that's partly to do with the number of cases, the type of cases you handle. Perhaps, you know, your training, additional reading you might have done, whether you have been to Court or not. Certainly going to Court sometimes will often highlight things for you which you might realise need attention if you haven't been paying more attention to them. I think that all forms part of the whole experience, rather than just doing, say, analysis of cases. So there are a multiple of things involved and I think, you know, as you are around you see different types of cases and then you're dealing with perhaps, say, the Garda, and sometimes they're looking for different things.

Robert believes experienced means:

> I suppose I knowledge you've gained through practice, through doing things, through solving problems.

Monique identifies three areas that she would consider allows one to be called experienced – length of time of experiencing case work, the approach and the efficiency:

> I suppose it comes, some of it comes from the length of time you are doing it and it's how you approach it, how you become more efficient at it. How you don't even think about what you are doing anymore. Whereas when you don't have experience I think probably work is much harder because you have to put that bigger effort in. that's not to say people with experience don't have to put in effort but you know I think there's a comfort level that is attained. And some of it has to be from the bulk of work you've put through your hands, that you've encountered instances before, it's not new to you and also it's not new to you as to what might happen down the road.

Georgina does not think that scientists who just approach a case through the direct process channels should not be called experienced – they need to do that something extra:

> I mean traditionally experience is kind of something by virtue of the fact you're here a long time that you have to unless you're completely blind, deaf and dumb, having said that, some people are much more open to experience you know. I mean I'm thinking of individuals here and I'm not gonna name names and I see people who would be here thirteen, fourteen, fifteen years and I see people who are here six, seven years and if I was to say like I've said to you I have a case and I want somebody to have a go at it, I wouldn't necessarily go to the fourteen, fifteen year person and the reason I wouldn't is because they haven't, they're not the person, you wouldn't associate them with having delivered a really good case, an important case, gone to court, stood up there, put themselves out, do you know what I'm saying, some people don't do that they just do the process and even though they're here fifteen years, they haven't gained the experience cause they haven't put themselves out for it.

Brianna believes to become experienced is a slow process:

> ...acquiring experience through working with different experienced people and experiencing different kinds of casework situations. And that's quite a slow process, depending on the, but if it's a complex area it can be quite slow. The kind of figure for the non-drugs area is that it is five years before somebody really has got that rounded experience that you would say that they were fully operating forensic scientists.

Alice sees the need of making sure that an experienced forensic scientist has a wide scope of experiences in case work:

> The trouble is experience can sometimes be identified as just doing the same thing over and over again, and if you are doing the same thing over and over again and not learning from it I don't believe it is experience, or at best it's not experience, at worse it is experience at doing the wrong thing. So if I consider experience forensic scientists, they are people who I hope have learnt from different situations.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Experience – View held by Individuals]

i <u>Full experience criteria in SOPs</u>

Within the SOPs there is a recognition of experience in that certain attained levels are judged through competency or completed training assessments.

> Scientists are authorised by head of section to take responsibility and report cases when...criteria are satisfied

> Full interpretation may only be carried out by scientists who have completed their training

> To be deemed competent...the trainee shall have completed a test where the expected outcomes are not known to the trainee

> Scientists when trained and authorised as competent are responsible for carrying out the casework procedures…

***<u>Something more than SOPs – an enquiry</u>***

Here the interplay of tacit and explicit knowledge in the training process was looked at, from an analysis of a completed structured questionnaire. With the questionnaire, the utilisation of explicit SOPs was compared to the use of tacit knowledge that the scientists had gained through practice.

The questionnaire was completed by forensic scientists from two CoPs; one comprising the Biology community where the casework and reporting is more qualitative to the other, the Drugs community where the casework and report is very much of a quantitative output [*see* Appendix: Survey – the use of SOPs in practice].

In their training to become competent forensic scientists, sixty five percent of those surveyed had the use of SOPs (See Figure 33). The remainder entered the laboratory before the ISO 17025 accreditation was in place. Of those scientists using SOPs, a third needed to seek extra assistance in carrying out procedures, eventhough SOPs existed for the full complement of procedures. This extra assistance was through advice from colleagues one hundred percent of the time. After having achieved competencies in carrying out all steps in their SOPs, none of the scientists felt sufficiently qualified to report casework.

In finding a problem in their casework process, all scientists surveyed SOPs to give a beneficial baseline of knowledge, and would use them as a refresher in their procedural knowledge, but three quarters of the same scientists found that the SOPs did not guide them in their day to day work. All only felt comfortable working on their own through continuous practice over years of service. One hundred percent of those surveyed found that the use of SOPs were an addition to the integrity and quality of the laboratory's work.

Hence shown here is that with the developing expertise of the trainee forensic scientists that they transit from a reliance on explicit knowledge to one with a tacit knowledge framework. Explicit knowledge has qualified foundations in the first steps of a forensic scientist's training, but is soon taken over by the tacit knowledge required to become a competent reporting caseworker.

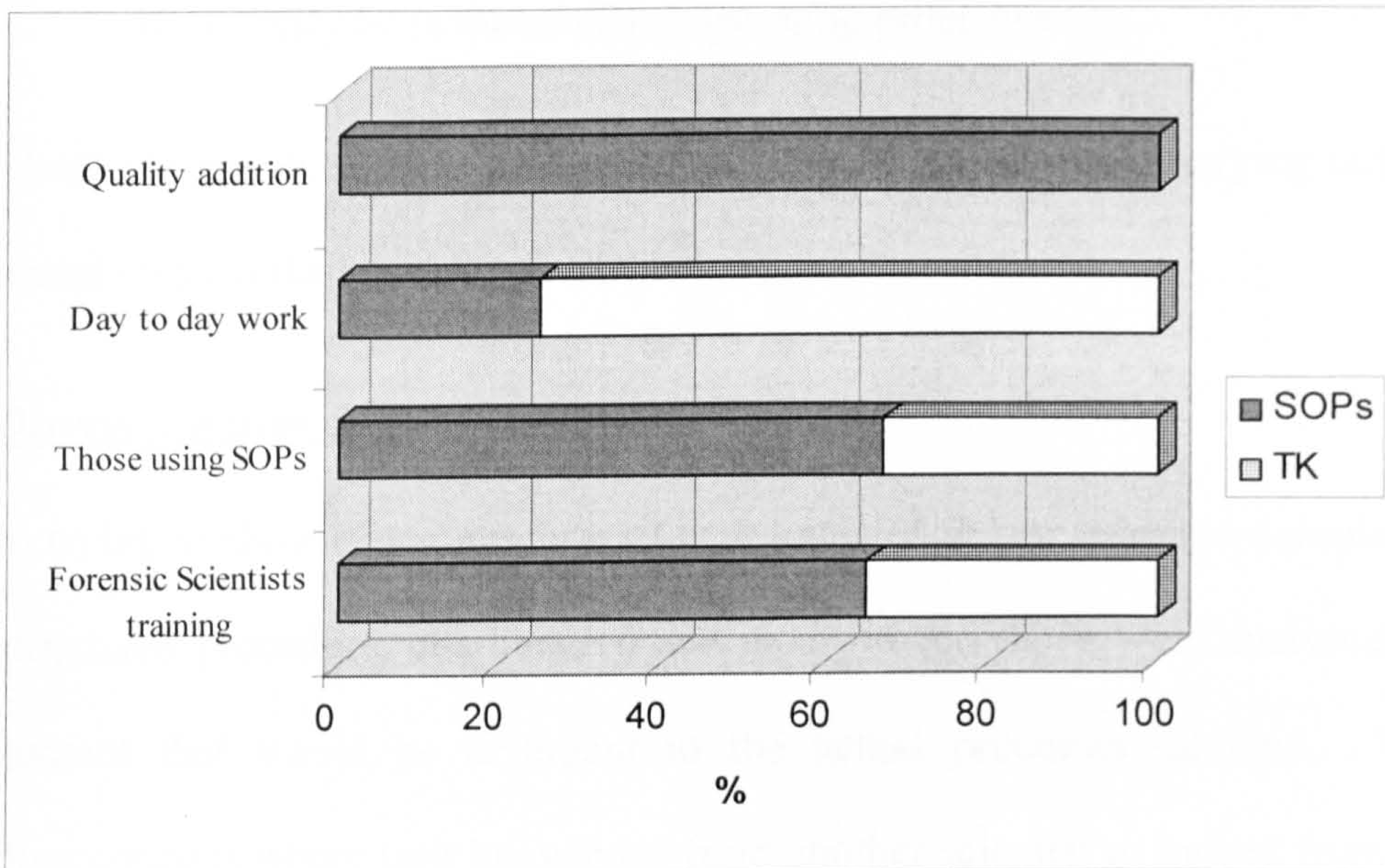



**Figure 33. Use of SOPs compared to use of Tacit Knowledge (TK) by forensic scientists**

A scientist especially carrying out analytical procedures under an accredited laboratory standard (ISO 10725) should typically need to only follow the prescribed standard operating procedures. However the forensic scientist can only progress through a case when they have collaborated with and sought advice from their colleagues. Why is this? – Because as shown through network analysis of presumed tacit advice relationships [figure 2], the forensic scientist needs to rely on an experienced scientist's tacit reserves. As a forensic scientist bluntly puts it:

> ...but protocols is a baseline. You only get to acceptable with protocols and then your interactions with people and your own thought processes will bring you beyond that.

Or another scientist posists:

> ...I see it as forming, getting other peoples opinions and then developing what I would feel be best practice and that might not necessarily be in the standard operating procedures...

These statements solidify the actions of forensic scientists in carrying out the actual steps in the laboratory's SOPs.

***Divergence from SOP***

In trying to show that some form of tacit knowledge is required to complete a structured procedure, one hundred and ninety seven SOPs were analysed for content that would be divergent to the actual processes detailed. This divergence is where tacit knowledge from another scientist or indeed from the performing scientist's own tacit resources are required in order to complete the explicit protocol. Actual diversions from the standard procedures were found which signified a call for some form of tacit knowledge. The diversions were coded into four groupings and then quantified by counting each instance. There were twenty seven instances of the need to pull from case experience in order to complete the detailed process set out in the SOP; ten instances in the requirement to seek advice from others during the carrying out of the procedure; eight instances of the need to reflect or assess the work that is required; and four instances of the need to be cognisant of the other type of casework required. These tacit diversion steps are detailed below.

i Divergence from SOP\pulling from case experience

Eventhough SOPs are supposedly completely self contained there is a recognition by the organisation that the tacit experiences of forensic scientist are needed to complete a certain amount of SOPs. Experience is the kernel of what goes on within the very nature of collaboration – forensic scientists continuously seek referral and behold reverence to the knowledge of scientists who have already experienced through their own practice how to carry out an aspect of a procedure correctly.

In twenty-six of the one hundred and ninety seven SOPs, case experience was required for the forensic scientist to be able to continue on with the procedure [see Appendix: Deviations from SOPs]. This shows how tacit knowledge built up from practice is critical if a scientist wishes to carry out a procedure correctly in order to reach the end of an analysis. The experience gained over the years of practice allows the scientist to make proper contextual decisions for the analytical event in front of them. As seen through the interviews, SOPs are just the basic minimum in work steps, and what is apparent here is that a scientist's prior experience is actually needed for a procedure to be carried out in full. A selection of the following shows how much the requirement for tacit knowledge gained through experience is embedded in the SOPs:

> In practical terms the decisions taken...when dealing with low-level DNA samples are governed by the circumstances of the case
>
> However in certain cases, circumstances may dictate that you will have to analyse more than this amount
>
> In these instances the scientist forms the opinion that an exhaustive search and recovery is not necessary
>
> Denim fibres are generally not suitable as a target fibre...in certain circumstances...of value to look for populations of such fibres
>
> There may be exceptions when it may not be appropriate to heat a sample
>
> A number of possible conclusions are open to the examiner ranging from a unique identification...to an exclusion
>
> In interpreting the results of a footwear comparison, there are three broad conclusions possible

> The number of fragments to be examined depends on the number recovered, the case circumstances and on the type of glass
>
> Significant damage...made with force...case circumstances are taken into account when determining significant damage
>
> Where the type of damage cannot be characterised, a full interpretation may not be possible...report...it as a cut/tear

The nature of such extensions to the protocols shows how endemic tacit knowledge is and how it is such an important factor in completing these structured procedures.

ii <u>Divergence from SOP\Advice seeking</u>

Set out below are some of the instances where the scientist is instructed to seek advice from another scientist, such as:

> If the assessment indicates that the damage is significant...another scientist is required to examine the item(s) independently
>
> if fingerprint examination has not been specifically requested...consult...to ascertain if fingerprints examination is required
>
> If you feel it is warranted, call another scientist of a different discipline to the scene
>
> When items in a case are to be examined for other types of evidence consultation with others...is recommended
>
> For impressions...known to have been made in blood...the Biology scientist...should be consulted in such cases
>
> A second competent scientist reviews each report and associated file [and] makes suggestions for corrections/changes
>
> If...apparent that the items need...to be stored outside the normal manner the receptionist can contact the...scientist for advice.

iii Divergence from SOP\assessment

Tacit knowledge is required in evaluating and considering what work is appropriate in the case sitting in front of the forensic scientist. Presented are such instances:

> Look at the body for stains...deposited by the assailant. Consider whether these need to be removed at the scene
>
> [if] reason to believe that...complainant...unable to communicate or remember...a swab from each area is examined
>
> further screening of the clothing is unnecessary, unless there is reason to believe that seminal stains[are] of evidential value
>
> If the panties are AP positive, further screening is unnecessary, unless there is reason to believe...
>
> information can assist in the selection of appropriate stain(s) [such as] How many people bled during the incident
>
> In selecting most suitable donor items, consideration should be given to the sheddability of relevant items
>
> [in circumstances] such as a case where information indicates...Certain substances...may be omitted from examination
>
> If a conclusion that the sample contained a controlled drug is not reached following the analysis, further testing may be required

iv Divergence from SOP\cognisant of other casework reqd

To be in the position of knowing what other case work is required, a forensic scientist needs the tacit experience of such events. Here are such instances detailed in the SOPs:

> The Forensic Scientist advises on the most appropriate samples or items to be taken to advance the investigation
>
> Prior to damage examination, preserve any trace evidence such as fibres

> footwear may be submitted...a particular class of trace evidence may also be requested e.g. glass, accelerants, fibres
>
> to examine for glass fragments...as well as considering the order if other types of trace evidence are involved

***<u>SOPs – a baseline of standard practice: an inherent shortfall of tacit Knowledge</u>***

The following interview excerpts describe what forensic scientists really think of standard operating procedures. With such a heavy emphasis on the use of SOPs evidenced by management thinking and investment monies it is worth examining the opinions of the actual operators carrying out the process. The common denominator from many comments made during interviews was that SOPs were only a baseline. There was a general feeling that only a minimal acceptable level of performance is achieved with protocols and it is the interactions with colleagues and one's own thought processes that would bring them beyond that.

From a senior executive management position, Alice speaks of Standard Operating Procedures as a good baseline for the organisation:

> I think they are a very good starting point and the way of making sure that we are uniform in how we use the technology and how we use that in a very broad sense that we have available to us. But the how and when are things that are not covered by the SOPs.

However, Alice does recognise that a lot of the casework involves complexity and being able to manage the different facets of a single case which are not necessarily covered by the baseline SOPs which cover the parts of the sum:

> The type of work we are primarily involved with here, there's more complexity in the cases. Calls for an ability to manage a case and I haven't clearly identified what the core competencies are for managing a case in a way that easily allows me to encourage people to transfer that knowledge from one to another.

Offering another view from the executive management, Brianna reinforces the view that higher level processes such as case interpretation and judgement of the work required for the circumstances of the case, the tacit processes of an experienced forensic scientist, are not covered by SOPs:

> The SOPs don't cover things like interpretation and how to take into account the different case circumstances, and I think it's a concern really as to how we make sure that people have that extra knowledge that enables us to make those decisions.

Adam, as a senior manager who has seen the evolvement in the way work has been processed at FSL. He reflects that the steps are more formalised but at the same time he is more comfortable with the knowledge that people are doing more or less the same thing in the procedures. However if the steps are not written down he outlines the danger that the unusual procedure required will not be carried out:

> I think the SOPs have driven that to quite a degree. By driven, I mean that people approach the recovery of evidence and the examination of evidence in a structured and similar fashion. What I don't think it covers is if there is something unusual, slightly different material present in the case. But you can use to, say, the analytical technique but because somebody hasn't got it written down somewhere, its maybe not...it doesn't appear as paint...its appears to someone as a kind of a smear on material maybe they won't follow up on it as much because it's not written down. We've decided its not paint; therefore we can't do anything with it.

In further explicating the dangers of not carrying out work because the work piece is not documented, Adam touches on the different tacit reserves that individuals possess; suggesting that newcomers are so used to just doing what is documented, dismissing something that they haven't seen before, whereas the more experienced scientists may realise that there is something more:

> The more experienced scientists would say, yes, hold on here – now I can go off on a tangent. I have a procedure for doing an infra-red spectrum. I can do this on this material to see what it is and have it transferred onto something else. Even though the material itself isn't specified in the SOPs.

Kieran speaks about SOPs from a senior operations perspective, recognising that they do not represent all processes:

> They capture what we do in the technical sense as in we wait ten minutes, we stain something, those type of things, we use some guidelines about when we would do certain tests...I think maybe sometimes they're too restrictive...they don't capture fully what we do and nor should they.

With Nathan's long period of practice, he is aware of the limitations of the quality system, which are only designed to capture the baseline of operations:

> You'd still need to have other background knowledge other than the SOPs. You know, there are so many things that you can't cover in an SOP. It can only be generic. If you were to try and cover every possible scenario, the bloody thing would be like the Encyclopaedia Britannica.

Relating to the tacit knowledge that an experienced forensic scientist would have, Nathan envisages what SOPs are intended for:

> I'd say the SOP training would bring you up to basic survival level as a forensic scientist but to become a good one or to get to the top of your field, you would have to incorporate the experience. There's no way, based on learning every SOP in the lab, you'd be seen as an expert in the field.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; SOPs – a baseline of standard practice: an inherent shortfall of tacit Knowledge]

## ***SOPs sufficient for the practice***

There are cases where the explicit protocols outlined in the SOPs are sufficient for the processes detailed to be completed without the need for the operators to confer with other colleagues. This is apparent in the more quantitative analyses found in the Drugs and DNA practices.

Nathan is of the opinion that SOPs are very suitable for a strictly analytical practice such as the Drugs section:

> Again it depends on the type of work. Drugs is very procedural and at the end of the day its an analytical result you're reporting rather than an opinion, whereas in other areas – say comparison work or just interpreting all the evidence you've perceived – you would have to form an opinion.

Jake reflects:

> I think they're generally fairly comprehensive; they cover most aspects as far as I can think of offhand. There's nothing that springs to mind to say – oh, this is not covered, in terms of following the SOPs.

Sophie within the largely analytical DNA speciality feels comfortable in that the protocols cover the work that is performed:

> Well because the DNA, it is all about following procedures, so you have to see the procedures performed. I mean when you go to do it yourself there is, you just follow that procedure but to see it first hand is quite important. I'd Say 95% is in the protocols, and then like working in DNA there is always going to be stuff that you tweak and you learn that as you go along. But there's very little of that, the vast majority is written down and because it is a protocol you don't really deviate from that.

Kieran as a head of section who has lectured to the various universities who have introduced science degrees with a forensic twist feels that the SOPs within FSL now suitably match the expectations of novice forensic scientists who have been 'spoon fed' within their own educational background:

> I think there's an advantage to having SOPs because in one respect it gives trainees, new people in the door [what they are used to]. The training regime in the college is now done different from when I did it and there's almost an expectation for having those. There wasn't the

> same expectation when I joined the lab because it wasn't part of the culture of the universities where I trained.

Alice as an executive manager discusses the current situation within the international forensic community where a model exists for work that is carried out on a simple analytical basis, which at present FSL does not practice. There is scope for FSL to look at the simple yes/no answer tests that would be sufficient for less complex case scenarios:

> In isolation from simple advisory control, I wouldn't try to say that they couldn't practice but there's a divided view in the forensic science work on this very topic, because there's a point of view that says that what you are doing is carrying out tests and you control those tests as much as possible and deal with the outcome. That's one model, the factory model if you like. And that's probably for a type of case work that we don't do a lot of. But we may well do in the future, where it is minor crime where you just take one shot at getting the right answer, if you get it great, and the biggest concern is to make sure you don't get the wrong answer.

***Disadvantage as result of SOP conditioning***

On the introduction of the quality management system (QMS) that oversees the whole remit of SOPs only recently when compared to the average length of service of forensic scientists, it is now only apparent that newly recruited forensic scientists whose full exposure to the SOP movement may think differently compared to forensic scientists who have had experience of both systems – the undocumented laissez faire system of the past and the formalised QMS SOPs of today.

Troy is worried that the newer forensic scientist entrants into FSL may become conditioned as a result of overly relying on SOPs:

> I think there might be a case with their less likely to think outside the box. With a lot of the more recent people in terms of training here has been that this is what you do and then you get the result and you write that up and you send the report off and you do another one, as opposed to thinking in a more kind of holistic way when a case is in – look, is there anything here that I can bring to this investigation, quite apart from the obvious questions, either based on my experience or my observation or my own particular skills or what have you – is there something that I can add to this that isn't actually written down on paper in terms of what they're requesting. I think some of them haven't had a whole lot of direct personal experience...

Also Troy believes that the SOP dependent forensic scientist may only do the minimum and that it is up to the more experienced forensic scientist to suggest that they should pursue other steps of analysis:

> I would feel possibly there is a situation where they may be inclined to maybe do the minimum and say well that's ones done, let's move on, as opposed to saying...I mean obviously you can't devote enormous resources to everything in every case but to, at least, be open to the idea that there may be something else there and it might be worth going back to the investigator and suggesting – have you thought about this, that and the other. And if they have and reject you, that's fine but if they haven't thought of it then it's up to you, I think, to possibly prompt them to consider that avenue of investigation.

Aoife is of the opinion that in situations like the court room that the over reliant scientist may not be suited for the hostile questioning environment where you are open to any eventuality:

> That is a very worrying aspect because I think when you go to Court you really do need to be able to fully stand over and be convincing to a jury as to what you've done and why you've done it, and I think the reliance on SOPs...it might be a more efficient measure, it might be easier to train people and it ensures that uniform high standards but it takes something away as well, I think.

Alice has had first hand experience of working with individuals who entered FSL as analysts and then were promoted through competition into the role of a forensic scientist. Without exception they all took longer to think conceptually about their cases when compared to forensic scientists who came straight into FSL from the outside without first passing through as an analyst.

Again these are real examples of individuals becoming conditioned at the process level without contemplating the higher interpretive judgement levels needed for a fully functioning expert forensic scientist:

> I've had experience of a few people who worked personally and directly with me as technicians, and then promoted into the scientists role. And their knowledge of process would have been very high in that they often did my processing for me. And my expectation was that they would transfer into the scientist role very very easily. And without exception, the time to get into being a competent scientist took longer than I expected. Which supporting your view because they had the process, they had the analytical techniques but they didn't have the thought process as to why and when and I mean I still find that amazing, when I think back, because I would have thought that they were working so closely with me that they were sharing, feeding it into a lot of the things they were asking, I would have thought that they shared my idea as to why I was doing something, but when it came to working that themselves it took way way longer to make those decisions and I think there's some unquantifiable aspect in there somewhere.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Disadvantage as result of SOP conditioning]

## *SOPs as an advantage in Knowledge Sharing*

The traditional view garnered from the knowledge management literature that knowledge is power, is dealt with here, discovering how the QMS has affected those practitioners who were known to hold on to valuable knowledge for their own machiavellian needs.

Adam as a manager who is immediately involved in quality sees that since the onset of the quality system that the spread of knowledge within the organisation is more apparent:

> I would be conscious that there were certain people who had the knowledge and didn't pass it on...or prior to the formalisation of the

> SOPs, the standard way of doing things, there were people who had their own methodologies and wouldn't easily share it with other people. So I think that's changed now. There is a standard way of doing it.

Adam sees that some knowledge held on by individuals that may not have been passed on in the past by them is now becoming more explicit within the protocols. He sees that those in the past who may have been powerful with their knowledge, not available elsewhere, have now become more integrated into the organisation, with their power transferred into other projects:

> Well certainly they're less powerful and the knowledge is passed on. What we are doing in a structured, measured way. So, they're less powerful at holding things up or having the ability to go their own way. They're not so worried about that any more so they're probably looking to do something else to promote themselves.

# 7 RESULTS – TACIT KNOWLEDGE IN THE CULTIVATION OF THE ORGANISATION

*Legitimate Peripheral Participation – a quantitative view*

As previously discussed, tacit knowledge is known to be gained through social interaction, personal experience over time, and/or serving in an apprenticeship fashion (LPP). In trying to establish the main knowledge players within the laboratory, Figure 34 was drawn to see the direct communications with the most experienced scientists (Dir 0) and colleagues (1). Within this clique the minimum length of service was 14 years.

On taking Biology as an example of a single community of practice, an interesting observation was made with regard to the longest serving member, which in our opinion reinforces the legitimate peripheral participation theory. Figure 35 shows the amount of times advice was given to an individual in the Biology community of practice over a three-day period.

In trying to capture whether a scientist mostly gave or received advice the 'net advices'/prestige were calculated (see Table 3). We found that the less experienced individuals (yrs of service) received on balance more advice than they gave. The more experienced individuals gave on balance advice. We found using a correlation coefficient [0.49387], indicating the strength of the linear relationship between prestige and years of service to be of a medium correlation (Cohen 1988). This would be expected within the legitimate peripheral participation theory. However, the longest serving member in the group (**) received the most advices, which at first observation would seem to be contrary to the theory. But, this forensic scientist is the newest member of this Biology CoP because he gained entry into the group through promotion as Head of Section (HOS), one year ago. This finding adds support to the claim in the literature of becoming newly peripheral, when a highly experienced individual moves to a new discipline, where there is a new CoP structure to be embedded and learning curve to climb.

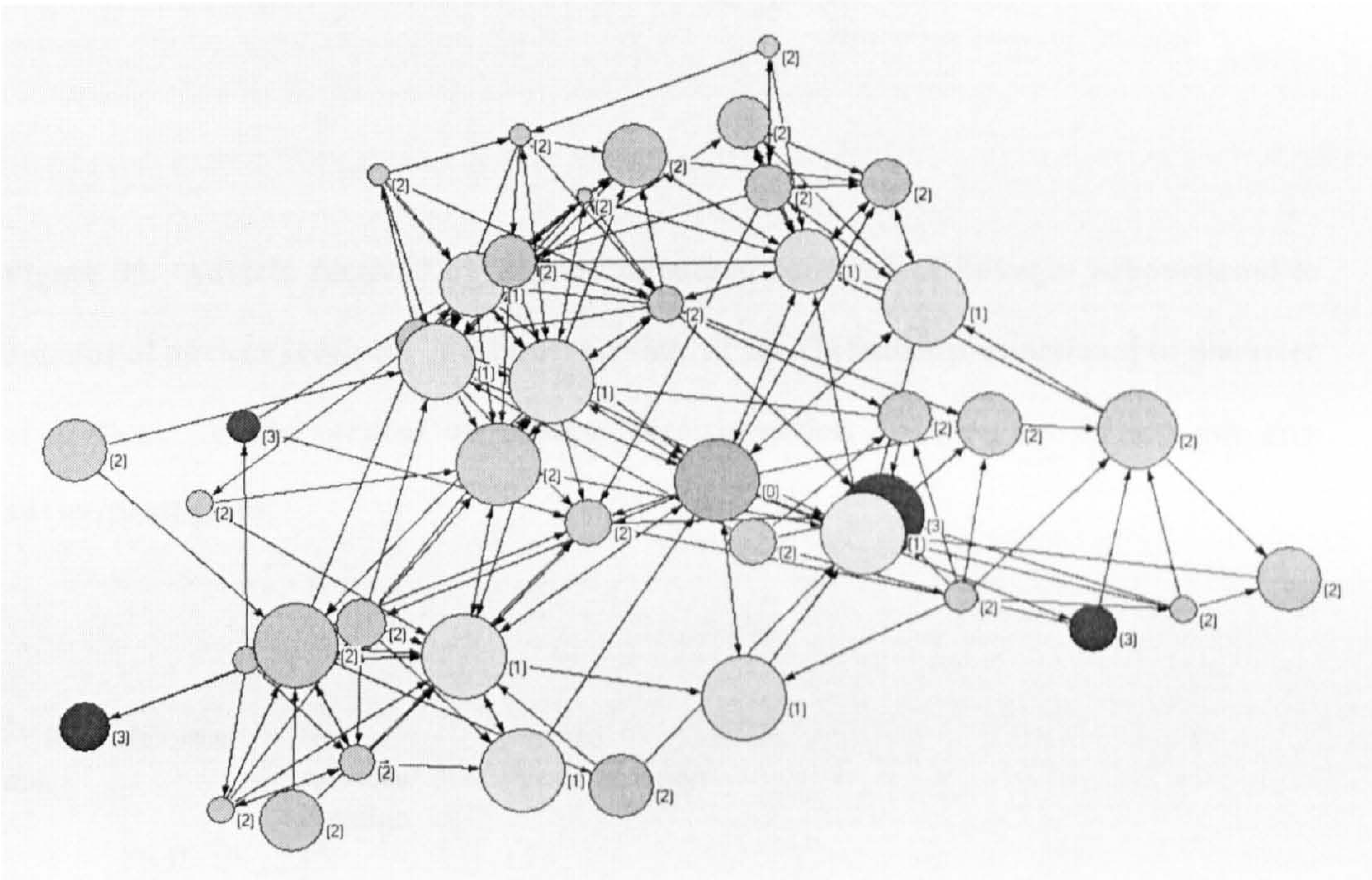


**Figure 34. Senior clique of advisors (yellow -1) giving advice directly to Director (blue-0)**

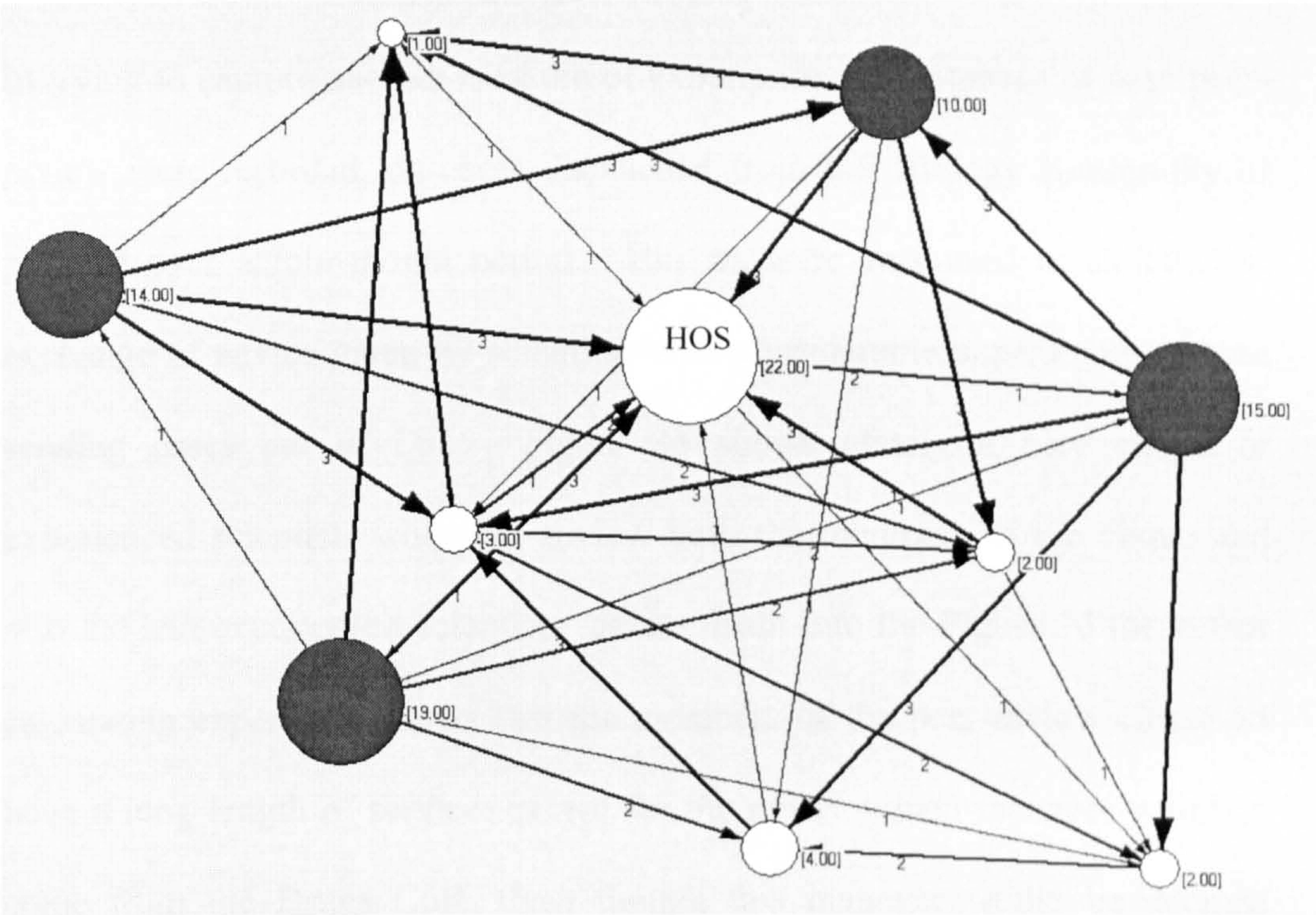



**Figure 35. Advices received by Biology scientists-thickness of linkages proportional to amount of advices received. Years of service of each scientist proportional to diameter of vertices. White vertices on balance receive advice, red vertices on balance give advice/prestigious.**

| Rank | Scientist | Net Advices/ Prestige | Service (Yrs.) | Correl-ation |
|---|---|---|---|---|
| 1 | FS II | 15 | 15 | |
| 2 | FS I | 12 | 19 | |
| 3 | FS II | 11 | 14 | |
| 4 | FS II | 3 | 10 | |
| 5 | FS II | -3 | 3 | 0.493872 |
| 6 | FS II | -4 | 4 | |
| 7 | FS III | -6 | 2 | |
| 8 | FS III | -6 | 1 | |
| 9 | FS III | -11 | 1 | |
| 10 | HOS FS | -11 | 22 | |

**Table 3. Advice league – Biology CoP**

In trying to capture another measure of experience, all instances of case peer-review were recorded, on cases dispatched from the Biology community of practice over a four-month period. This measure was used to capture the exchange of advice given by scientists with considerable experience to those sending cases out of FSL. Figure 36 shows clearly a core clique of experienced scientists who peer review both the members of the clique and also the less experienced scientists' cases. Built into the Figure 36 the vector calculating experience shows that the members of the peer-review clique all have a long length of service, except for the newly joined manager who had come from the Drugs CoP. Even though this manager would be deemed peripheral from the point of view of experience, he is seen as central in the information channels within the community of practice. However, the information exchanged would be functional in nature, as would be expected in the role of a manager.

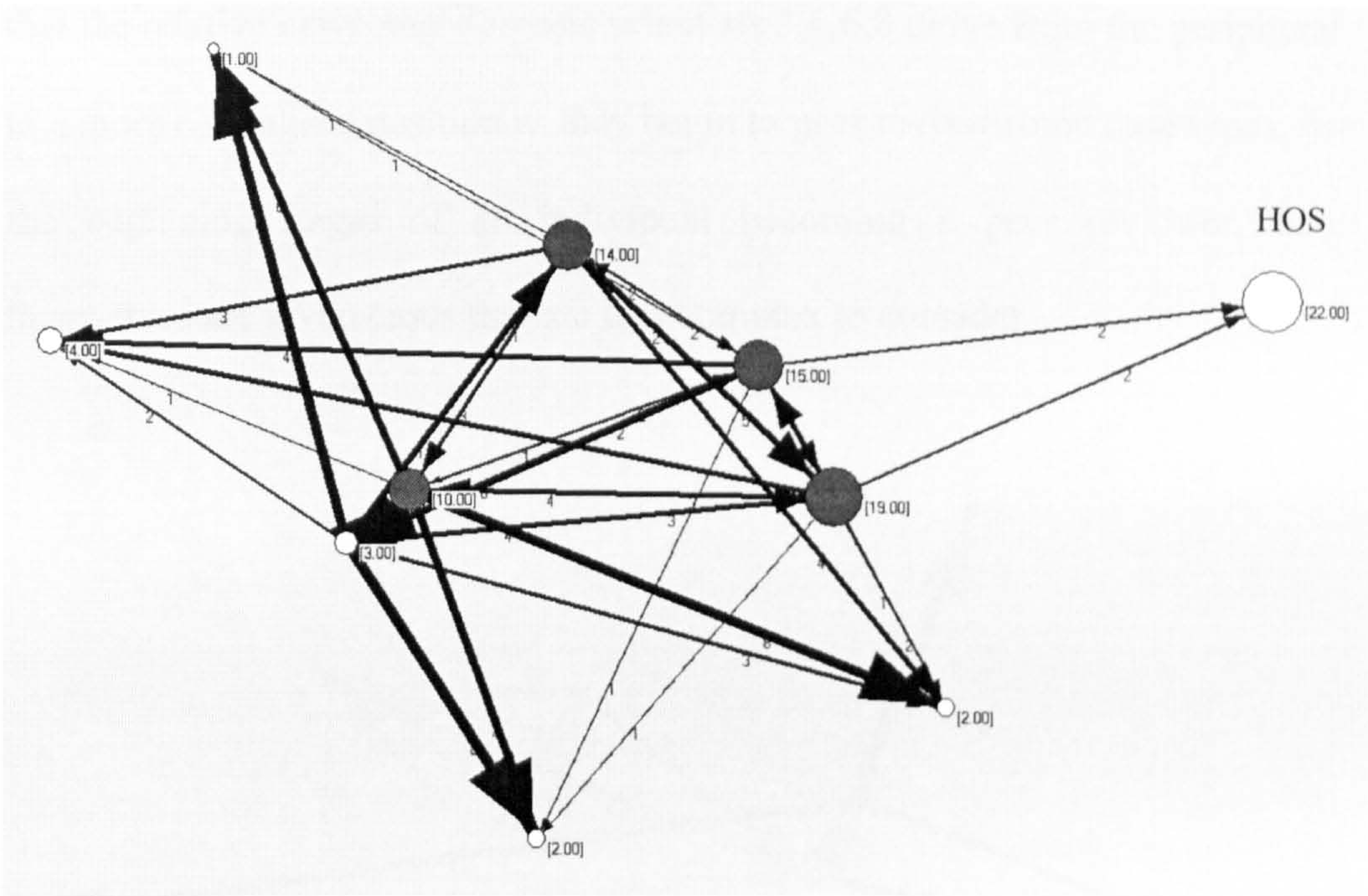



**Figure 36. Peer Review at Biology CoP-thickness of linkages proportional to amount of cases peer reviewed. Years of service of each scientist proportional to diameter of vertices. Red vertices represent scientists who peer-review case reports leaving laboratory, white vertices do not peer-review.**

***Peer Review in Biology over two years***

Here graphically, using the procedure of peer review of all case reports before they are despatched out of FSL, one can see the progression of newcomer forensic scientists within the Biology community as they move from the peripheral to a more central position of the group. On being deemed an individual who can be a reviewer of other's cases, it is a recognition that you are experienced enough to be able to judge that extra work is required to be done in a particular case – you have to have the experience of many cases before you can make that judgement.

Over two years one can see in the diagrams [Figure 37 – Figure 40] that the relative newcomer forensic scientists 3,4,6,8 move from the peripheral to a more centralised position as they begin to peer review some case types. In the beginning stages of an individual becoming a peer reviewer, they themselves are given cases that are less complex to consider.

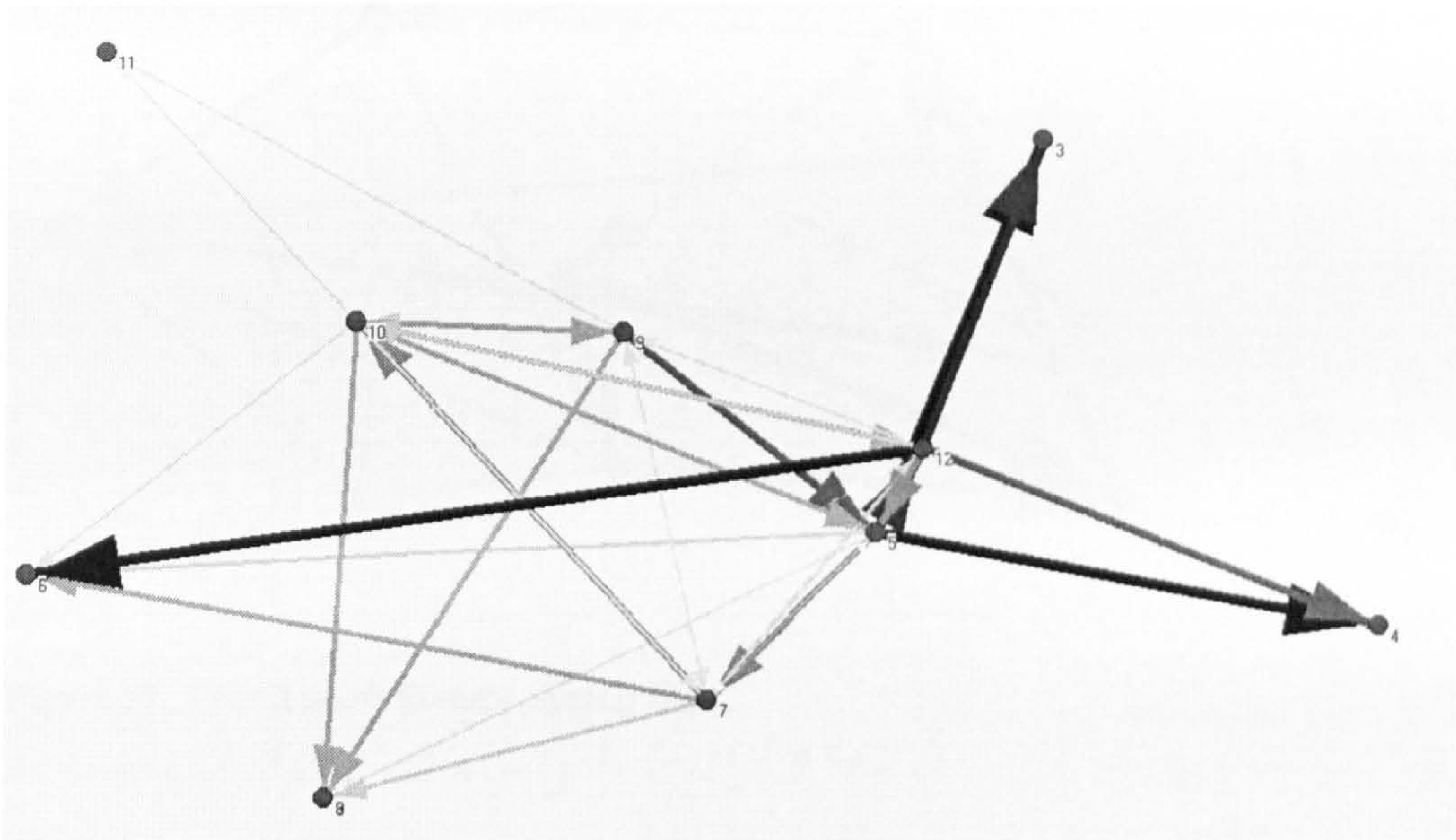



**Figure 37. Peer Review Biology Spring 2005**

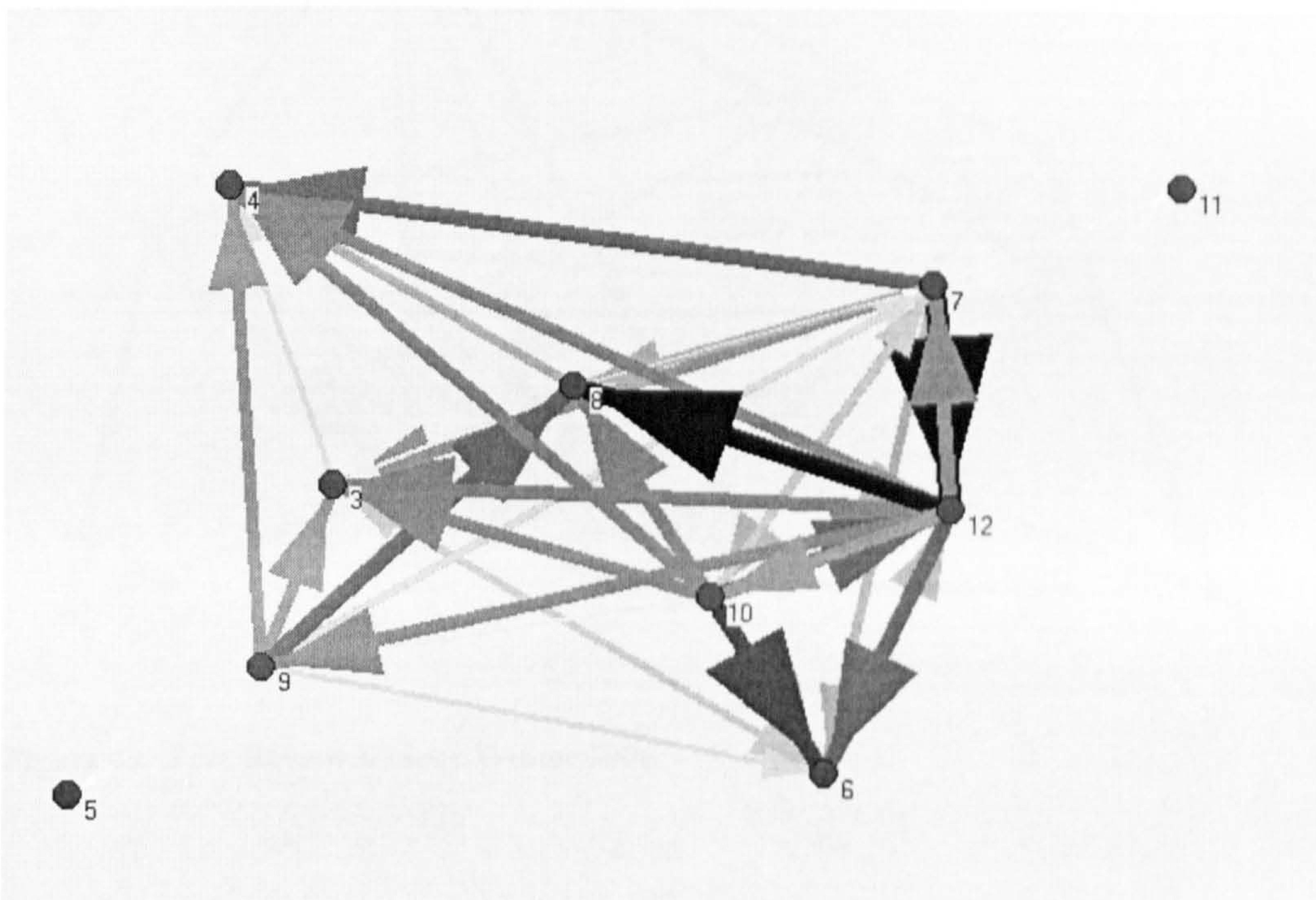



**Figure 38. Peer Review Biology Winter 2005**

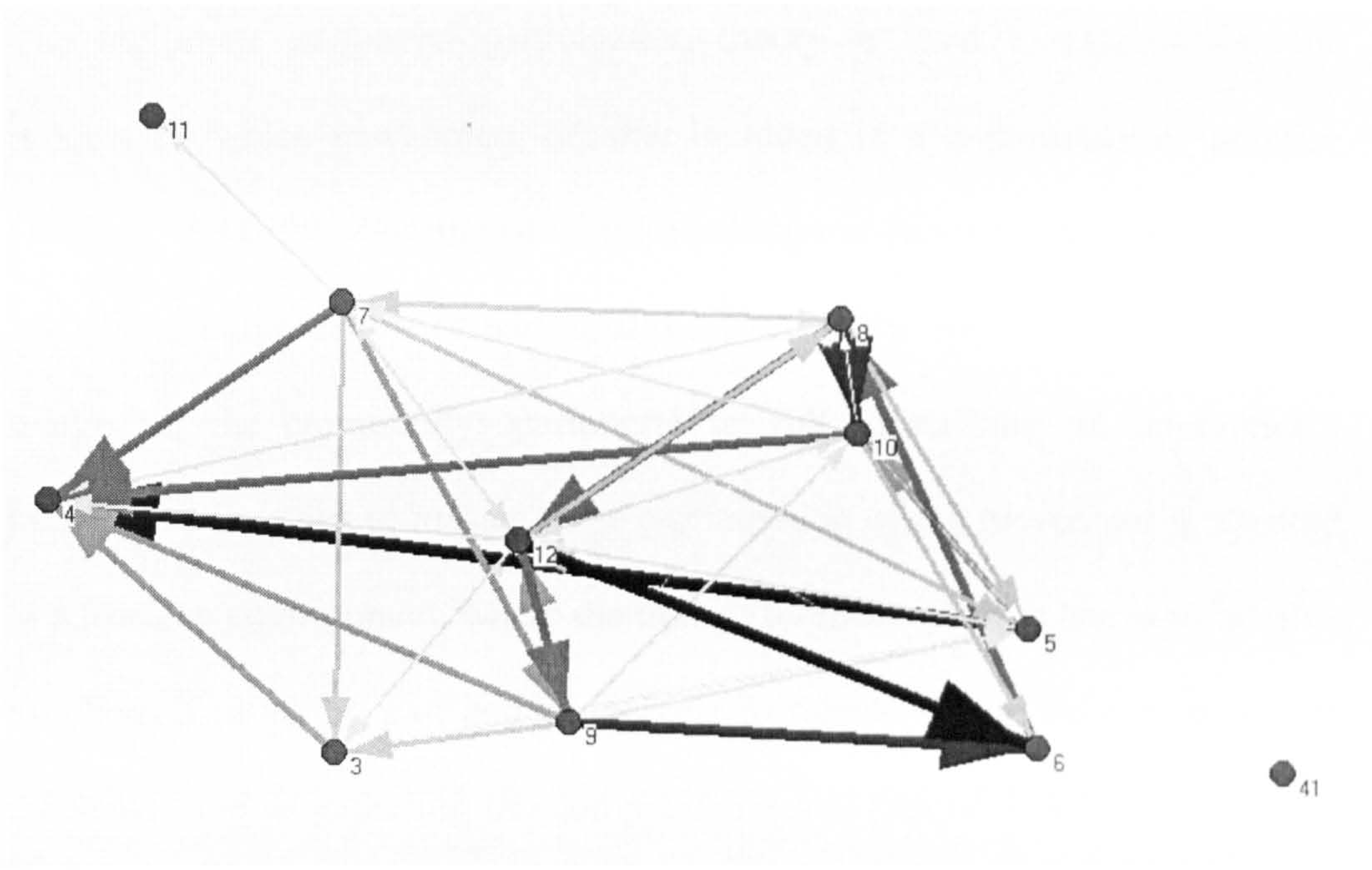



**Figure 39. Peer Review Biology Spring 2006**

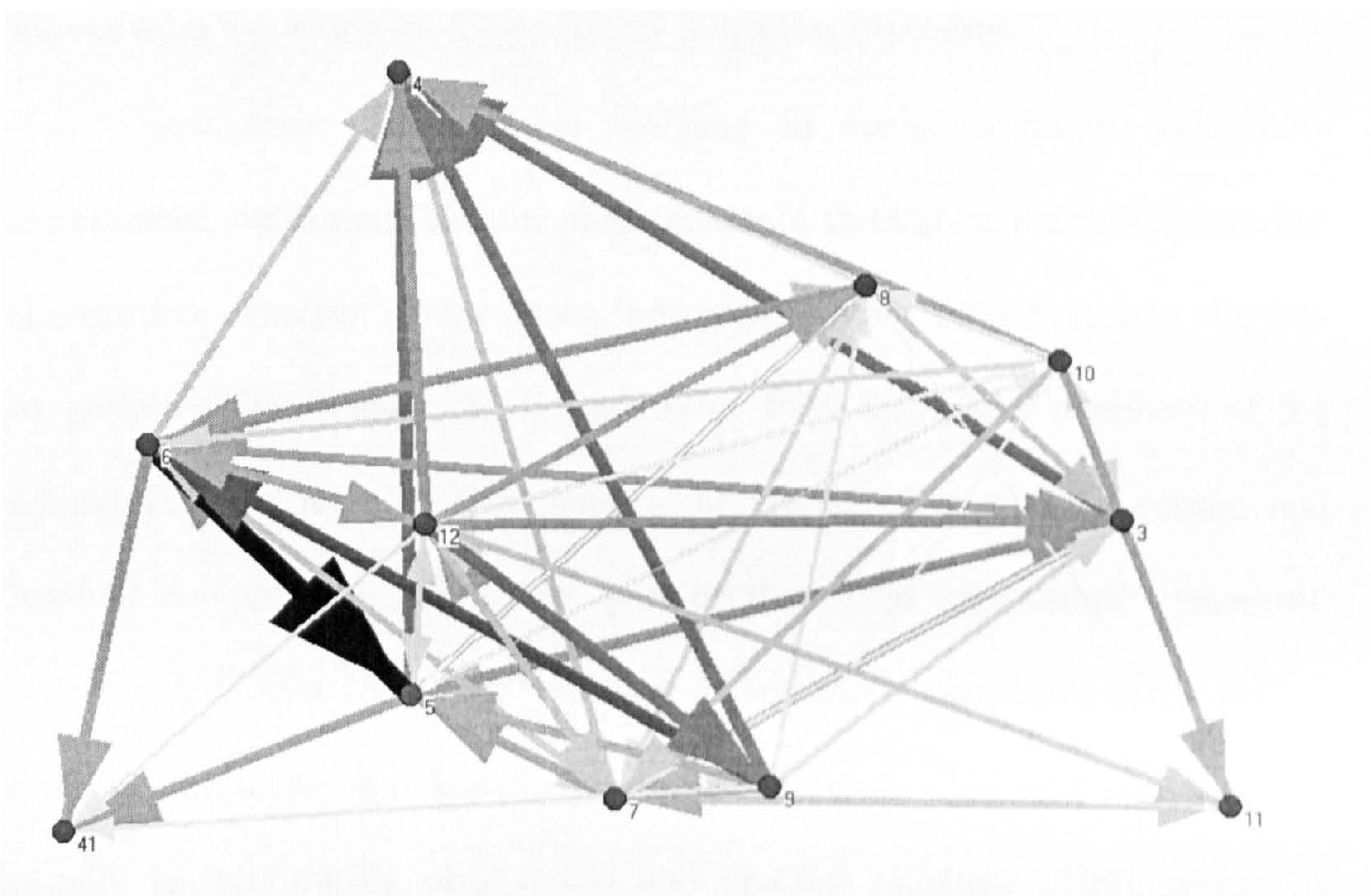



**Figure 40. Peer Review Biology Winter 2006**

***LPP – a qualitative insight***

The legitimate peripheral participation theory is used to characterise the process by which newcomers become included in a community of practice (Wenger 1998) [see Sharing of tacit knowledge within a social environment]. Variations in the degree of participation describe the status of the knowledge worker in the community: peripheral or full, describing an apprentice's journey from novice to master. The participation of the newcomer is situated in a learning environment, where the trainee forensic scientist learns to involve him/herself in taking part and connecting to others within the community at the same time as gathering the competencies and practical skills to carry out the casework. Gradually, through increasing levels of participation, the newcomer learns more about the ongoing practice of the organisation and moves from a position on the periphery to greater centrality.

Newcomers (apprentices) working in social contexts with more experienced old-timers become their students through a mentoring process (Leonard & Sensiper 1998). Once 'newcomers have moved on from the role of peripheral participants to the status of fully legitimate members of the community, the learning they have acquired, together with its pattern and implicit complex logic, becomes part of their tacit knowledge' (Gherardi, Nicolini, & Odella 1998). Where there is legitimate peripheral participation, there is sure to be tacit knowledge moving around. The tacit knowledge is usually learned during observation and practice (Epstein 1999), where its transfer is facilitated by intensive interpersonal contact (Collins & Hitt 2006).

Chloe is a good example of gradually being let do more of the casework on one's own as trust increases and concerns of quality and accuracy diminish:

> I had somebody else who was looking over my shoulder for a few cases until I felt fully comfortable. So I didn't have a problem anyway because I could go ask somebody if it was complex. I was...given easier stuff to start off with.

Wanda learned through practice as well as reading up on the background of the techniques:

> A lot of in-house training on the practical side of things and then a lot of reading the theory for the interpretation side of things.

Laura who has just completed her training, reflects that although she maybe signed off technically competent, she is still not fully legitimate within the speciality community that she is practicing in:

> So when it came to doing that for those cases I had no option but to go to whoever was nearest and then go – what do I do – where does this go? But I mean that is very much the understanding within our section – is that you are signed off but you're not...you're deemed competent but nobody expects you to actually completely know what you're meant to be doing or where you're meant to be going.

Jason during his time as a newcomer training worked with more experienced forensic scientists through a mentoring system, each specialty having its own resident expert:

> You'd be given a mentor for each phase of your training. So you'd have a mentor to train you on heroin and then there may or may not be someone else then who'd do cocaine and maybe someone else that did cannabis. There tends to be a number of different people.

In her experience Georgina feels that the mentor is very important in the training regime:

> I think your mentor would be the greatest influence depending on your mentor and how good your mentor is.

Melissa captures the steps of the mentoring process in her own words:

> When I started first is was around eleven years ago and we weren't accredited so there weren't per se fixed protocols hanging around the lab as there are now, but I would say I started through being mentored

> so, in other words, I tagged along with somebody for nearly up to six months and everything they did, I watched what they were doing, saw how they were doing it – all the way from searching up to writing reports.

Adam outlines the learning steps in actually writing up cases and issuing the final report the next stage after the analyses of items:

> Once people can do the technical side of it, they would be given lesser cases and the scientists would mentor through it and they'd discuss what they were going to do in it and then let them off and do it and have them write up and then discuss the report they'd written. And the scientists gain experience, eventually signing off on it. There is kind of a big learning area there for people.

Likewise, Georgina describes the comfort zones created for trainee forensic scientists:

> When I was trained there was an ethos here that you protected people from the high profile, high media case, you were not given a murder and you were given time to develop as a scientist and I think that was a good thing.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; LPP – a qualitative insight]

i <u>LPP\peripheral participation process</u>

Within the SOPs the process of training individuals is documented. Such training is carried out with a mentor who is an experienced forensic scientist. Those who become fully trained are deemed to be so through judgements or tests of being competent.

> The potential trainees knowledge requirement as outlined...to be checked by means of an oral or written examination

> The program for trainees is a mentoring process.

> Heads of section must make available to the trainee...less complex cases

> Training can extend over a long period of time as different areas of work within the laboratory are introduced
>
> At an appropriate stage, the trainee may undertake the analysis and preparation of draft reports in cases
>
> During the training period, the work performed by new trainees will be monitored
>
> train personnel to be competent to carry out procedures...to test this competence before...unsupervised work is accepted

ii View of previous experience held by organisation

A thread of discussion was picked up during the interviews, where new entrants to FSL, albeit highly qualified themselves and sometimes moreso than the serving members of FSL, were not appreciated for their own practical knowledge reserves that they had brought into the organisation.

Laura captures the indifference of the newcomer's previous experience held by the oldtimers.

> There is resistance to new knowledge and its not appreciated and I don't think it is utilised in a very effective manner. If you just look at, say, the last four...well, even the last, I'd guess, say ten people that came in. Everyone is coming in with a PhD...and is coming in with...you know, you're talking – depending on the case – maybe three or four years post-doctoral work plus work in other companies, other areas, and its an awful lot of knowledge and just because you've come into a new job as a forensic scientist doesn't negate your ten years of knowledge in obviously related fields.

Laura outlines the difficulties a newly appointed forensic scientist when in their efforts to affect the socialisation process, as they try to impress the oldtimers with their experiences on the previous job or academic position:

> I think a lot of people are quite good at reminding you that you are new.

In the newcomer trying to bring in some new ideas or innovations that are obvious to the outside world but fuzzy to the oldtimer serving in FSL because they have not had he opportunity to be exposed to the new developments, Laura meets resistance:

> So you find resistance in that. Even just simple tricks. You know, they're brought in and then they kind of go – oh yeah, you're right, that's actually really handy.

Aaron too makes reference to the indifference a newcomer forensic scientist faces:

> I think people coming in here it's assumed that they've the basic entry level requirement or whatever and they're just sort of treated like a blank canvas from scratch.

Jake relays the message that the fully legitimate members intimated to him on his joining FSL:

> I was told that – you're in here today and you should forget everything you've done yesterday – so people might feel that as being uncomfortable.

Kieran a senior forensic scientist manager and section head knows of the lack of interest that the experienced staff show to the new recruits and offers a suggestion as to why it happens:

> I would think that we probably, as a rule, do not draw on those resources as well as we should but partly because it's more important for us to train people on the job because most people say with what they've gained here so to have reference back too much to what was done before mightn't suit our purpose as well as we want it too.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; View of previous experience held by organisation]

## ***Learning & Training***

Here in this case study, one can see that learning is very much carried out within a social environment. Brown and Duguid (2001) feel that 'learning any but the most simple job,' 'is a complex social process' and 'cannot simply be captured in the notion that "all learning takes place inside individual human heads"'. Learning by doing and training allows the individual to access the knowledge realm of both the group and entire organisation (Nonaka & Konno 1998). We can see here how forensic scientists perceive how they learned.

Isabella saves the tacit filled learning moments from her previous cases to help her with similar cases she will meet in the future:

> The results that you got in the past are what trains you for the future, because you're going back and saying – yes, that worked that time – or – this is the stain that gave me the right results the last time, so I'll stick to that – or – I never get a result from that kind of thing so I won't do that one.

Georgina speaks of learning in a case as a foundation stone to future cases with similar case scenarios. She details the steps in accruing the collective tacit knowledge in processing such cases:

> I think only you get a lot of knowledge internally because every case we do challenges us and someone learns a little bit and I'm thinking in terms of the Alan Green case that Ella had that would be a case....how many people would have said goodbye and goodnight, I've done it quickly, it hasn't taken any time, she took her time over it, beat it to death, probably to her own detriment cause her numbers would be down etc. but she's somebody who is able to extract so much information from that and the process by which she learnt that by, that we hadn't leant before cause we hadn't done it and she passed it on, so I think that's a very good example of knowledge being learnt and passed on in cases.

[For other similar subject responses, *See* Appendix: Edited surplus Interviewee transcripts; Learning & Training]

# PART THREE

# 8 EVALUATION OF RESULTS

## *Introduction*

The literature explaining tacit knowledge 'as a whole has remained conceptual' and there is now 'a need to know much more empirically about the nature of tacit knowledge (Ambrosini & Bowman 2001: p.811)'. There are only a few empirical research studies of tacit knowledge utilisation (Assimakopoulos & Yan 2006;Cook & Brown 1999;Gherardi & Nicolini 2000) within organisations. This is one such study. This empirical analysis through the lens of relational thinking affords the reader a concrete understanding of knowledge sharing in practice in a knowledge intensive organisation. Now is examined, in light of the theoretical theory the empirical results.

The scope of this research has been to delve deeply into the organisation and look at the *process* level primarily to demystify the concept of Tacit Knowledge used by knowledge workers and to allow for the discovery of how tacit knowledge is actually used at the level of process. This answers the call from current researchers as 'little is known about the process of knowing in complex organisations', and 'it suggests the importance of examining how people in their ongoing practices constitute knowing (Orlikowski 2002: p.253)'. Giving recognition to the tacit aspects of knowledge, enables one to focus on the actual *mechanisms* of the knowledge worker; that of knowing – its explanation grounded in what it is people *do* every day to get their work done (Orlikowski 2002: p.249)'. As a result this research used both quantitative and qualitative results to understand the way the tacit dimensions of processes work, focusing on organizational knowing as an 'aspect of our interaction with the social and physical world (Cook & Brown 1999: p.381)' as opposed to focusing on organizational knowledge as a possession which has occupied much of the contemporary discourse on knowledge management.

This research importantly has an added dimension of looking at how knowledge workers deal with codified collections of explicit knowledge from whence they supposedly work from. As is evidenced here much knowledge in FSL, a practitioner-rich practice is experience-based and tacit. Nevertheless, the organisational management in this case study take the typical strategy for knowledge management having focused on standardised operating procedures and knowledge databases for capturing and disseminating knowledge as their means of managing knowledge. Here in this research it is found that in their highly knowledge-intensive processes, forensic science professionals bypass these collections of explicit knowledge, only to reuse core experts' tacit knowledge through face to face contact.

Ultimately these findings will help improve the way process is carried out in a knowledge intensive environment by having insights in how tacit knowledge works.

As is already evident tacit knowledge has been well defined encompassing both broad and finite explanations. From this research we can say that tacit knowledge is context-specific and of a personal nature and is scoped between two aspects: cognitive elements, including personal beliefs, values and mental models; and technical elements including technical skills and know-how (Assimakopoulos & Yan 2006). However, one has arrived at many explanations for tacit knowledge garnered from an abundance of writings on tacit knowledge at a performative abstract level. There has been little documented on the *process* of tacit knowledge exchange between knowledge workers in organisations, save for the documented ethnographic studies on communities of practice (Wenger and Snyder, 2000; Lesser and Storck, 2001; Lathlean and le May, 2002).

Unlike many of the qualitative performative abstract level ethnographic studies, this case study on a forensic science community, FSL, has shown the intricacies of tacit knowledge exchange, allowing readers to understand from a *quantitative* viewpoint what happens between knowledge workers during their daily work practice. Here *empirical evidence* has been presented, qualifying the theoretical assumptions laid down within the community of practice literature, on how tacit knowledge evolves and is transferred among members of the community.

Found here is that social relational networks underpin the diffusion of tacit knowledge having looked at patterns of advice seeking relations among forensic scientists. In particular, the mapped advice network of actors featuring their exchanges allows the reader to understand the structure of knowledge flows.

Over the following pages, the evaluation of the results will encompass how the findings here fit within the already documented literature base, either adding to, or fortifying the established academic knowledge foundation.

At first instance, I question why there is a need to look at the actual process of tacit knowledge generation and use, where unlike the already well published macro-level studies, this micro-level study gives one an understanding of how knowledge workers actually operate.

Secondly, in establishing the need for tacit knowledge in addition to the organisational standard operating procedures, answers are set out in how one lets these exchanges occur. The relational mechanisms of tacit knowledge traffic amongst actors are discussed, where the many different relationships between knowledge workers are explicated showing how these cooperative face-to-face contacts (from different transactional relationships) increase the likelihood or indeed allow for tacit knowledge transfer.

Thirdly, on describing the importance of relationships between individuals, the role that communities of practice and additionally networks of practice play as a driver of these relational exchanges of tacit knowledge is discussed.

Fourthly, on elucidating these relationships within communities one finds that they are as a result of actors networking together. Instead of imaging such networks within organisations here an evaluation of Social Network Analysis visualisation methodology is carried out, where it can be used as a tool in making networks more effective.

Fifthly, in looking at the process level, the research findings are presented with respect to the interplay of standard operating procedures and the practitioners' tacit knowledge requirements. This work on all accounts has not been done before as the quality management movement is removed both physically and from the academic knowledge management literature. The explicit world of management's view of knowledge is directly compared to prima-facia cases of how the knowledge workers use, or over time not use, the cogent explicit protocols or knowledge databases, in favour of their own or like-minded stores of tacit knowledge from colleagues. Eventhough after much investment by management, questions need to be asked about the formalised explicit knowledge base and whether or not they do cover the real knowledge needs of practitioners.

And finally, how learning is facilitated by communities of practice is discussed.

***Looking at process (why the need)***

According to Knorr Cetina (1999) the literature recognises the thick interweaving of professional knowledge and other aspects of social life, but has paid scant attention to the nature of knowledge processes and knowledge cultures, as some authors tend to see knowledge as an intellectual product rather than as a production context in its own right. The traditional definition of a knowledge society puts the emphasis on knowledge as statements of scientific belief or as intellectual property. Here in this research the emphasis has been switched to knowledge as practised within structures, processes and the organisational environment.

Although there is a well developed literature on organisational behaviour, where organisations tend to be seen as frameworks of coordination for human groups, it is very much worth viewing the substance of the inner workings of process of the organisation, giving an understanding of how the knowledge worker actually operates, thereby using the results of this research to allow any cogent recommendations to be applied to existing organisational procedures.

Furthermore, thinking about process or indeed the set up of SOPs is not enough. In looking at process more intrinsically from within, one can then bring in the whole domain of Tacit Knowledge exchange within practice, which itself is not recognised in Quality Management stylistics.

Shotter ( 2006) prefers that in theorizing about process, instead of thinking about process 'from the outside' or about processes that we merely observe as happening 'over there', a perspective in which academic authors are mostly oriented towards, that one should focus on understanding process from within. The 'aboutness-thinking' that is more familiar to us should be relegated to allow one to turn to the 'thinking-from-within'. Shotter in tasking us to change our way of thinking on process (to in-process), states that it is similar to a *subsidiary awareness* – a concept provided by Polanyi (1958).

Looking at a more intricate level of how such communities of practice operate when compared to the well published higher order concepts, I ask what is it that knowledge workers actually do in such communities – what makes them operate and how do they go about their business. At the level of the knowledge worker within the practicing community, one needs a clearer picture as to how such workers operate in their process environment with each other and within the organisational community. The literature is now only beginning to address this issue, getting down to the more micro-levels of doing business. There has been little research done at the worker process level – the actual steps in allowing for such communities to function.

This kind of intimate analysis of such knowledge workers has not been carried out previously – only the more gross ethnographic studies of such communities have been carried out, yielding those higher order concepts we all know of. Here there is a mixture of the quantitative and qualitative methodologies used to discover more about tacit knowledge used within organisations, at a *micro-process* level. The actual working process of tacit knowledge exchange from a quantitative perspective has only been touched on within the Community of Practice literature (Assimakopoulos & Yan 2006;Borgatti & Cross 2003).

Shown here is that knowledge workers in local communities operate together within a network dimension sharing a common language and technical background. This doctoral research uses quantitative analysis using social network analysis to quantify tacit knowledge exchanges. Uncovered were pictorial maps of relational knowledge flows between forensic scientists within communities of practice at FSL. Not reflected on before in the literature, this research designed a proxy to measure the levels of tacit knowledge in individuals. Identified was the use of the *prominence* marker of forensic scientists within network maps as the proxy yielding the size of their tacit knowledge repositories. Popularity and prestige, two measures of prominence allowed the identification of those scientists who had become central cogs in the tacit knowledge exchange networks within this case study. It is evident from this research that the less experienced forensic scientists selectively choose to seek advice in casework problems from those fellow forensic scientists who have major sources of evident tacit knowledge, as identified from their network prominence and betweeness centralities. In showing maps of individuals seeking advice from other peers of the same community this research fortifies existing quantitative research findings, carried out on inter-firm cognitive linkages of a wine cluster in Chile, where local communities of knowledge workers form spontaneous (but not random) networking practices, which boost processes of knowledge exchange and generation between individuals (Giuliani & Bell 2005). Such network mapping allows one to change their concept of knowledge from a passive part in the existence of such working communities, to an action view of knowledge – the process of knowing in practice.

Traditional qualitative semi-structured interviews were additionally used to discover the tacit nature of knowledge involved in organisational process. Through qualitative analysis of interviewee comments, this research strengthens other author's findings that tacit knowledge has an implicit richness embedded in collaborative traffic (Tschannen-Moran & Nestor-Baker 2004). All interviewees mentioned tacit knowledge as a major contributor as to why they would collaborate with colleagues. This research discovered why forensic scientists needed to continually communicate and confer with each other. Although very adept at examining any piece of evidence that added to the bigger picture of interpretation, their need was to collaboratively confer with fellow forensic scientists, who had already the experience through their own years of practice, to seek the answer to the question that they had proffered, often a tangential point in their examination procedures. This research solidifies the findings of other authors, in the nascent quantitative community of practice field, as to why knowledge workers form such networks – they 'seek advice from other community members in search of complementarity, different solutions to their specific technical problems, or simply interconnect to exchange experiences and improve their technical knowledge accordingly (Giuliani & Bell 2005: p. 51)', mediated within a relational environment (Gherardi & Nicolini 2000).

Keeping in mind that 'knowledge is an activity which would be better described as a process of knowing (Polanyi 1969: p.132)'. Results here in this research complement the findings of others where they describe that new knowledge can be generated by the 'interplay of knowledge and knowing' within the situated social interaction of practice (Cook & Brown 1999: p.381). In looking at the organisation with such concepts, we see that the knowledge worker uses knowing along with a dynamic interaction with the environment in carrying out their practice. This research project answers the calls of Cook and Brown who state more case studies in knowing are needed.

***How tacit knowledge is spread – Relational***

Tacit Knowledge is usually learned during observation and practice, or from prior experiences (Epstein 1999) and its transfer is facilitated by intensive interpersonal contact (Collins & Hitt 2006). The assumptions that learning and the resultant knowledge gained are mainly as a result of an individual's mental processes have been replaced in recent times by the concept that knowledge is instead gained as a result of mainly social and cultural phenomena (Blackler 1995;Brown & Duguid 1991;Cook & Brown 1999;Gherardi & Nicolini 2000;Gherardi, Nicolini, & Odella 1998;Lave & Wenger 1991;Tsoukas 1996), in that 'knowledge is performed in, by and through social relations' (Gherardi & Nicolini 2000: p.331). Here, I focused on how the informal social structure allows for tacit knowledge to flow between practitioners inside and somewhat outside the organisation, answering the call for empirical analysis of knowledge sharing practices using the relational thinking concept (Osterlund & Carlile 2005), where the relationships among tie strength, tacitness, and ease of transfer has yet to be investigated (Reagans & McEvily 2003). The relational facet 'describes the kind of personal relationships people have developed with each other through a history of interactions (Nahapiet & Ghoshal 1998: p.244)'. It is recognised that informal interpersonal networks are thought to play a critical role in the knowledge transfer process (Reagans & McEvily 2003) and that knowledge transfer is facilitated by intensive social interactions of organisational actors (Inkpen & Tsang 2005). A unifying concept of the knowledge and learning gained through participant practice, is its construction from '*relations* among people engaged in an activity' (Osterlund & Carlile 2005: p.92).

In utilising social relations to help elucidate knowledge creation, two broad categories are found in the current research writings: that of focusing on dyads and the properties of such relationships between them, and a broader perspective focusing on the structural dimensions of such network relationships. Here, this doctoral research has focused on the former – the relations between actors who exchange knowledge of the tacit nature (Argote, McEvily, & Reagans 2003), for structural approaches to networks that ignore social qualities inadequately specify how networks function (Inkpen & Tsang 2005). Relative to research on how properties of network structure affect knowledge exchange, research on how properties of relationships between actors in such networks affect learning and knowledge management outcomes is a newer theme (Argote, McEvily, & Reagans 2003). Indeed the role of weak and strong ties intensely covered in the literature (Burt 1997;Granovetter 1973;Hansen 1999) have paid less attention to the relational characteristics of such ties that ultimately govern who seeks whom for information (Borgatti & Cross 2003). Argote et al (2003) call for research in dyadic relationships beyond tie strength to be carried out that affect knowledge management outcomes. Despite the variety of ties that have been examined, analyses to date have stopped short of incorporating many types of informal, interpersonal relationships (Ingram & Roberts 2000): the elucidation of such relationships are hence presented ahead.

Conceptually, I have shown that tacit knowledge has a relational nature, embedded in social networks, from this study of tacit knowledge exchange at a micro-level between social actors – forensic scientists. A tightly bound relational environment was found, where through quantitative network analysis and semi-structured interviewee comments, there is evidence of tacit knowledge flowing through the web of social relations, easing the journey for tacit knowledge to travel (Doak & Assimakopoulos 2007c), adding to the thinking that 'tacit knowing begins within the embodied interaction of human beings with the surrounding physical and social environments (Gill 2000: p.57)'. Such a system of relationships in which the forensic scientist practitioners are embedded is known to promote cooperation amongst themselves increasing the scientist's willingness to share knowledge with each other (Kostova & Roth 2003;Reagans & McEvily 2003;Tsai & Ghoshal 1998). Here, I mapped the advice relation showing knowledge flows among forensic scientists within/between communities of practice at FSL, where I found using density and betweeness network measures, that some actors within their communities are close in distance allowing for knowledge to travel between them. Such closeness allows for a quality to their communication, an important point to consider where 'acquiring tacit knowledge relies on the quality of a knowledge seeker's *relationship* with a knowledge source (Levin & Cross 2004: p.1481)'. Clearly as in the example with one forensic scientist, who is closely connected and community bounded, she has direct contact with nearly all her colleagues in Biology. She speaks highly of reciprocity, realising the informal collective nature of a community of practice contrasting it with an environment that is more structured.

> ...informal...it's very important because when it's informal it actually will capture really important situations that aren't usual whereas if you have a structured environment, those situations are gone because you have to wait for it to happen at a particular time or a particular day and on top of that people are much more open to learn because it's pure system...

Instead of looking at process alone in judging how outputs are created, this research has looked at the social relational dimensions *surrounding* and *encircling* the process [see Figure 41], for understanding the relational processes and the properties of the relationship necessary to transfer knowledge is important in acquiring tacit knowledge. It is these relationships that create common experiences and a mutual understanding of symbolic meanings, allowing the successful acquisition, diffusion and application of tacit knowledge to more likely (Collins & Hitt 2006).

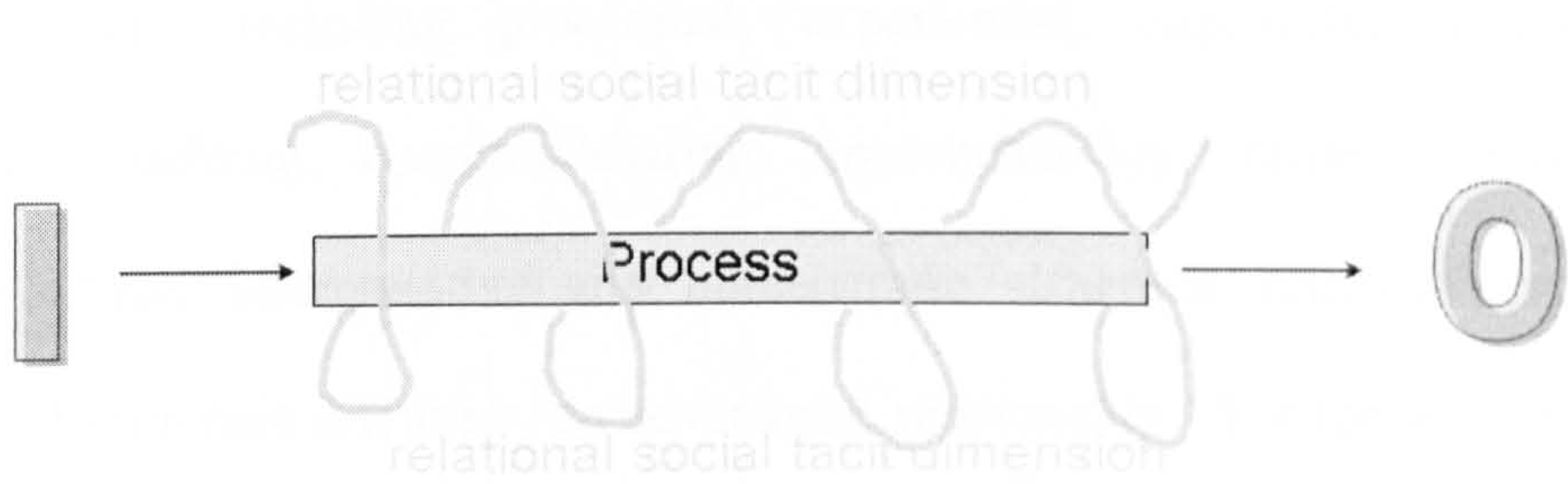



Figure 41. The relational social tacit dimension of knowledge encircling the process of converting input to output (author).

This relational thinking concept falls well into the already discussed theory of Lave and Wenger's (1991) situated knowledge in communities of practice, where knowing and learning are constructed by *relations* among actors engaged in an activity. Kogut and Zander have emphasized that firms should be seen as social communities that specialise in the transfer of tacit and idiosyncratic knowledge (Kogut & Zander 1996).

The relational dimension focuses on the role of direct ties between actors within a network (Inkpen & Tsang 2005), as explored in this research with the geodesic calculations carried out on the advice networks [see v Network Closeness Measures within CoPs]. Levin and Cross (2004) call for the need to better understand the role of relational factors such as trust and emotion for effective knowledge transfer, in that they matter *most* when the exchange involves *tacit* knowledge, for trust plays a key role in the willingness of network actors to share knowledge (Inkpen & Tsang 2005). Respect, friendship (Ingram & Roberts 2000), identity and social norms are other examples of such relational dyadic ties that have been discussed in the literature. Answering the call of researchers, this doctoral case study has found more, including processual, experiential, capability, mentoring, informal, helping, openness/sharing, approachability, respect, proximal, cohort/clique, interpretative and bureaucratic structural relationships, and unique to forensic scientists, an adversarial relationship. For the less obvious of those relations listed, a further explanation is set out below:

Processual

As work within this organisation cannot be carried out without the completion of the standardised processes, the significant dealings around the carrying out of the process ensures that process in itself becomes a relationship. The amount of SOPs and the many steps that need to be signed off by independent peer assessments can make the codified collection of explicit knowledge daunting.

> ...rather than go through the hassle of having to thumb through the SOPs...if the person standing beside you is more experienced – just ask them...

The daily work of forensic scientists involves processes where face-to-face contact allows for the tacit tips to be exchanged. A forensic scientist reckons that knowledge is spread through personal networks.

> ...it's people to people contact...

Experiential

Because experience itself is treated with deference amongst forensic science practitioners who have allowed it to become a reified trait of an individual's ability, experience is chosen in this research as a relation between actors:

> ...interested and listening and using other people's experiences as well because obviously working on casework for a number of years and things cropping up...and things you mightn't have thought of...

In the main the less experienced forensic scientist would always confer with a scientist who is more experienced. This can be seen clearly in the relational advice networks [Figure 25-Figure 28] where clearly it is seen that advice is not mediated by the organisation's structural order but by the relationship of experience. In certain of the SOPs, the process under completion to the satisfaction of the proper standards of FSL, would not have been concluded were it not for the advice incident proffered by the experienced colleague conferring a tacit dimension to the knowledge gained (Sternberg 2000). This research finding backs up Cross and Cummings' ( 2004) suggestion that awareness of others' expertise can affect performance by increasing the likelihood of obtaining relevant information to solve novel problems.

The experience dimension was based on a subjective judgement and was not related to an actor's structural bureaucratic position or indeed to length of service:

> ...I go to people with most experience, not necessarily choose somebody with fifteen years over ten years.

This evident mismatch between length of service and experience fortifies Wagner's (1987) arguments that tacit knowledge is not a direct function of service, postulating that there are those with long years of service who do not evidence higher levels of tacit knowledge. This self-choosing of those who are experienced was backed up with the quantitative relational advice graphs, where one can see that each scientist put him/herself in a natural pecking order, where in the main those more experienced than themselves gave advice and those less experienced than themselves were in receipt of advice from them.

Capability

Individuals go to those recognised as being capable, where they have the ability necessary to do something or have a particular talent or acquired skill. This relational dimension is made clear by Sternberg (2000) who adds that practical abilities are used to navigate everyday life which includes interpersonal skills and the ability to solve practical problems, all features of tacit knowledge. A scientist contributes to the understanding of such a relation:

> ...I'd probably seek out the one I think knows most about it. I'd be aware that there are certain people...that there's different levels of knowledge in different areas – like if I need to know something legal I'd probably go to herself, or something about quality assurance, I'd go straight to him...

Where each scientist has different capabilities or competencies:

> ...some people have strengths in different areas, maybe developed a particular area, you know brought something on stream and therefore obviously had to deal with all the pitfalls along the way...

Levin and Cross (2004) suggest that competence-based trust mediates the link between strong ties and receipt of useful tacit knowledge. This research has *found* this where participant actors within their communities admit to selectively seeking out their advisors for requisite finite sets of knowledge based on judged capabilities, where they have the ability necessary to do something or have a particular talent or acquired skill. Of those scientists selected, their capabilities are judged by evaluating the individual's prior performance in previous consultations and their reflective prowess to questions posed.

Informal

Casual renewal of acquaintances at coffee or at the water cooler are well known sites of informal interaction and are highly important for knowledge diffusion (Brown & Duguid 1998). In witness to this research a forensic scientist captures such informality:

> ...if you're passing down the lab, two or three people sitting around and I'd be looking at a file or something, or it could be something that maybe would be useful to you so you kind of earwig if you think...it's casual, some people like talking to you...yeah, when people come across something new or different they tend to mingle...

In the sharing of tacit knowledge it requires such informal interaction and can be typical of the learning surroundings found in a community of practice setting, such as storytelling, conversation, coaching and apprenticeship (Wenger, McDermott, & Snyder 2002). These informal arrangements force the organisational management literature to realise the 'importance of people as creators and carriers of knowledge', rather than knowledge lying in its databases over its people (Brown & Duguid 2000a: p.121). Importantly, such informal knowledge is transient and not permanently caputured.

> ...over coffee or in a bit of a huddle somewhere – and its not written down...

Helping/reciprocity

Within FSL the noble nature of helping as a relationship is evident where a reciprocal culture of helping in return predominates, evident in the feeling of a forensic scientist.

> ...I'd be quite happy because I know that it could be me on the other end of the stick tomorrow and I'd like...it would be nice for somebody

> to stop what they're doing and say – oh, actually I can help you there...

This research finding catches on to the belief that communities of practice 'arise out of a natural desire to share ideas, get help, learn about new ideas, and hearing the latest professional gossip (McDermott 1999). Such a practical experiential environment based on trust and a helping attitude can allow tacit knowledge to become disentangled (Johannessen, Olaisen, & Olsen 2001). A relaxed feeling from such obvious brotherhood is evident from findings in this research.

> ...you feel, yeah, you've been helpful and letting them kind of progress as well. I same with myself, you know, you feel that everybody else has been very helpful to me, why shouldn't I be helpful to people who are coming up as well who are learning...I'm just happy to help people and in the same way...but it works both ways, I have a strong expectation that if I go to someone for help I'm given it...

These cooperative norms provide experienced actors holding knowledge with some assurance that if they share knowledge with somebody today, someone else will be willing to assist them in the future (Reagans & McEvily 2003).

<u>Openness/sharing</u>

The open and sharing environment at FSL for any knowledge to be transferred is important, especially knowledge of the tacit dimension. The important aspect of such technical professional communities (Bouty 2000), is that actors will 'share know how, or tacit knowledge (Brown & Duguid 2001: p.204)'. This is evident in such a community as Biology, which is closely tied together, based on network density measures, within a knowledge network.

> ...I think in biology people are very good...I think there is a lot of dialogue there...they are interested in it [knowledge] and like the opportunity to talk. I would think that we are good at sharing knowledge here; there is a lot of discussion...

This trusting environment encourages knowledge sharing by increasing the disclosure of knowledge to others and by granting others access to one's own knowledge (McEvily, Perrone, & Zaheer 2003). Indeed, individuals who communicate with each other frequently or who have a strong emotional attachment are more likely to share knowledge than those who communicate infrequently or who are not emotionally attached (Reagans & McEvily 2003). Indeed in prolonging their reputation, actors are more likely to cooperate with a colleague when strong third-party ties surround their relationship, because they know that if they do not cooperate, news of their uncooperative behaviour will spread to other network members, quickly limiting their ability to interact with them in the future (Coleman 1988).

Approachability

Because many of the processes involve the forensic scientists to seek advice, the people who are sought for advice must be accessible in their demeanour.

> ...somebody that you find approachable...somebody that you know doesn't mind dealing with queries and is willing to put down whatever they're doing to talk to you...

Identified in this research is that approachability is a major contributor for positive person-to-person interactions:

> ...whether we like it or not approachability is one major factor, irrespective of knowledge. There's some people, no matter what they have, you would be reluctant to...that's the nature of human interactions...

Others see the need for such ease in accessing knowledge from actors:

> ...I'd go to somebody who I knew was amenable to answering questions and would be able to help...interested and not rushing to do their own work. There would be certain people I would go to more than other people within the section...

<u>Cohort/clique</u>

As found in the network analysis some of the friendships that have formed during socialisation together in FSL have followed through where the same scientists now seek advice from each other [see Results Chpt. 5]. Through participant observation in this case study, it is evident that socially during the working day that these cliques mingle as such in the canteen or during functions. However such cliques can be a disadvantage to process effectiveness. On the downside, disorders of communities of practice include imperialism in the domain, cliques in the community, and dogmatism in the practice (Wenger, McDermott, & Snyder 2002: p. 150). As they are so evident, the clique and cohort are judged here to be a relationship between individuals that allow scientists to circulate with ease with each other along the path of least resistance to social acceptability. A forensic scientist paints a picture of the bleakness of such actions.

> ...I think there's a lot of times when people come into the organisation you can see...I think any of the groupings within the organisation are very much based on when you came in and I know, myself, I tend to – I'll say, socialise on the level of going to lunch and coffee with the people who joined the organisation in and around the same time...particularly in the Chemistry section, because there are a lot more people who were here a lot longer, they tend to stay together and that's why I'm saying that the knowledge isn't really dissipated down much – they stay together, they tell each other everything and then people like me, who don't actually go to lunch with them, who go with other people, miss out on all that. That was always my impression...

While there are intense knowledge exchanges within a clique, there may be little between cliques (Inkpen & Tsang 2005), a negative relationship that impedes the exchange of performance-enhancing information (Labianca & Brass 2006): a finding adding to the scant literature on negative relationships within organisations – answering the call to explore some of the dysfunctional or negative aspects of relationships (Argote, McEvily, & Reagans 2003). Indeed, as seen quantitatively friendships formed through cohort entry, increase the potential for collaboration and for the enhanced flow of information through selected individuals who share the same genesis (Ingram & Roberts 2000), thereby promoting selective knowledge transfer (Reagans & McEvily 2003). This is a serious concern of the Director:

> ...I am slightly concerned about the transfer of knowledge from one generation to the next and by generation I am talking about layers of people who have come in at different times and who, when they need advice will go to their own peer level as opposed to maybe people ahead of them who have more experience, and that's a concern for me...

Hence, the uniformity of knowledge amongst members of the same cohort is evident in that they inherit the same common knowledge, clearly identified by Reagans and McEvily (2003), who give the example of two engineers who entered an organisation in the same cohort group and were found to more likely to share similar experiences and knowledge in common, than individuals who entered at different points in time.

<u>Interpretative</u>

Within FSL, the compilation of results needs to be interpreted with respect to the whole case scenario, in that case propositions have been addressed correctly by the scientist. The interpretive skillset of the scientist is learned from the experience of completing many cases, and as such is not covered in any of the organisational SOPs. Interpretation and judgement go hand-in-hand, and are points of much discussion during peer review sessions, which are designed to ensure that case reports entail the full complement of work, which have to be fit for purpose.

> ...that the findings are appropriately interpreted and are expressed in a way that is understandable to the recipient without compromising the content of the report...

Adversarial

Unique to forensic scientists their work can be contested by legal counsel – adding an additional dimension not normally experienced by other professionals. It is often that the forensic scientist carrying out that analysis has an imaginary thorough cross-examination going on in the back of his/her head, readying themselves for that eventual dreaded court case.

> ...because of the adversarial system in the Courts, you really need to be bouncing your ideas and your opinions and your decisions off somebody else, because they're always going to be challenged in the long run by somebody else, either by a defence scientist or by a defence barrister...

Structural

As FSL is designed along the lines of a functional bureaucracy because of its civil service origins, structure in this case study can very much mediate the pathways of advice seekers. It is both the structural and relational mechanisms that capture the concept of social capital. Organisational structure provides certain actors with access to different information over others (Kostova & Roth 2003).

> ...In here its very much power play. It's very structured and its very – you know – Victorian, and the higher up the food chain you are, the more you're allowed to voice your opinion...

However, this empirical research has shown that although an actor can be structurally significant, they may be of no value when looking at how they relate to others when people seek knowledge.

There was a predominant pattern found within these results where through relationships it was found that there are many chances for face-to-face discourse, allowing for tacit knowledge to be transferred. Many of the more formal organisational procedures that affect the forensic scientist in their daily work were found here to be supplemented by a huge informal relational environment. Such 'relationships are likely to lead to positive and cooperative behaviours, since they create a psychological environment conducive to collaboration and mutual support (Kostova & Roth 2003: p.301)'. Through a social environment the organisation is strengthened considerably by the individual actor maintaining those relationships, a felt obligation to reciprocate past favours of other social actors, and an expectation that other social actors will also reciprocate. This research has found this where because of the helping culture that predominates forensic scientists can ask each other for advice with ease. Individuals once they proffer assistance can rely on the return help.

***Communities of Practice as the driver of relational tacit knowledge exchange***

Communities of practice have a role in enabling tacit knowledge creation and exchange (Wenger and Snyder, 2000; Lesser and Storck, 2001; Lathlean and le May, 2002). As is evident in this research, a strong community fosters interactions and relationships based on mutual respect and trust (Wenger, McDermott, & Snyder 2002: p. 28). This relational thinking concept falls well into Lave and Wenger's (1991) situated knowledge theory of communities of practice, where knowing and learning are constructed by relations among actors engaged in an activity.

Having knowledge transferred is not just a matter of acquiring it (Hsu & Shen 2005) and is indeed even more difficult for the tacit aspects of knowledge (Nonaka 2007). For knowledge to be generated requires intensive and laborious interactions among people, leading to a socially capitalised cohesion having a positive effect on knowledge transfer, primarily through influencing the willingness of individuals to devote time and effort to assisting others (Reagans & McEvily 2003). There is evidence suggesting that knowledge transfer is facilitated by intensive social interactions of organisational actors, where these networks of relationships are a valuable organisational resource (Inkpen & Tsang 2005). It is the community's strength that drives the desire to share knowledge and expertise, and is sustained by its member's passion and interests to achieve a shared outcome (Wenger & Snyder 2000). Enhanced information exchange is another of the advantages of ties embedded in such social relationships (Ingram & Roberts 2000). Much of these social interactions are the domain of informal groups of employees or networks who join and commit to local sets of relationships or communities of practice (Cross, Nohria, & Parker 2002). Also known as social networks, actors within these knowledge-intensive organisations, use personal relationships to find information and do their jobs (Cross, Nohria, & Parker 2002). Compared to individualistic cultures which tend to emphasize explicit knowledge, these collectivistic cultures place greater emphasis on tacit knowledge (Collins & Hitt 2006).

Based on the findings in the FSL case study this doctoral research shows that it is not the documents (SOPs) that allow for the new generation of knowledge but it is intense face-to-face interactions with the other members of the community of practice that allow for the spread of the tacit dimensions of knowledge, for strong interpersonal connections within a dense network cluster ensure that knowledge will diffuse quickly within that cluster (Reagans & McEvily 2003).

***<u>Graphical visualisation of networks</u>***

The phenomenon of social network analysis has been well used in drawing sociograms of general public groupings or networks and also organisational networks. Cross and Parker (2004) discuss how such analysis can be optimised for managers to recognise unique features of employee networks. A manager in charge of a department or embedded within one, is affected by information flow and webs of relationships between organisational actors within social networks which are somewhat invisible at prima facia observation. The network analysis identifies critical actors for information flows which would not be immediately apparent to a manager in charge of a group of workers. As a corollary, peripheral actors are identified who are distant to the network, not because they are social enigmas, but because their expertise is untapped or because they may be senior people who have become too removed from the group's day to day operations from carrying out more administrative tasks, making them less accessible and knowledgeable about the work of their colleagues. Rather than leave the inner workings of a network to chance, managers can leverage the graphical visualisations of social network analysis to address critical disengagements or inflexibilities caused by the misplacement of actors in networks. For managers need to take a more targeted network perspective approach where more excessive or deficient relationships can burden the actual workings of such relational networks. There is evidence that well-managed network connectivity is critical to performance and learning (Cross & Parker 2004). However just having collections of teams is not enough, in that managing the network requires understanding of the actual relationships that are the basis of all interactions between the actors of such teams, where relationships are critical for obtaining knowledge, solving problems, and in learning (Lave & Wenger 1991; Brown & Duguid 1991).

There is an importance of the virtual visualisation of social networks for knowledge and learning, because it is the very relationships that are critical for solving problems and learning in how work should be done. Allen ( 1977) has shown that scientists and engineers were five times as likely to turn to a colleague for information as to an impersonal source such as a database of a file cabinet. In this doctoral research it is found that the forensic scientist's preference is to turn for knowledge from colleagues rather than turn to standard operating procedures. In today's flatter organisations, work of significance demands effective collaboration within and across functional and hierarchical boundaries, where more than ever this work occurs through informal networks of people (Cross & Parker 2004).

In using social network analysis one can bring the concept of distance in networks, knowledge information will reach a person more easily if it does not have to travel a long way – the shorter the distance between actors in a network, the easier it is to exchange knowledge, where the shortest path between the actors is known as the geodesic – a direct face-to-face contact [one step]. If the distance between actors is below two steps, communication is accurate and fast, whereas if there are three or more steps knowledge exchange is not accurate (Cross & Cummings 2004). With the concept of distance, closeness centrality was used to indicate the knowledge flow from one actor to another. This research showed a closely bounded community where a sample actor (Georgina) in the main had only direct contact with her colleagues in that community and with no direct contact with the other actors within the other communities. It is obvious that she was bounded within her particular community [see Figure 19].

This research also showed how an effective managing head of a community (Keiran) had direct advice contact, exchanging tacit knowledge, with his fellow community colleagues. This finding contrasted with another but less effective managing head of a community who had no direct contact through advice networks with all but two of his community he was in charge of [see Figure 21].

Shown here is the evident difference between being structurally directly connected through the managerial office of head of community [see Figure 17], but conversely not being directly connected with members of the same community through relational advice networks.

As seen in this research the value of communities of practice can be considerable. It is evident that communities of practice systematise the exchange of knowledge as well as encourage the interchange of tacit knowledge between individuals. Here one sees that the individual is exposed to an immense sharing of knowledge and experiences, is provided with an in-depth appreciation of the operations process (or micro-process), allowing the overall effect of giving them an enhanced performance. Setting up a nascent community of practice, I propose, would not automatically allow for tacit knowledge to be shared, because you are relying on the participants to form social relations – there is an intricacy in the way such actors work, which develops over time encompassing the tacit dimensions of knowledge and practice.

These results show that knowledge including that of the tacit perspective is passed on from skilled forensic scientist practitioners with high levels of accumulated tacit knowledge, but only on being asked. Others interviewed expressed their dismay at only picking up some valuable tacit insights almost accidentally. In light of these findings it may be appropriate to provide for a more formal systematic way of bestowing this tacit knowledge to newcomers [see mgt. recs]. This research adds to the literature in that transferring tacit knowledge is more sensitive to having the right person with the right connection at the right place (Reagans & McEvily 2003).

Within the resultant interviews and network density measures one sees that one particular community of practice has a strong a strong sense of identity [Biology]. They have found their own rhythm and are able to develop their own agenda of topics of interest to themselves. This must happen in order for the community to genuinely share the learning tasks and resources. As is evidenced by those newcomers who had been interviewed, this community of practice was presented naturally to newer operators as opportunities to share, compare and learn for the benefit of all.

*Networks of Practice – a positive influence from outside*

Outside of their own local communities, it was shown quantitatively in part, that forensic scientists gain access to new tacit insights through their participation in ENFSI and other professional associations and their respective conferences.

Shown here is that tacit knowledge within a collaborative network umbrella, is both exchanged between actors at a bounded local community of practice level (Lave & Wenger 1991), and is transferred to actors who share a common interest externally outside of an organisation to the open environment through Networks of Practice (Wasko & Faraj 2005). The networks of practice tie in directly with community of practices, where a community from one particular organisation becomes linked through common practices to communities in other organisations. Seen here and also in the literature, the relations among collaborative network members are significantly looser than those within a localised community of practice (Brown & Duguid 2001), who commonly are geographically distributed (Wasko & Faraj 2005). From a network of practice perspective, individuals have practice and knowledge in common but are mostly unknown to each other, whereas from a community of practice perspective, individuals are tightly knit into groups who know each other well and work together directly (van Baalen, Bloemhof-Ruwaard, & van Heck 2006). However, even if the knowledge is available locally networks of practice show their strength in innovation when organizations that do not possess all required knowledge within their formal boundaries, must rely on linkages to outside organizations and individuals to acquire knowledge (Anand, Glick, & Manz 2002).

The tacit dimensions of collaboration outside the FSL were captured, where gatekeepers are apparent who represent FSL on various specialty groups. In essence, as one gatekeeper forensic scientist expressed the function of such network groups:

> ...it is a great way of gaining knowledge and learning about situations other people have been in and how they have dealt with them. Increasingly we are looking outside...

and another expressed their usefulness:

> ...I think you get a lot of information from outside, going to meetings and things like that...

where:

> ... there is a certain amount of knowledge you'll gain by references and literature and by conferences and by networking with other forensic scientists

These personal insights demonstrate how tacit knowledge is brought from the outside back to within the organisation. The advantage in having been involved in such collaborations is that the forensic scientist feels that they are working on a par with the best practice in Europe, stating:

> ...now we are as experienced as they are ...

Reinforced here in this research are the boundaries of the internal communities of practice, where unexpectedly there is evidence that forensic scientists prefer to go outside to their inter-organisational forensic science counterparts in other countries for certain advices, rather than their home-bred colleagues who are not apparently accessible because of the actor's mental block of not approaching a fellow actor who is locked in another inaccessible boundaried local community. From a knowledge management perspective this seems a wasteful use of resources such as unnecessary time being spent on trawling emails to international counterparts, when the very knowledge required is available locally down the corridor, albeit in a different boundaried CoP.

***Tacit Knowledge needed additionally to codified explicit procedures and knowledge databases***

Polanyi (1966) was clear that there is no objective explicit knowledge independent of the individual's tacit knowledge. Assimakopoulos (2007) states that Wenger's analysis shows that very often 'normal practice' does not correspond to the explicitly described functions and standard operating procedures within an organisation. Normal practice is often interpreted according to personal experiences, and the membership of one or more community of practice. Hence as is the case here, having access to a knowledge repository of SOPs and technical facts does not guarantee that the person accessing the repository actually understands the documents when reading them. Individuals still have to select, integrate and augment information to create understandings and knowledge. All knowledge is either tacit or rooted in tacit knowledge. Tacit knowledge should not be seen as knowledge that is independent of explicit knowledge; there is a tacit dimension to all forms of knowledge (Polanyi 1966).

This research found that there were those who thought that the knowledge databases were not the best way to actually simulate the knowledge back into the lab where others seemed to prefer the personable face-to-face option of gaining knowledge.

> ...I don't think it fully reflects what's happened – you know, how complete the [database] reports are – and sometimes you'll get other information out from talking to someone about the case – what was it like, how did it go – than you might get from just reading the report on its own...

The database was found to act as a notifier to new knowledge generated, as a prelude to a personal encounter with the individual who had written the original entry. Another dismissed the databases and reflected that for knowledge transfer to occur that direct face to face contact was the ideal way.

Eventhough processes are explicit by their nature, this doctoral research has shown that there is still a very much tacit element attached to the process which has been overlooked in the literature, save for two studies. The normative approach involving the use of SOPs described by the nuclear reactor industry contrasts with research evidence that has indicated that in emergencies, decision making of supervisory staff is often based on naturalistic condition–pattern recognition and tacit knowledge (Carvalho, dos Santos, & Vidal 2005). Additionally, in an aluminium smelter process study, the authors recognise the shortfall of SOPs in that they do not cover every eventuality, instead recommending that one should rely on the collective tacit knowledge to make improvements in such procedures (Nicholls & Cargill 2008) [see shortfall in SOPs relative to tacit knowledge workarounds]. These two papers are the only ones that refer and make conclusions on tacit knowledge within the world of process governed by standard operating procedures. The findings in this thesis on a forensic science community strengthen this early field of discovery. The forensic scientist can only progress through a case when they have collaborated with and sought advice from their colleagues. The common denominator from many comments made during interviews was that SOPs were only a baseline. There was a general feeling that only a minimal acceptable level of performance is achieved with protocols and it is the interactions with colleagues and one's own thought processes that would bring them beyond that.

It is clear that the higher tacit level processes employed by an experienced forensic scientist, such as case interpretation and judgement of the work required for the circumstances of the case, are not covered by SOPs. Importantly, from a philosophical view 'we do not work our way from the parts to the whole, but rather from the whole to the parts (Gill 2000: p. 44)' – a very valid point to keep in mind when looking at how practitioners use standard operating procedures.

In addition with the onset of the availability of SOPs for nearly all the procedures within this organisation there is a danger that newcomers become so used to just doing what is documented, carrying out work by rote, with a danger of them dismissing something that they haven't seen before.

> ...I mean they could do all the tests, they could take out the [protocol] and they could follow all the tests but its in the selection process and deciding what to test and how much to test ...

There is a danger of over-conditioning.

> ...Danger on relying on SOP and not use their heads when something anomalous comes up. People over rely on them...

Whereas the more experienced scientists, who have built up tacit reserves from their past exposure in a less structured knowledge environment, may realise that there is something more.

This research has shown that much knowledge is derived from practitioner-rich practice and is experience-based and tacit, where it takes time to build up.

> ...It actually takes a number of years, five or six years, before you're fully competent and I honestly believe that...

Nevertheless, the typical organisational strategy for knowledge management as in this case study organisation is focused on standardised operating procedures and intranet databases for capturing and disseminating explicit knowledge. For their highly knowledge-intensive processes, forensic science professionals are found, from interview comments, to bypass this codified collection of explicit knowledge, only to reuse core experts' knowledge through advice seeking during face to face contact.

In addition to the results from the interviews, empirical analysis for content that would be divergent to the actual processes detailed (proved to be tacit knowledge) was carried out on the one hundred and ninety seven FSL standard operating procedures. Forty-nine instances occurred where a further tacit-type step outside of the protocol was required to continue on with the work detailed in the protocol. Indeed there were ten instances in the SOPs where the scientist is instructed to seek advice from another scientist. A scientist especially carrying out analytical procedures under an accredited laboratory standard (ISO 10725) should typically need to only follow the prescribed standard operating procedures. Actual diversions from the standard procedures were recorded that involved tacit knowledge being used by pulling from case experience, from advice seeking, from assessment capabilities, and from being cognisant of other casework required. Although standard operating procedures are supposedly stand alone, here is shown that some form of tacit knowledge is required to continue on with a process in a portion of the explicit procedures. In effect this is an organisational recognition that some form of tacit knowledge is required to carry out some of the defined procedures. This type of analysis of standard operating procedures has not been published before in the literature as the tacit world has not yet diffused into the very explicit world found in quality management writings.

As a result of this doctoral research, these findings make additions to the very obvious lack of literature that discusses standards and quality management SOP documents relative to the human operator's needs which in some instances definitely require tacit dimensions. Three quarters of a sample of scientists surveyed found that SOPs did not guide them in their day to day work, and all only felt comfortable working on their own through continuous practice over years of service. The problem with SOPs is that they provide explicit knowledge explaining the details of a specific technique in a rather abstract and static way. Metaphorically, they are cold descriptive processes that do not give the comfort or warmth of well honed tacit knowledge available from very reliable experienced individuals.

***Learning – facilitated by communities of practice***

Brown and Duguid feel that in sharing a practice, people will then share know how, or tacit knowledge ( 2001: p. 204). Tschannen-Moran & Nestor-Baker ( 2004) consider tacit knowledge acquisition and application, as a result of participation in communities of practice. The participation of the newcomer is situated in a learning environment, where the trainee forensic scientist learns to involve him/herself in taking part and connecting to others within the community at the same time as gathering the competencies and practical skills to carry out the casework. The tacit knowledge is usually learned during observation and practice (Epstein 1999), where its transfer is facilitated by intensive interpersonal contact (Collins & Hitt 2006). As one of the newcomers moved from the peripherality of his community he began to receive more complex work as he became more competent of what he had learned, where his experiences of learning were positive, feeling that he was in a nurtured learning environment.

> ...To be honest I did feel as if I was being a nuisance sometimes, constantly plaguing my trainer but I never felt that back, to be honest I thought they were very very patient...

A senior scientist spoke of his early days where he had learned through observation of others whilst not having the benefit of standard operating procedures. These observations from this case study agree what is found in the literature where Tsoukas (2003: p.14) states that 'we learn to engage in practical activities through our participation in social practices, under the guidance of people who are more experienced than us'. Polanyi (1958: p.53 speaks about how an apprentice behaves in acquiring knowledge from a knowledgeable master of authority – 'By watching the master and emulating his efforts in the presence of his example, the apprentice unconsciously picks up the rules of the art, including those which are not explicitly known to the master himself'.

In summary, new members of a particular community of practice have to socialise and go through a peripheral participation process before they can move into the centre of such a community, including those forensic scientists who move to a new discipline eventhough they were established as members of the wider organisation. Even within such a relatively small and tightly knit organisation such as FSL, knowledge generating practice is discontinuous along the disciplinary boundaries and practice traditions of constituent communities of practices.

# 9 CONCLUSIONS

## *Summary of results*

### i Tacit Knowledge within the process

Other than the well-documented ethnographic studies, there is a scarcity of *empirical* research on the knowledge processes between actors within a community of practice setting in the workplace. Any of the latter work has employed macro-level studies based on organisational strategy and needs, whereas this case study employed a micro-level of research inquiry, purposely designed to give one an understanding of how knowledge workers actually operate at the *process* level – carrying out standard operating procedures – within such communities. This study accomplished the empirical analysis of relational tacit ties and interviews of forensic scientists, where the rich tacit dimensions encircling and permeating the organisational processes were explored.

Empirically, the concept that tacit knowledge can be looked at as being a major part of organisational process was examined. This work used a quantitative methodology, social network analysis, to help uncover patterns of connections shaping knowledge flows with a tacit dimension between forensic scientist practitioners. The forensic scientist and his/her network of advice relations was treated as the unit of analysis indicative of tacit knowledge exchange. The network map was highly informative, yielding details of how forensic scientist practitioners actually work in carrying out their process – a resultant snapshot of tacit knowledge exchange mediated by the advice relation. The prominence of individuals within network maps was used as a proxy, yielding an estimation of the tacit knowledge that each forensic scientist had to offer. Popularity and prestige, two measures of prominence allowed the identification of those scientists who had become central cogs in the tacit knowledge exchange networks within this case study. Communities of practice within FSL were identified through hierarchical clustering. Density measures were used, attributing a value to the cohesiveness of each community of practice, based on the amount of linkages each had. In looking at the type of work that the Biology community of practice processes, the measure of its group density correlates to the high degree of qualitative work that the forensic scientists within carry out, involving more face to face encounters with each other. The other three communities, DNA, Drugs and Chemistry carry out more quantitative work, and two of these had much less density measures.

ii <u>Tacit knowledge – a relational dimension</u>

Using semi-structured interviews it was found that forensic scientists needed to acquire, through advice received, the tacit dimensions of how to proceed within a certain amount of their processual SOPs. This research found that forensic scientists who were very adept at examining any piece of evidence that added to the bigger picture still needed a localised relational social acceptance recognising that they carried out the correct procedures. This research added to existing findings that within a technological community tacit knowledge is transferred within a relational environment (Assimakopoulos & Yan 2006;Gherardi & Nicolini 2000;Osterlund & Carlile 2005). Indeed a quantitative graphical view clearly showed that advice is not mediated by the organisation's structural order but by the relationship of experience. This empirical analysis through the lens of relational thinking has given a concrete understanding of knowledge sharing in practice. Understanding the relational processes and the properties of the relationship necessary to transfer knowledge is important in acquiring tacit knowledge.

The following various relationships mediating the exchange of tacit knowledge between actors were elucidated: the significant dealings around the carrying out of *process* ensured that it became a relationship between forensic scientist practitioners; because *experience* itself is treated by actors in this case study as a reified trait or measure of an individuals ability, it was chosen as a relation; because competency capabilities feature prominently here in an individual's judgement of others and mediates the choosing of whom they seek advice from, *capability* was chosen as a relation; the *mentor* relationship is very apparent here and was chosen as a relational mediator of face to face tacit knowledge transfer, which is the crux of how new entrants who may be academically highly qualified become practically functioning forensic scientists; the *casual* relationship was chosen because of its obvious function in affording individuals the increased chances of tacit knowledge assimilation; because of the helping culture that predominates in FSL, the relationship of *helping* was nominated as a relational transaction medium within process; the endemic medium of email allowed for *sharing* to be nominated as a relation; because many of the processes engage the scientists to seek advice, *approachability* was nominated as a relationship because of its definitive need in smoothing the process of advice seeking; because it was evident that in some instances that *trust* was required of the advice given in quite complex circumstances, and was seen to mediate the decision as to whether a scientist sought advice from another, it was nominated as a relation; the close-quarters relationship of *proximity* was nominated because it allows the tacitness of practice to be absorbed by actors; *cliques*, symptomatic of communities of practice, and as a result of a cohort effect from batched recruitment campaigns here, was designated as a relationship mediating the tacit knowledge movement between entrenched individuals; as *interpretation* is educed during peer review, it became a nominated relationship mediating much of the operations at FSL; also nominated is the obvious relationship of *friendship* formed insitu and during socialisation into the organisation have followed through, where those same scientist friends now seek advice from each other; unique to forensic scientists being *adversarial* is apparent as a relationship mediating the seeking of tacit hints; in certain instances a *structural* relationship inherent in a functional bureaucracy mediates the pathways of advice seekers.

iii <u>Tacit knowledge flows inside and outside the organisation</u>

This research gives a better understanding of tacit knowledge acquisition, how it is formulated in organisations, and how it is passed on to individual knowledge workers. From the point of view of practice it is possible to understand the flow of tacit knowledge into and within organisations. Seen is the transfer of tacit knowledge is linked to social relations and the relationships of social actors developed through shared practice.

As seen in the case within the forensic science community, professions are a good example of collaborative networks, where similar practitioners, by virtue of their practice, are able to share professional knowledge through conferences, workshops, and web/email contact (Brown & Duguid 2001). The sharing of knowledge is an important aspect of these technical professional communities (Assimakopoulos 2007, Bouty 2000). Such inter-organisational relations while implied in the literature, have rarely been examined empirically (Swan, Scarbrough, & Robertson 2002;Wasko & Faraj 2005). In this case study on a forensic science community, FSL, examined empirically was such tacit knowledge sharing, mediated within a relational environment at an inter-organisational collaborative level.

### iv Tacit knowledge required within a workplace of standardised practice

On the introduction of the quality management system (QMS) that oversees the whole remit of SOPs, only in recent times, it is now only apparent that newly recruited forensic scientists who have full exposure to the SOP movement may think differently compared to forensic scientists who have had experience of both systems – the undocumented laissez faire system of the past, and the formalised QMS SOPs of today. There is a danger of conditioning newcomers not to think outside of the remit of the SOP coverage.

Polanyi was clear that there is no objective explicit knowledge independent of the individual's tacit knowledge (Polanyi, 1966, p. 143).

Found here in the main is that individuals rather than turning to databases and procedure manuals to obtain information, seek knowledge in a tacit form from trusted and capable colleagues. Consequently the organisational databases are destined only to act as a prelude to a personal encounter with the forensic scientist who had written the original entry, emphasizing tacit knowledge and using explicit knowledge in a supporting role (Woo et al. 2004).

Evident here is that forensic scientists actually seek advice from fellow experts as opposed to consulting SOPs. In defining what makes a fully trained expert when asked, the scientist's responses range from: thinking of competencies; having a sufficient amount of cases over the years that allow for all case-type eventualities; having a fulsome holistic view encompassing interpretation and assessment; to having the accomplished knowledge to enable a scientist to have the judgement to know when to follow up if all expected results are not achieved. This research has shown that in focusing on organisational process, that the experience gained by the expert over the years of practice allows him/her to make proper contextual decisions for the analytical procedure in front of them to progress. Identified is that in some instances that tacit knowledge built up from practice is critical if a scientist wishes to carry out a procedure correctly in order to reach the end of an analysis. In certain cases SOPs are just the basic minimum in work steps, and it is apparent here that a scientist's prior experience is actually needed, for a procedure to be carried out in full. For this to occur the scientists themselves have to have/gain 'the experience' – a experienced forensic scientist has a wide scope of experiences in case work. An increasing difficulty for management is to ensure that all scientists have the opportunity to gain such experiences [see Implications for Management, Practice & Policy].

Found here is the likelihood that when processing a complex case, trainees may tend to rely too heavily on SOPs, as opposed to the more experienced scientists who know when to pull from their tacit knowledge reserves in order to balance their findings. The interplay of tacit and explicit knowledge in the training process was examined through an analysis of a completed structured questionnaire. With the questionnaire, the utilisation of explicit knowledge SOPs was compared to the use of tacit knowledge the scientists had gained through practice. It was shown that with the developing expertise of the trainee forensic scientists, they transited from a reliance on explicit knowledge to one with a tacit knowledge framework. Discovered was that explicit knowledge has qualified foundations in the first steps of a forensic scientist's training, but is soon taken over by the tacit knowledge required to become a competent reporting caseworker. All of those surveyed found that SOPs gave them a beneficial baseline of knowledge, using them as a refresher in their procedural knowledge, whereas three quarters of the same scientists found that the SOPs did not guide them in their day-to-day work.

In agreement with the survey results, the common denominator from many comments made during interviews was that SOPs were only a baseline. There was a general feeling that only a minimal acceptable level of performance was achieved with protocols and it is the interactions with colleagues and one's own thought processes that would bring them beyond that. These research findings are in broad agreement with Sternberg & Horvath ( 1999) who state that tacit knowledge is important in the development of professional practice, and can be a source of highly effective performance in the workplace. Most often the forensic scientists turn to colleagues within the local community of practice, before seeking knowledge from external sources, such as ENFSI networks.

Although standard operating procedures are supposedly stand alone, on analysing a couple of hundred SOPs, here is shown that some form of tacit knowledge is required to continue on with a process in a portion of the explicit procedures. There are cases where the explicit protocols outlined in the SOPs are sufficient for the processes detailed to be completed, without the need for the operators to confer with other colleagues. This is apparent in the more quantitative analyses found in the Drugs and DNA practices.

However since the onset of the quality system the spread of knowledge within the organisation is more apparent by becoming more explicit within the protocols, where in the past some knowledge was held on by individuals as a power play.

v Tacit Knowledge in the cultivation of the organisation

The gaining of tacit knowledge and the learning of 'experience' primarily takes place through situated learning by participation within communities of practice, where it involves both action in taking part and connection to others in the community. Variations in the degree of participation describe the status of the knowledge worker in the community: peripheral or full, describing an apprentice's journey from novice to master. The phrase – legitimate peripheral participation (LPP) – has been coined to characterise the process by which newcomers become socialised and included in a community of practice situated within the organisation.

This research sheds fresh light on the legitimate participation of peripheral members of such communities when they start being a member of such a knowledge intensive community. New members of a particular community of practice have to socialise and go through a peripheral participation process before they can move into the centre of such a community. In addition the very experienced actors also become newly peripheral when they move from their old community of practice to a new one due to a promotion or other career move. This concept of looking at what happens to old-timers is of significance in today's fast moving knowledge based economy with world career opportunities, when vast experience in one area of specialty is perhaps a barrier to exit from the old community of practice, and a barrier to entry to a new community of practice specialty. Shown quantitatively in this research is the legitimate participation of peripheral members when they start become more integrated members of such a knowledge intensive community. It also shows comprehensively that when a highly experienced individual moves to a new discipline, that there is a new community of practice structure for the individual to embed and a learning curve to climb.

When asked about their own experiences of peripheral participation the trainee forensic scientists said they worked with more experienced forensic scientists through a mentoring system, having learned through practice and learning their practical skill sets by working on less complex cases in the beginning. Eventhough being academically highly qualified on entry into FSL for the majority of forensic scientists, this research has found that it is the practical on the job hands-on experience that qualifies them for their position as forensic scientists. Hand in hand with the relational dimensions of tacit knowledge, a unifying concept of the knowledge and learning gained through participant practice, is its evident construction from *relations* among people engaged in an activity.

This research also showed the indifference a newcomer forensic scientist faces: new entrants to FSL, albeit highly qualified themselves and sometimes moreso than the serving members of FSL, were not appreciated for their own practical knowledge reserves that they had brought into the organisation. Through interview comments it was found that this might be used as a ploy by the organisation, as it is more important for management to train people on the job.

### *Implications for academic theory*

The acquisition of tacit knowledge is not an entirely passive happening, where this research has shown that it evolves in an actionable social relational environment, requiring the work of both the giver and receiver, grasping an area of organisational research where 'little is known about the process of knowing in complex organisations (Orlikowski 2002: p.253)'. This research has added to the nascent relational network explanation of knowledge management becoming evident in the literature (Assimakopoulos & Yan 2006;Borgatti & Cross 2003), where knowledge workers in local communities of practice operate together within a relational tacit knowledge network environment through the performance of operational transactions.

A new way of looking at the knowledge that individuals hold is taking a foothold in the literature, a position that this research additively supports.

The 'traditional understanding of knowledge' which 'treats knowledge as something people possess' should instead be thought of within organisations as 'a tool of knowing' where 'knowing is an aspect of our interaction with the social and physical world (Cook & Brown 1999: p.381)', in that 'knowledge is an activity which would be better described as a process of knowing (Polanyi 1969: p.132)'. Hence new knowledge can be generated by the 'interplay of knowledge and knowing' within the 'situated social interaction of practice (Cook & Brown 1999: p.381)'. In looking at the organisation with such concepts, one sees that the knowledge worker uses knowing along with a dynamic interaction with the environment in carrying out their practice. For knowing 'is an explanation grounded in what it is people *do* every day to get their work done (Orlikowski 2002: p.249)'. This research answers the call for more case studies in knowing (Cook & Brown 1999), where here, forensic scientists with their own evident tacit knowledge that they possess, interact with each other whilst carrying out their case work processes, concomitantly producing new knowledge, within a rich relational social knowing environment. Here the production of new knowledge 'does not' now 'lie in a continuous interaction between tacit and explicit knowledge but rather from our interaction with the world (Cook & Brown 1999: p.397)'. Hence knowledge sharing is indeed 'a complex process that goes beyond the mere transfer of abstract bodies of knowledge (Osterlund & Carlile 2005: p.91)'. In taking the sociological view, 'knowledge always manifests itself as social action sustained by symbolics, technologies and relations', and hence it follows that 'knowledge is performed in, by and through social relations' (Gherardi & Nicolini 2000: p.331). There is a change in the treatment of knowledge from which something people possess, known by some as the "epistemology of possession", to knowledge being looked at as something people do together known by some as the "epistemology of practice" (Cook & Brown 1999). Moreover, the epistemology of possession tends to privilege explicit over tacit knowledge. So, as can be seen from the discussions above, the purely 'taxonomic perspective' of the tacit/explicit knowledge dichotomy only 'reifies knowledge by treating it as a stock or set of discrete elements', a view of which researchers have been openly critical of.

Here in this research case study, the emphasis has been switched to knowledge as practised within structures, processes and the organisational environment. At the level of the knowledge worker within the practicing community, one needs a clearer picture as to how such workers operate in their process environment with each other and within the organisational community. The literature is now only beginning to address this issue, getting down to the more micro-levels of doing business (Assimakopoulos & Yan 2006;Borgatti & Cross 2003). There has been little research done at the worker process level – the actual steps in allowing for such communities to function – only the more gross ethnographic studies of such communities have been carried out, yielding those higher order concepts we all know of (Knorr-Cetina 1999;Latour & Woolgar 1979;Lave & Wenger 1991;Orr 1996).

Although there is a well developed literature on organisational behaviour, where organisations tend to be seen as frameworks of coordination for human groups, it is very much worth viewing the substance of the inner workings of process of the organisation, yielding an understanding of how the knowledge worker actually operates. For processes that one merely observes as happening is a perspective in which academic authors are mostly oriented towards, should be changed so that one can focus on understanding process from within, a view that is only being proffered now as authors begin to want to understand how knowledge workers actually juggle the process of knowing (Orlikowski 2002). In other words, it is about redirecting or reorienting our attention, to noticing things which 'no one has doubted, but which have escaped remark only because they are always before our eyes (Shotter 2006: p. 589)'. The best way, as in this research, is to start by bringing exemplars to their attention. Here, then, one can begin to see another way within 'theory', by looking at the practical actions in the world of our everyday, practice.

Looking at a more intricate process level of how such communities of practice operate when compared to higher order concepts, this research addresses what is it that knowledge workers actually do in such communities – what makes them operate and how do they go about their business. This doctoral research adds to the emerging school of investigations in knowledge sharing events, at the micro-level between knowledge workers, using quantitative social network analysis (Assimakopoulos & Yan 2006;Borgatti & Cross 2003;Cross & Parker 2004).

There is an evident gap between an organisation hosting a relational tacit knowledge environment populated by experienced practitioners and an organisation mandated by Quality Management System governance. Such QMS management is gaining currency within large technical organisations, where there is a rush for accreditation to published standards such as ISO.

There are only a few published journal articles on quality systems (Hackman & Wageman 1995;Manley 2000), and there are only two papers that refer and make conclusions on tacit knowledge within the world of process governed by standard operating procedures (Carvalho, dos Santos, & Vidal 2005;Nicholls & Cargill 2008). This doctoral research has shown that much knowledge is derived from practitioner-rich practice and is experience-based and tacit, where it takes time to build up. Hence this case study should translate to a bigger picture affecting all knowledge workers in high-tech organisations that now require a standardised work practice. Found here is that a relational tacit environment is required in order to actually allow supposedly stand-alone SOPs to be carried out by practitioners. The findings were based on a study of the actual working environment where the carrying out of a large amount of SOPs within different communities of practice was evident. This case study has brought back to the fore the absolute need for a relational tacit environment that has been largely ignored by the quality management movement, who have strived for a codified explicit knowledge-based working environment, cutting away any social dimensions that have been found here to be critical in actually carrying out such work.[see Figure 42].

Eventhough processes are explicit by their nature, this doctoral research has shown that there is still a very much tacit element attached to the process which has been overlooked in the literature, as there is a tacit dimension to all forms of knowledge (Polanyi 1966). As a result of this doctoral research, these findings make additions to the very obvious lack of literature that discusses standards and quality management SOP documents

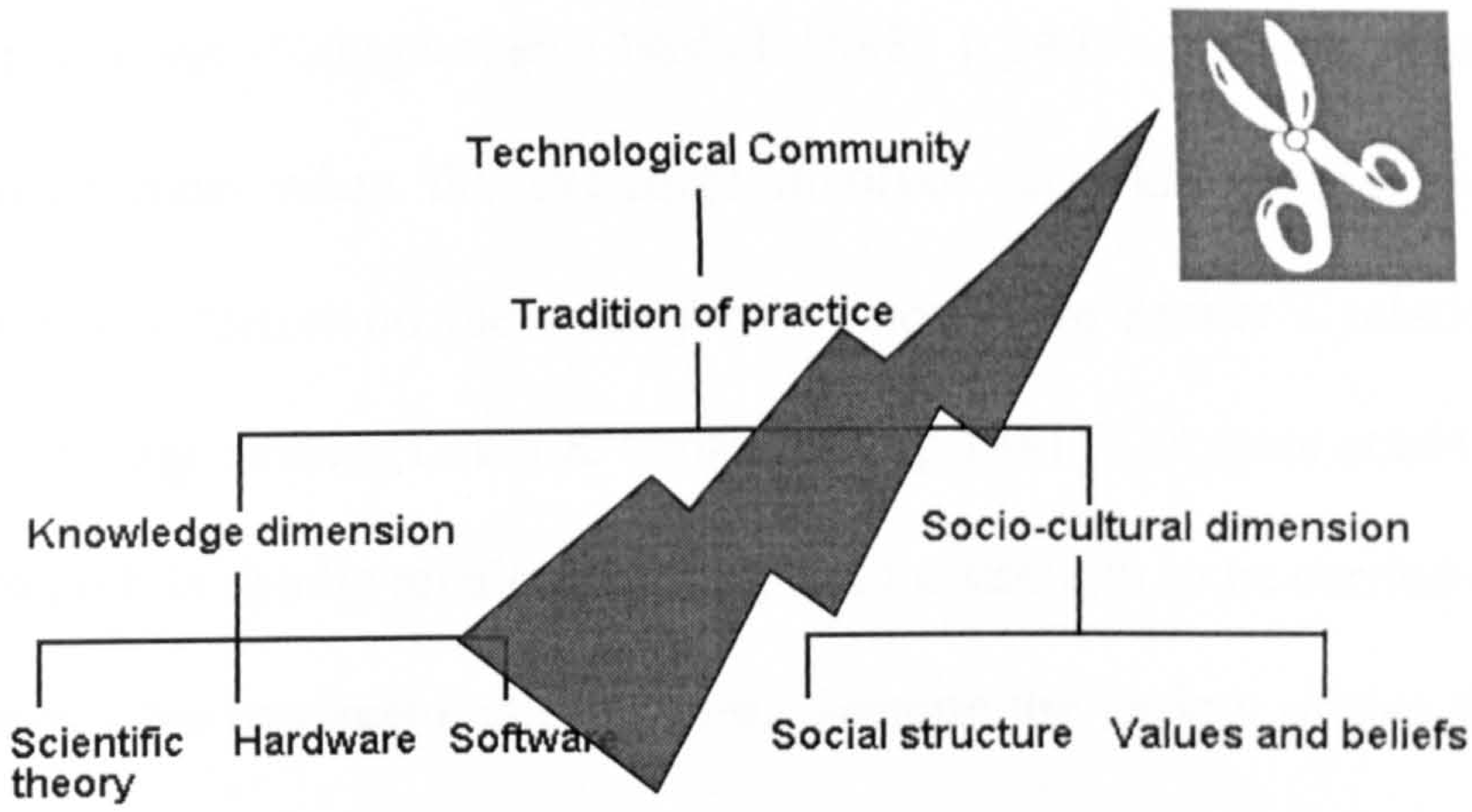



**Figure 42. Bringing back the balance of the social relational dimension of practice [edited version from Assimakopoulos 2007].**

Relative to the human operator's needs which in some instances definitely require tacit dimensions.

Relative to research on how properties of network structure affect knowledge exchange, research on how properties of relationships between actors in such networks affect learning and knowledge management outcomes is a newer theme (Argote, McEvily, & Reagans 2003). Organisational learning can be seen as a function of relationships sitting on top of the structural properties within social networks. Indeed the role of weak and strong ties intensely covered in the literature (Burt 1997;Granovetter 1973;Hansen 1999) have paid less attention to the relational characteristics of such ties that ultimately govern who seeks whom for information (Borgatti & Cross 2003). When viewing the relational aspect of social capital it is the nature of the relationships in the social structure that leads to certain benefits for the participant actors. The relational facet 'describes the kind of personal relationships people have developed with each other through a history of interactions (Nahapiet & Ghoshal 1998: p.244)'. These relational factors matter most when the exchange involves tacit knowledge and indeed the exchange 'relies on the quality of a knowledge seeker's relationship with a knowledge source (Levin & Cross 2004: p.1481)'. Argote et al (2003) call for research in dyadic relationships beyond tie strength to be carried out that affect knowledge management outcomes. Despite the variety of ties that have been examined, analyses to date have stopped short of incorporating many types of informal, interpersonal relationships (Ingram & Roberts 2000). The elucidation of such relationships within this research is hence an addition to the literature, for understanding the relational processes and the properties of the relationship necessary to transfer knowledge is important in acquiring tacit knowledge. Levin and Cross (2004) call for the need to better understand the role of relational factors such as trust and emotion for effective knowledge transfer. Respect, friendship (Ingram & Roberts 2000), identity and social norms are other examples of such relational dyadic ties that have been discussed in the literature. Answering the call of researchers, this doctoral case study has found more, including processual, experiential, capability, mentoring, informal, helping, openness/sharing, approachability, respect, proximal, cohort/clique, interpretative and bureaucratic structural relationships, and unique to forensic scientists, an adversarial relationship. This research has added to existing findings that within a technological community tacit knowledge is transferred within a relational environment (Assimakopoulos & Yan 2006;Gherardi & Nicolini 2000;Osterlund & Carlile 2005). Indeed a quantitative graphical view clearly showed that advice is not mediated by the organisation's structural order but by the relationship of experience. This empirical analysis through the lens of relational thinking has given a concrete understanding of knowledge sharing in practice.

Tacit knowledge within a collaborative network umbrella, is both exchanged between actors at a bounded local community of practice level (Lave & Wenger 1991), and is transferred to actors who share a common interest externally outside of an organisation to the open environment through Networks of Practice (Wasko & Faraj 2005). It is the technological tradition of *practice* that binds these communities of technological practitioners together (Assimakopoulos 2007), through sharing knowledge with socio-cultural dimensions.

This research has shown in agreement with the literature that the relations among collaborative network of practice members are significantly looser than those within a localised community of practice (Brown & Duguid 2001), who commonly are geographically distributed (Wasko & Faraj 2005). Also shown is that from a network of practice perspective, individuals have practice and knowledge in common but are mostly unknown to each other, whereas from a community of practice perspective, individuals are tightly knit into groups who know each other well and work together directly (van Baalen, Bloemhof-Ruwaard, & van Heck 2006).

However, a surprising finding was made in this research, reinforcing the boundaries of the internal communities of practice, where there is evidence that forensic scientists prefer to go outside to their inter-organisational forensic science counterparts in other countries for certain advices, rather than their home-bred colleagues who are not apparently accessible because of the mental inaccessible boundaried view they hold of the local communities.

The sharing of knowledge is an important aspect of these technical professional communities (Bouty 2000). Such inter-organisational relations while implied in the literature, have rarely been examined empirically (Swan, Scarbrough, & Robertson 2002;Wasko & Faraj 2005). In this case study such relations have been examined empirically. Recent research has emphasized the need for a better understanding and characterisation of the basic principles and mechanisms of collaborative networks (Sofia Pereira & Soares 2007). The actors within such networks rely very heavily on their network of relationships to find information and solve problems (Cross, Borgatti, & Parker 2002).

This research intends to bring back to the literature the importance of tacit knowledge, where there has been an overemphasis on codification of explicit knowledge, suitable for databases, and that the emphasis on information technology may have compromised effective tacit knowledge transfer (Stenmark 2001). Deep concern has been expressed that knowledge management initiatives in companies are 'limited to the transfer of explicit (codifiable) knowledge...' and 'that this may relegate tacit knowledge to the background' and 'hence lead to the mismanagement of knowledge (Johannessen, Olaisen, & Olsen 2001: p. 4)'. One of the remits of this research is to remind the organisational scholarship of the references to tacit knowledge made in the psychology literature.

In the sociology and psychology literature, in distinguishing individuals who are more successful from those who are less successful in their everyday lives, it has been found that much of the knowledge needed to succeed in real-world tasks is tacit (Sternberg, Nokes, Geissler, Prince, Okatcha, Bundy, & Grigorenkoa 2001;Sternberg 2000). Indeed tacit knowledge is important to the development of professional practice, and can be a source of highly effective performance in the workplace (Sternberg & Horvath 1999). In measuring tacit knowledge, Sternberg (2000) has found that individuals who exhibit the ability to use tacit knowledge are more effective, where the difference between experts and novices is related to their inventory of tacit knowledge. Tacit knowledge may be seen as a thread woven through the development of expertise (Nestor-Baker & Hoy 2001). According to Stenmark ( 2001) expertise is a 'quality highly dependent on tacit knowledge. People at different levels of a hierarchy of expertise or of a hierarchy of an organisation have different tacit knowledge capacities (Cimino 1999), as is evidenced by newcomers who tend to rely too heavily on standard kinds of operating procedures.

A call from Brown and Duguid ( 2000a: p. 121), which is similar to the emphasis within this research, relates to us the 'importance of people as creators and carriers of knowledge', 'forcing organisations to realise that knowledge lies less in its databases than in its people'. Wenger, McDermott and Snyder ( 2002) similarly claim that not everything we know can be codified as documents or tools. They view from a business standpoint that the tacit aspects of knowledge are often the most valuable.

## *Implications for Management, Practice & Policy*

Here in this research, the ideas and theories discussed allow for the best possible reusing of experts' tacit knowledge within a standardised operations organisation. Although tacit knowledge is important to success, most organizations often give little recognition to it, or as in the case of FSL have not labelled the knowledge exchange as having a tacit dimension. Organizational knowledge bases are both explicit and tacit. In the organisation featured in this case study, forensic science professionals actively emphasize tacit knowledge and use explicit knowledge in a supporting role, for tacit knowledge, part of the practical intelligence, is highly developed in experts (Sternberg 2000). The findings in this research show that a more structured and purposeful tacit knowledge strategy seems more appropriate for the Forensic Science Laboratory, and indeed by extension for similar practices based on a standardised process. This new strategy would allow a more holistic model of knowledge exposure to be employed by management.

The nurturing of Communities of Practice and a concomitant a social relational environment more intentionally by management within an activated tacit knowledge strategy may hold great potential for a more optimal performance in the management of processes within organisations. The typical organisational strategy for knowledge management is focused on standardised operating procedures and the use of knowledge databases for capturing and disseminating explicit knowledge. However, it is clear that the higher tacit level processes employed by knowledge practitioners are not covered by SOPs. In some instances the carrying out of procedures detailed in SOP documents definitely require the operator to pull from their own or others' tacit dimensions of stored knowledge, gained from a mentoring process whilst training and graduating from a peripheral to a more centralised practitioner role, or from continuous advice seeking from colleagues. This is problematic for managers who want to ensure that the processes are being carried out to their full potential, especially when it extends to newcomers, who may have become conditioned to just doing what is documented, dismissing something that they haven't seen before. A recommendation is that a procedure be put in place within an active community of practice structure that nurtures and cultivates the way operators should look at how processes be carried out allowing increased chances of hidden tacit knowledge to become more exposed to those operators needing it as required. A solution process *per se* will provide a focus to achieve future knowledge improvement and long term better understanding of the operations.

Even if it is known that actors in a organisation network together, there is indeed a requirement to establish if they as employees collaborate effectively. Just being present in a network is not sufficient, and social network analysis allows for the discovery of clusters of individuals and of those that are unnecessarily peripheral, both conditions indicating that the network is not well integrated. The whole point of this research has been in part to help management diagnose the effectiveness of their organisational networks by providing a deeper view of relationships. Monies for IT projects which are normally immense, could in some part be re-allocated to initiatives that promote vibrant employee community of practice networks.

The perpetuation of knowledge over generations of knowledge workers needs to be adopted as a knowledge management strategy. A haphazard approach to the knowledge transfer from experienced hands to newcomers *may* be sufficient, but also leaves a large amount of knowledge preservation and transfer to chance. Each generation of skilled operators with high levels of accumulated tacit knowledge needs to systematically pass this knowledge to the newcomer operators, or the organisation has failed to manage its knowledge base. In using a community of practice approach management can more consciously capture, preserve and perpetuate crucial knowledge of various processes which are otherwise difficult to codify into conventional training courses or on-the-job ones.

The emphasis on standardised analytical tests should be shifted to standardising or denoting competencies in interpretive judgement and assessment for practitioners. Under today's performance management initiatives, individuals in performing their tasks need a competence or a set of competencies. At a team level, Koskinen et al take the view that tacit knowledge is a part of an individual's competence which they see as being divided into three parameters: explicit knowledge, tacit knowledge, and personal characteristics (Koskinen, Pihlanto, & Vanharanta 2003: p.282). Even those who are uncomfortable with the notion of tacit knowledge recognise that it is impossible to make explicit all aspects of professional competence (Epstein 1999), where conceptual skills that need to be developed take place through imitation and practice via tacit integration (Gill 2000).

A recommendation for management would be to design competency tests in professional practice that allow managers and indeed practitioners to see how good they are in qualitatively weighing up the works to be done in a case. For organisational knowledge standards that do exist, they are not specifically related to knowledge and Pawson et al (2003) have come to the conclusion that tacit practitioner knowledge is effectively standards-free. Every so often practitioners should be given case vignettes where they have to discuss in an open learning forum how they approach their work. This is where learning can occur, where suggestions are made in how to make improvements.

However, as seen in this research how individuals group themselves, it must be recognized that communities of practice can also be limited in effectiveness, cliquish and exclusive, although careful cultivation and stewarding of the community can positively steer the group away from these negative face. On their downside, communities of practice can hoard knowledge and hold others hostage to their expertise (Wenger, McDermott, & Snyder 2002: p. 139). The natural boundaries of a group need to be observed to some extent but a recommendation is that management should see to them being bridged rather than remaining a sealed and excluding border group. Without this bridging, the community of practice can simply serve to reflect relations of power among practices (Wenger et al 2002). A forensic scientist gives a clear example of the boundaried islands of knowledge within the one organisation:

> Well, I would think there is a fair exchange of information within the sections but I wouldn't think there's much exchange of information between the [communities]...people sort of identify with their [communities] and they're organised on a [community] basis...

Simply focusing on knowledge, as a knowledge management process is also not adequate because a recipient's absorptive capacity to acquire knowledge is built on his or her own pre-existing knowledge stock. The actual transfer of knowledge takes place because the individuals between whom it is transferred have a rich set of mutual understandings. It is in this research at FSL that we see this happening because of the existence of domains of knowledge within communities of practice. Without enough overlapping knowledge stock on both sides, knowledge cannot be transferred. Thus, for the success of Knowledge Management, it requires both to manage the knowledge stock accumulation and knowledge process flow within organizations (Hsu & Shen 2005).

## *Work that can be done*

### i Work not carried out in thesis

This research was seeking to understand more of how the tacit dimensions of knowledge interact with the actual processes of operations within professional practice. This research took various snapshots in time both at the network analysis stage and from interview findings of how tacit knowledge lubricates the process. What was not carried out was a more dynamic and in effect a real-time study primarily because of its very evasive nature that would have resulted amongst an already accommodating actor network. Because the researcher in this case study has been embedded within the actor network for a period of time much longer than the time period over which this research occurred, the snapshots have been transformed into a narrative of action making presumptions that would have been fully explicated if a real-time study had been carried out. For the more dynamic study to have been carried out, one would need survey forms on when actors gave advice and for what reasons on a daily basis, accounting for hour-by-hour interactions. Observations would have to have been made that saw many of the advice or relational transactions mentioned in these research findings occurring as they happened. Hence these busy forensic scientists would have had a research tool interfering with the very interpretive process of which was originally being studied (whereas this study was more in the background, hidden behind the facia of a participant observer). Eventhough this research uses the tool of social network analysis to show the interactions of actors as they give or receive advice with tacit dimensions of knowledge, only certain time periods were used as temporal reference points. Ideally what should have been carried out was a recording of daily representations of tacit knowledge exchange which could have been combined to represent the empirical findings as a motion picture of the process of knowledge exchange. Again this would have been too invasive in an already accommodating group of individuals.

ii Future work recommendations

This study was concentrated mostly on the inner workings of one population which had four communities of practice embedded within. Fleeting references were made to this organisation's contacts with outside collaborative network of practice partners within ENFSI and other networks. Interesting findings would more than likely be made if additional work of a wider scope incorporating actors from the other forensic practices within Europe was carried out. The time required and the resources of just one researcher did not allow for this. With monies and the resources offered by a team of researchers such a widely scoped project could be carried out. Such a pan-european research endeavour would seem appropriate within the knowledge management arena of EU policy. A better understanding of ENFSI would act as a model for the knowledge management of other European collaborative networks, acknowledged as being major contributors to the knowledge economy that the EU so expressly wishes to nurture.

Within the quality management systems such as those provided by the International Standards Organisation, there is a lack of emphasis on the tacit perspective of managing operators, which of course by their very procedural nature are very heavily catered to the explicit dimensions of the knowledge continuum. Research including this case study should be used to show how important the human dynamics of operations are with a view that changes should be made to such QMS/ISO procedures that allow them to become more living rather than very static.

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# 11 APPENDICES

## *Appendix: The Knowledge Dichotomy*

Depicting tacit and explicit knowledge as being mutually exclusive is not correct. This has distorted the original meaning of Polanyi's thinking. Polanyi (1966) was clear that there is no objective explicit knowledge independent of the individual's tacit knowledge. As discussed in the introduction of this thesis, the whole of Polanyi's work should be couched as an attempt to counteract the one-sided emphasis on explicit objectivity and turn to concentrating on tacit knowledge.

Much discussion has been based around the tacit and explicit dimensions of knowledge within the knowledge dichotomy especially within the organisational literature. The discussions have changed direction from writing on the advantages of explicit collections, to a concern on our thinking of such codified collections, and to bringing our thinking around to tacit knowledge.

There are those who too simply consider, that in making explicit knowledge available to the firm, the explication of knowledge positively correlates to the effective performance of the knowledge-intensive organisation (Zack 1999). Deep concern has been expressed that knowledge management initiatives in companies are 'limited to the transfer of explicit (codifiable) knowledge…' and 'that this may relegate tacit knowledge to the background' and 'hence lead to the mismanagement of knowledge (Johannessen, Olaisen, & Olsen 2001: p. 4)'. Whilst others are critical of new technology that is ostensibly meant to help knowledge management efforts when in fact it simply 'attends primarily to individuals and the explicit information that passes between them (Brown & Duguid 1998: p. 105)'. The capture approach has an emphasis on capturing explicit knowledge in databases, manuals, books and reports, and then sharing it in a hard form (Hildreth & Kimble 2002), where 'the rise of the networked computers has made it possible to codify, store, and share certain kinds of knowledge more easily and cheaply than ever before (Hansen, Nohria, & Tierney 1999)'.

There has been an overemphasis on codification of explicit knowledge, suitable for databases and it is this emphasis on IT that may compromise effective tacit knowledge transfer (Stenmark 2001). Indeed, it has been found in aerospace engineering consulting firms that although they have been successful at collecting and storing explicit information in enterprise databases, they are not always good at tacit knowledge retrieval and sharing (Woo, Clayton, Johnson, Flores, & Ellis 2004).

Hildreth & Kimble (2002: p. 12) state that one has to move from trying to capture/codify/store towards emphasising the human aspect and postulate that a method is needed which recognises that knowledge resides in people and not in machines or documents. They suggest that a key part of the management of knowledge is to 'facilitate communication and interaction between people, rather than simply attempting to implement technological solutions'. Brown and Duguid ( 1998: p. 106) warn of the ubiquitous corporate intranets and e-mail systems being used as substitutes for informal discussion, stating that 'these systems in many ways replace the coffee pot and the water cooler as the site of informal but highly important knowledge diffusion'.

Brown and Duguid ( 2000a: p. 121) relate to us the 'importance of people as creators and carriers of knowledge, which is forcing organisations to realise that knowledge lies less in its databases than in its people'. Wenger, McDermott and Snyder ( 2002) similarly claim that not everything we know can be codified as documents or tools. They view from a business standpoint that the tacit aspects of knowledge are often the most valuable. Tacit knowledge will be the part of knowledge that will make a difference in creating and sustaining competitive advantages for companies, as opposed to the current practice of enterprises unilaterally investing in IT explicit information capabilities, thus creating a level playing field (Johannessen et al 2001). Baumard ( 1999: p. 10) posits that 'it is more interesting to question the phenomenology of knowledge than to view organisations simply as information processors'.

There are those who make a balanced argument for the two knowledge types. Woo et al ( 2004) espouse that individuals should emphasize tacit knowledge and use explicit knowledge in a supporting role. As opposed to a dichotomy, Tsoukas ( 1996) states that tacit and explicit knowledge are inseparably related. Lam ( 2000) adds that although it is possible to distinguish conceptually between explicit and tacit knowledge, that they are not separate and discrete in practice. She feels that the learning and innovative capability of an organisation is critically dependent on its capacity to mobilise tacit knowledge and foster its interaction with explicit knowledge. Conversely, Brown and Duguid ( 2001: p. 204) argue that the tacit and explicit are separate, maintaining 'knowledge is two-dimensional and that practice underpins its successful circulation'. They inform us that organisational knowledge is more than the 'know-what' explicit knowledge shared by all, requiring the more elusive 'know-how' – the particular ability to put know-what into practice. They state that while these two work together, they circulate separately (Brown & Duguid 1998: p. 91). Indeed Spender ( 1996: p. 50) in his osmosis-like argument of knowledge, states that the 'boundary between explicit and tacit types of knowledge is both porous and flexible' with 'traffic between the domains'.

Others speak of a social dimension to keep in mind when discussing knowledge. Nonaka & Takeuchi ( 1995: p. 61) argue that in organisations 'knowledge is created and expanded through social interaction between tacit knowledge and explicit knowledge'. Nonaka and Konno ( 1998) describe knowledge creation as a spiralling process in interactions between explicit and tacit knowledge, and use their SECI model (see below) as an outline for this process. Their approach traces the link between different forms of knowledge to the processes through which they are created. They state that conversion of tacit to explicit knowledge, and vice versa, gives rise to four modes (SECI) of knowledge conversion. During the socialisation stage, they note that knowledge may move from tacit to tacit, from exchanges through joint activities such as a craft apprenticeship (Nonaka & Konno 1998: p. 42). In practice, they describe *socialisation* as capturing knowledge through physical proximity. At the *externalisation* stage, they describe the conversion of tacit to explicit knowledge through metaphors and story telling, translating tacit knowledge into comprehensible forms that can be understood by others (Nonaka & Konno 1998: p. 43). At the *combination* stage, explicit knowledge is converted into a more complex set of explicit knowledge, where hitherto distinct but related bodies of information are brought together (Blackler 1995;Nonaka & Konno 1998: p. 44). During the *internalisation* stage, the conversion of explicit to tacit knowledge is involved where the explicit is embodied in action and practice to give a tacit dimension.

According to Nonaka & Konno, learning by doing, training and exercises allow the individual to access the knowledge realm of both the group and entire organisation ( 1998: p. 45). Their described dynamic process in which explicit and tacit knowledge are exchanged and transformed, sits on a platform that Nonaka & Konno ( 1998: p. 40) call 'Ba', a shared space that serves as a foundation for knowledge creation. Interestingly they espouse that if knowledge is separate from ba, it turns into information. They state that knowledge resides in ba, being intangible.

The above discussions lead one to consider what are the tacit dimensions of knowledge within organisations.

## ***Appendix: Anonymous Code set***

Anonymous code set kept with author.

## *Appendix: Semi-structured Interview Guide*

# Interview Guide

The purpose of this interview is to explore how forensic scientists learn their practice in carrying out casework, and understand the processes and conditions that stimulate the sharing and cultivation of knowledge.

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How did you as a forensic scientist newcomer learn the practice of forensic science work?

- *Is knowledge gained from theory alone / practice*
- *What were the tools of your learning: protocols/people? ie could you learn on your own/or not.*
- *From interaction of mentor(s)/ other persons involved in same practice*
- *Were supports given to you (workloads, complexities)*
- *Did barriers to you learning confront you*
  *-> dependent on resources eg. Trainer's time*

What makes a fully trained forensic scientist?

- *checklist in your mind*
- *development of competencies in practice to full*

Does being fully competent in the laboratory's SOPs reflect your work fully?

- *Do you work absolutely to a SOP eg set procedures?*
- *Can you carry out your work relying totally on SOPs? Do they capture the whole way forensic scientists work? If not why not?*
- *Eg.Triggers? such as normally/usually in SOPs?*

- 
- *What do you do when SOPs do not cater for your work needs?*
- 

Do you seek advice?

- *Why. If knowledge gaining, What is this knowledge you describe? Elucidation of steps or more nuanced such as others experiences?*
- *When? What triggers you to go to seek?*
- *How?*
- 

In participating in the work of your section how is knowledge gained/given?

- *Checking/peer review?*
- *Training?*
- *Meetings?*
- *Conferences?*
- *Scene of crimes?*

How do you come to perceive those that have the vital knowledge that you require in helping you?

- *Why choose them over the others?*
- *Would you view all in your section to have the same knowledge capabilities?*
- *Their creditbility/status taken into account?*
- *Do the more senior scientists have more knowledge to give?*
- *Do their years of experience relate directly to their perceived knowledge capabilities?*
- *Comfortable to go to them to seek?*
- *Are they approachable?*

Do you gain all the extra knowledge from within your section?

- *Do you go outside?*
- *To other sections?*
- *To other organisations?*

Organisationally, is knowledge given freely?

- *Is it expected of you to give knowledge*
- *Is it formally recorded, or just casual contact.*
- *Face to face, email, phone?*
- 
- *What do you gain/effect your work, when you give knowledge*
- *Reciprocity - Is there an evenness of knowledge given by individuals: those who do not/do. Sectional.*

-
- *Why? Collegiality, trust, willlingness, nothing to offer, power play*
- *Does knowledge flow, do you feel there is a knowledge network*
- *Where are you within knowledge network; significant/normal player*

---

What is your concept of experience?

- *Case histories*
- *Knowledge of procedures*
- *Pulling together of facets of learning*
- F.S. + exp. Can one work without that experience

Do you pull from those experiences in carrying out your own work? Or do you use others' experiences?

How do you gather from their experiences- Db, coffee

---

Does your work/academic studies previous to FSLab add to your abilities of being a forensic scientist.

What to you are your chief qualifications.

Is the experience gained from your previous work/studies recognised as adding to your 'knowledge status' as perceived by others in the FSL?

- *colleagues, management?*
- *Could your previous knowledge gained be better used/be seen as an addition?*

---

Draw your forensic science practice community picture, identifying the key individuals and groups involved in your practice. (Bubble/Venn diagram). *Piece of Paper*

## *Appendix: Interviewee Consent Form*

**Informed Consent Form**

**Purpose of the Study**

This study intends to provide a better understanding of the process of how knowledge is exchanged between knowledge workers. Forensic Scientists at the Forensic Science Laboratory, Dublin, Ireland are the objects of this study.

The primary research question that will guide this study is: *What are the tacit dimensions of knowledge management within/between Communities of Practice in an accredited scientific professional organisation?* The questions asked will only be around how we work with knowledge, that within or between ourselves. The data collected in this study will be used to draw conclusions to help management academics/practitioners better understand the actual processes in knowledge management of knowledge workers.

**Methods that will be used to meet this purpose include:**

- One-on-one interviews lasting approximately twenty-five minutes.
- Our discussion *will be audio taped* unless otherwise requested by the participant, to help me accurately capture your insights on knowledge in your own words. The tapes will only be heard by me for the purpose of this study and will be confidential.

**Subject's Understanding**

- I agree to participate in this study that I understand will be submitted in partial fulfilment of the requirements for the degree of Doctor of Business Administration at Newcastle University, UK.

- I understand that my participation is voluntary.
- I understand that all data collected will be limited to this use and to any journal article publications arising from the study.
- I understand that I will not be identified by name or by identifying information in the final research findings.
- I am aware that all records will be kept confidential in the secure possession of the researcher.
- I acknowledge that the contact information of the researcher and his advisor, and the doctorate programme details have been made available to me along with a *duplicate* copy of this *consent form.*
- I understand that the data I will provide are not be used to evaluate my performance

as a forensic scientist in any way.

- I understand that I may withdraw from the study at any time with no adverse repercussions.

Subject's Full Name: ______________________________

Subject's Signature: ________________________ Date Signed: ____________

**Researcher:** Stephen Doak, Forensic Scientist, Forensic Science Laboratory, Department of Justice, Equality & Law Reform, Garda HQ, Phoenix Park, Dublin 8, Ireland.

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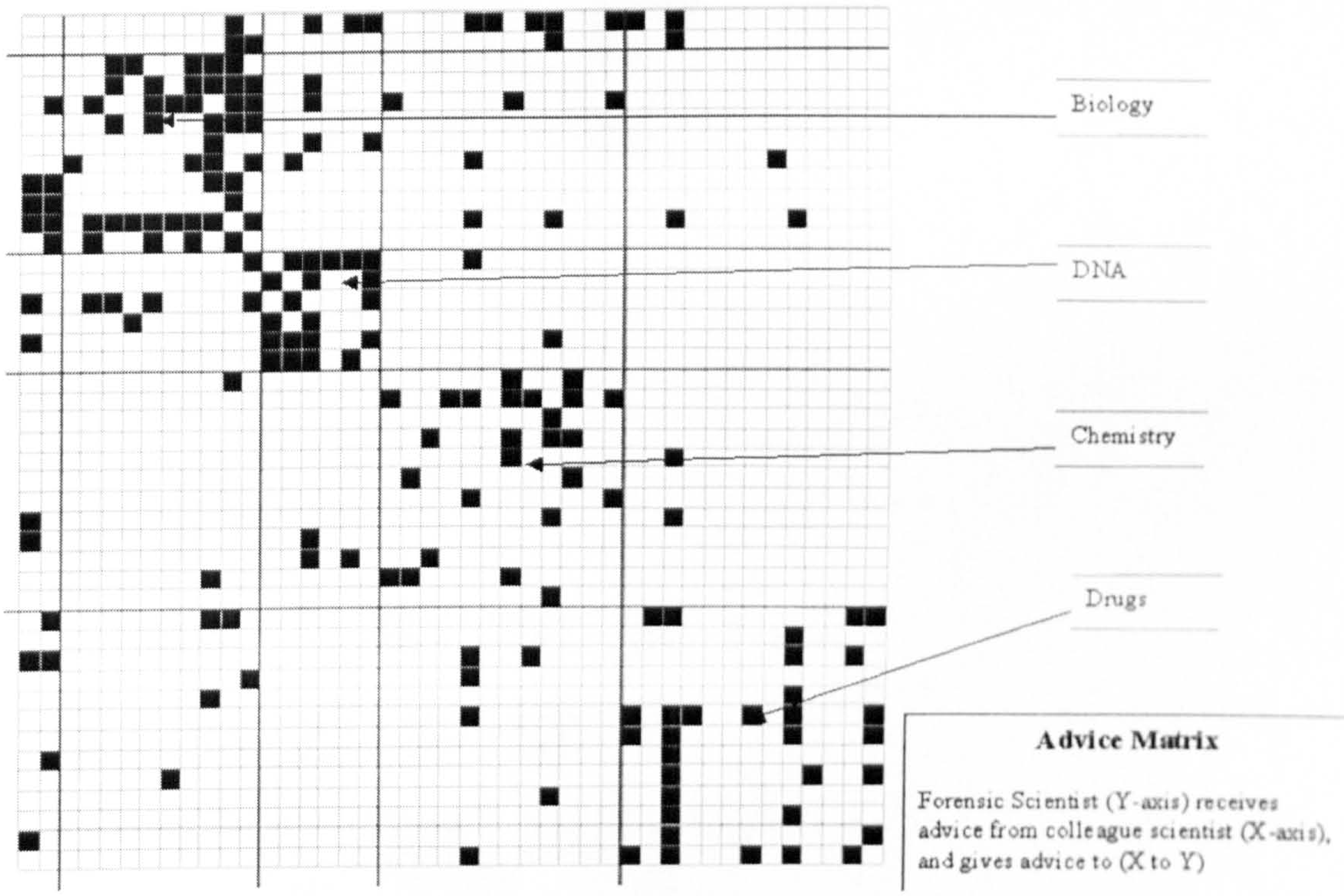
## *Appendix: Keywords used to screen SOPs*

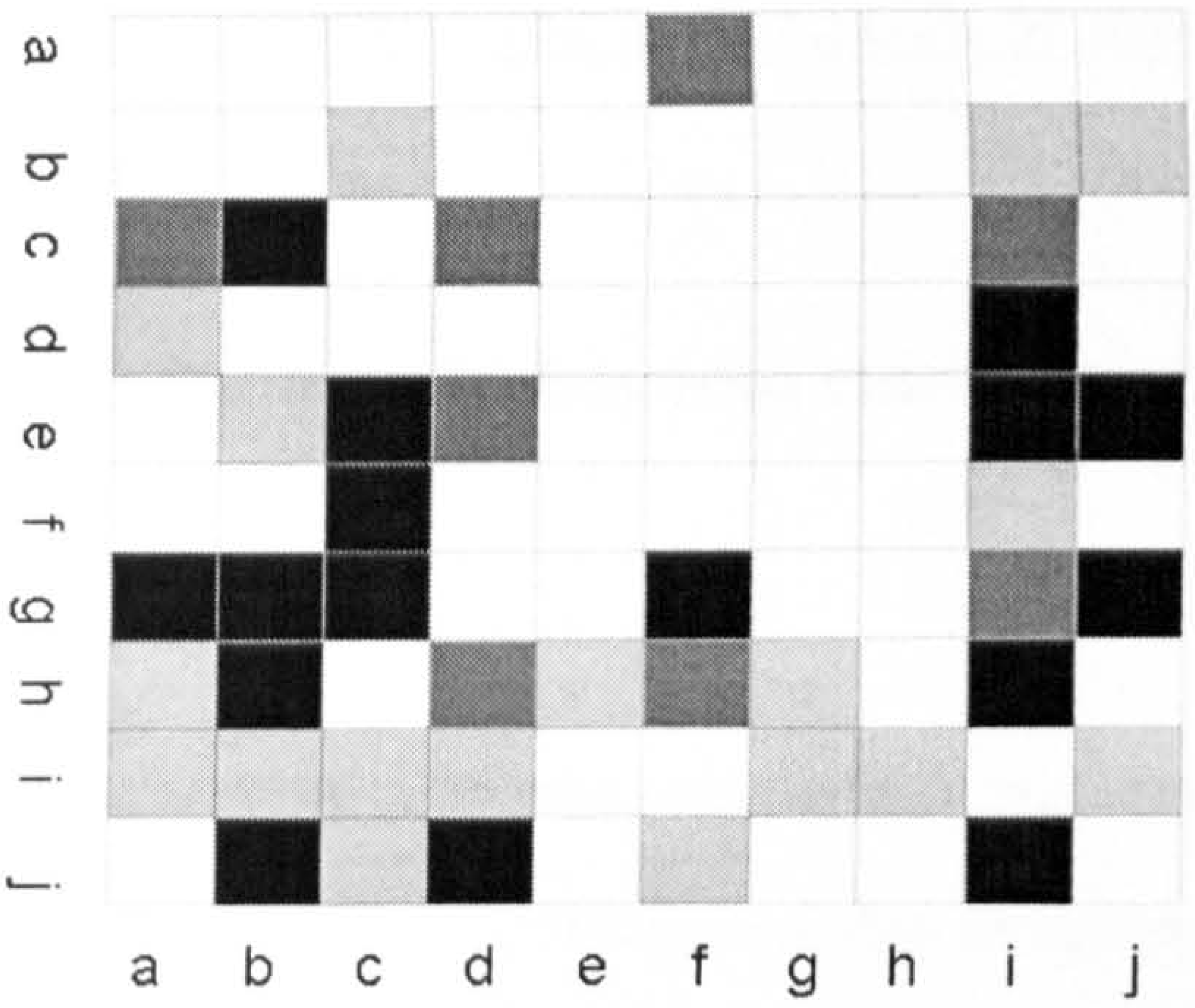
| Keyword | Total hits |
|---|---|
| may | 661 |
| trainee | 5 |
| suggests | 5 |
| desirable | 5 |
| circumstance | 5 |
| feel | 5 |
| preferable | 5 |
| unsupervised | 5 |
| expertise | 5 |
| believe | 5 |
| depend | 6 |
| ideally | 6 |
| depends | 6 |
| advising | 6 |
| interpreting | 7 |
| advice | 8 |
| ascertain | 8 |
| familiarise | 8 |
| decisions | 8 |
| undertake | 9 |
| occasion | 9 |
| evaluate | 9 |
| peer review | 10 |
| suggests | 10 |
| assist | 10 |
| experienced | 10 |
| interpretations | 10 |
| conclusions | 12 |
| experience | 13 |
| occasions | 14 |
| consult | 14 |
| complex | 15 |
| suggested | 15 |
| knowledge | 18 |
| consideration | 21 |
| instances | 33 |

**Keywords used were selected from a word frequency search and were subsequently used to screen the SOPs**

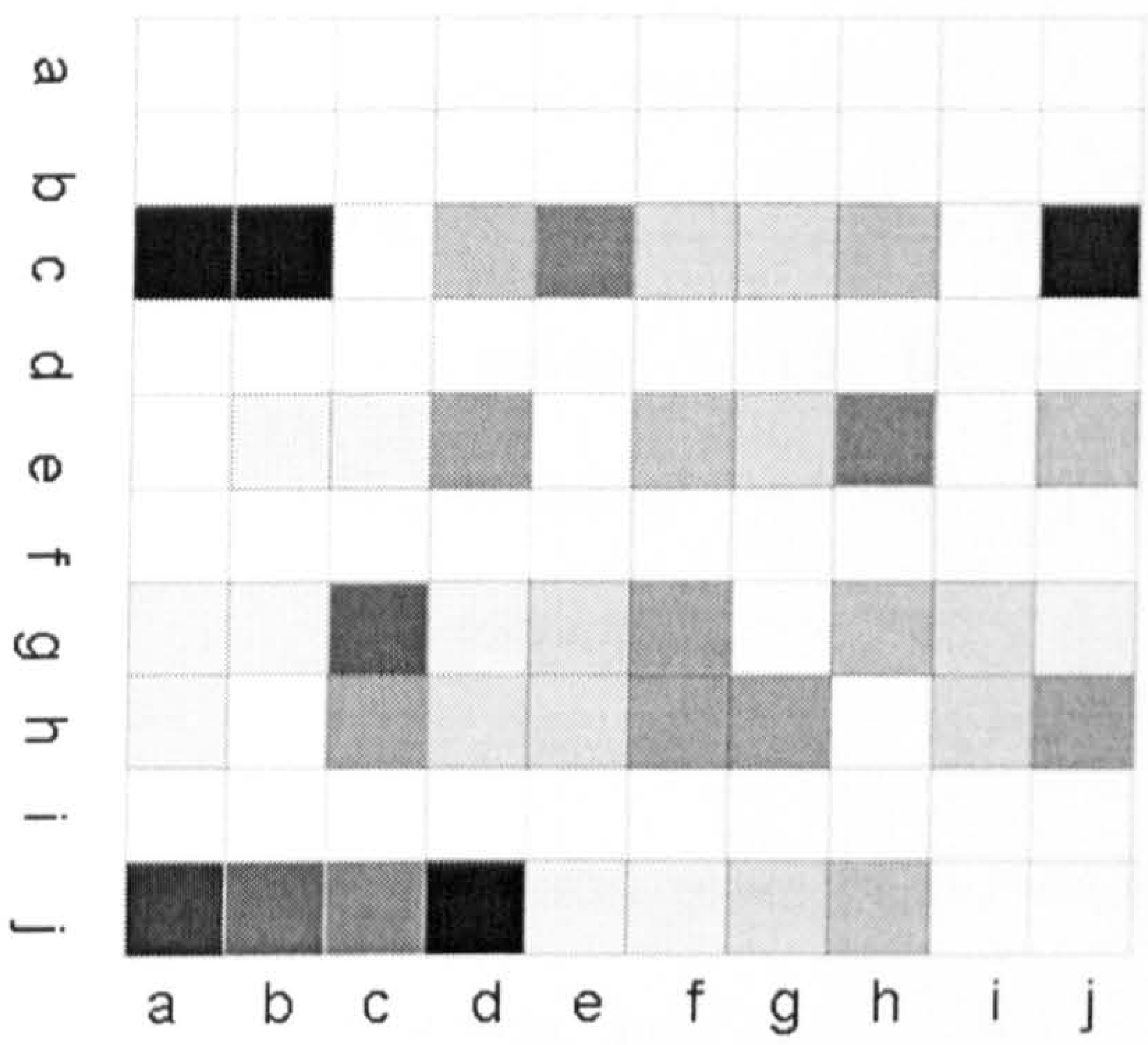
## Appendix: Sociomatrices




**Advice Matrix – Scientists at FSLab, Ireland. Forensic Scientist[each open square along axis] (Y-axis) receives advice from colleague scientist (X-axis), and gives advice to (X to Y).**




**Matrix of Biology advices**




**Peer Review Matrix - Biology**

## ***Appendix: Survey – the use of SOPs in practice***

### **Training to become competent as a Forensic Scientist**

(1) In your training to become competent did you have the use of SOPs? Yes / No

If No, were they in existence at the time? Yes / No

---

If you answered Yes in Q1 please answer Qs 2-5.

(2) If you had the use of SOPs, were they in the following?

Searching. Yes / No.

Carrying out of procedures. Yes / No.

Note-taking. Yes / No.

Report writing. Yes / No.

Court testimony. Yes / No.

(3) Could you do all your work based on only using SOPs?

Searching. Yes / No.

Carrying out of procedures. Yes / No.

Note-taking. Yes / No.

Report writing. Yes / No.

Court testimony. Yes / No.

(4) Did you find that you needed extra information to that covered in the SOPs in carrying out your tasks?

Searching. Yes / No.

Carrying out of procedures. Yes / No.

Note-taking. Yes / No.

Report writing. Yes / No.

Court testimony. Yes / No.

(5) If you answered yes in Q4, what form was the extra information in?

Other written protocols such as user manuals. Yes / No

From the literature. Yes / No

Information from colleagues. Yes / No

Other forms ____________________

---

(6) If you received extra information from colleagues, or you trained without SOPs [ie. You answered No in Q1], how was the information given?

Advice in person (face to face). Yes / No

Following worked examples eg Looking at files completed by competent scientists. Yes / No

During case peer review/checking. Yes / No

(7)When did you feel comfortable working on your own?

Eg. Was it from repetition of same process; was it from being able to carry out your SOP a-z, Was it a logical progression, many steps leading to competence; was it when you received enough advice from colleagues to cover all aspects of what you might face; years of service etc.

______________________________________________

______________________________________________

______________________________________________

(8) Do you ever refresh your procedural knowledge by relooking/ looking at the issued SOPs? Yes / No

(9) Do you find the use of SOPs beneficial?

Give Baseline knowledge. Yes / No

Guide you day to day. Yes / No

Rely on your own work, SOPs not needed. Yes / No

A valuable addition to your task knowledge. Yes / No

(10) Overall do you see the use of SOPs as an addition to the integrity of the laboratory's work; improved quality? Yes / No

(11) When you have a problem in your process and you need to find out information would you/

Consult your SOP. Yes / No

Go to somebody else to get first hand experience. Yes / No

## *Appendix: Edited surplus Interviewee transcripts*

### Qualitative view of knowledge outside

Harry because of his senior management position is concerned with the more managerial aspects which he picks up from outside bespoke courses:

> Not within section. Management team source of knowledge – courses.

Troy speaks of the logistics of how he actually gets that extra knowledge or advice:

> Either by referring to, let's say I have a contact in a particular organisation and I say, look I have a question here about this, perhaps you could direct it to whoever you think might be able to solve it in your organisation.

Robert mentions how the knowledge gained from outside sources such as ENFSI meetings is brought back to his section:

> Oh we get feedback from their meetings via people who attend them.

Kieran, a section head does get 'exposure to other laboratory personnel', but is wary of the knowledge for the more day to day activities:

> People who work in other labs but I don't necessarily believe that it is a great mechanism of transferring knowledge on what we use on a daily basis.

Melissa is a reflection of how forensic scientists feel in general when they come back from conferences:

> I always come back from conferences very enthused and you hear all these great ideas. I mean once or twice I have come back with new ideas and techniques and we have actually put them into operation. For example, the mini-taping. I mean I met a girl there and now we mini-tape everything, rather than swabbing things for DNA, and I mean I'd met this girl and I'd listened to her lecture and she was from Strathclyde and she gave me all the details on how we could do it.

Or Holly another scientist who although is not a gatekeeper gets a buzz from outside knowledge sources:

> I actually find that a huge benefit in broadening your horizons and experience and you get great ideas coming back here about where you can put your thoughts into practice.

Alice as an executive manager reflects on the phenomenon of being more impressed with knowledge from an outside source when it is already available from within FSL:

> I say it again and again, that people go outside whether it be to a conference or a meeting and come back full of the joys because they have discovered something new that I know is in the laboratory already. So that's a little bit disturbing. It is the really kind of you know, an expert of somebody who delivered advice, and it's not that people don't want to give the advice here, but it's more convincing when you get it from an outside source.

### Yielding gatekeepers

Nathan is a permanent member of one of the ENFSI working groups, and one can see how busy he has been:

> I have been to the last three...two...I'm going to the third one this year...drugs ones...I've been to two EAFSs – the Helsinki and the Turkey one – and I've been on the quality one...I'm just back from it in Sweden.

Aoife a middle grade forensic scientist is wary of the permanency of the tenure for individuals to serve on the ENFSI groups:

> But previously you would have individuals that would be rotated to go to those groups so the knowledge would be all checked, because that's what the knowledge is for to be heard by everybody here. Now you have the same individuals going, who are not issuing any bulletins about what they saw at meetings etc.

Shane feels that there are more benefits from the outside knowledge:

Well for me, personally, I suppose its most gained in terms of international meetings and conferences – the working group that I go to, ...in the sense that you're meeting people at the same level as yourself.

Isabella a gatekeeper in the biological area shows the enthusiasm of her role:

Like the Body Fluids forum is a great way of gaining knowledge and hearing about situations that other people have been in and how they have dealt with them.

Brianna a gatekeeper with an extensive network of outside contacts gives an example of a particular incident:

So I certainly, and I also got onto the Forensic Science Service to ask them to check their database of fibres to see how often they could pass the fibres, so I would be very much looking for outside information.

Procedural relationship amongst actors

Shane details the formal steps within the procedures where another experienced forensic scientist gives advice or signs off on a process agreeing with an observation made by the scientist who is carrying out the procedure:

Say, for example, in somebody carrying out a case – I think I remember reading in the footprints that there are some decision gates that need to be made and you can either go on and its quite simple, you can decide yourself what to do, but in other times you may need an experienced scientist in to tell you that this type of footprint...there's some various things that you need to be aware of or indeed, say if you were doing some casework and you found that there's blood, well then obviously you would go and ask somebody working in the blood area to take a look. For a footwear identification you're suppose to get another person to witness it or satisfy themselves that there is an identification and sign it, but that was insisted on by the external auditors.

Robert would seek advice in trying to complete a procedure in the most appropriate way:

I would assume you would think about what you perceived as the best way of doing it. I would always...if it were me I would...having done what I could, I would go and consult with one or two others and say, what do you think about this – is this the way to go or how would you do it – and obviously that might change my approach.

Danielle is also cognisant of the process improvements needed within the new management practices:

I'm also conscious of the fact now that there's a big emphasis on not doing work that's unnecessary – that's a big thing now.

Experiential relationship amongst actors

Nathan captures why those of less experience are triggered to seek advice often:

Well usually what triggers it is if something that is not covered by the SOP pops up and they'll go and ask then, but once they know that they won't have to ask subsequently when that pops up. You know, there are so many things that you can't cover in an SOP. It can only be generic. If you were to try and cover every possible scenario, the bloody thing would be like the Encyclopaedia Britannica.

Robert, who has had experience as a forensic scientist in two jurisdictions also offers his opinion on gaining from other people's experiences:

Well, receiving – a lot of it's covering your arse – let's be honest about it. If its something you're not totally familiar with, you'll want – I mean its only commonsense you'll want to see if there's other experience out there – is it something somebody else has seen, and as for giving advice normally that would be because somebody has come to me looking for something. We don't have time to peer over other people's shoulders while they're working and say, - hey, wait and minute, why are you doing it that way?

Ella, a relatively experienced scientist admits:

I go and ask people when I'm unsure myself.

However Ella on herself coming through the system has changed her perspective on asking the more experienced scientists for advice:

I suppose...when I started first of all I would have looked to the most experienced but that has changed as I'm getting more experienced, because all the other people that are either just above me or just below me are getting experience too, so its not as pronounced now as to who I would go to.

Adam warns that not everybody can get on the experience train as they can be error-prone:

> I think there are probably two elements about it. There's time based but also possibly personality based. Some people don't learn from experience or learn very little and forget it quickly and I don't have an answer to that problem. Its kind of an [inherent] characteristic within some people that they repeat mistakes.

Indeed Harry, a section head manager would ask somebody for advice:

> if you need to know something.

If Monique, a highly experienced forensic scientist and a head of section, were to go and ask an individual for advice, she would choose experience as the determining factor:

> I suppose I would see them as having experience, that doesn't necessarily mean that they've been here a long time, because I might be asking a question about something that I think they've had experience of before they came in here.

However, Shane a senior grade forensic scientist feels that he is slightly above seeking advice because he would already know what is needed in the process of completing a case and ultimately its report:

> Not that often [would I seek advice]. I think the main situation where I might seek advice is if...not so much over a scientific matter as over maybe a certain procedure matter or an ethical matter, if you want to know something about the laboratory's policy on something

But when pushed, Shane does seek advice for those odd occasions:

> yes, if I was vaguely aware that somebody...if it was an unusual type case and if I was vaguely aware that somebody else had something like before, I might go and ask them – what did you do?

Danielle, who although has carried out the processes for many different types of cases, is concerned with the process because of her relatively new experience in a new specialty for her:

> Sometimes I'd go to somebody just to find out...you know...should I continue on doing this or should I stop now and go on somewhere else. Particularly with fibre cases I find that [I'm newer in the area] I take a lot more advice...and it would be things like if there's a fibre I hadn't seen before or if there's something unusual about it, I might be asking somebody to check something for me or to look and see if I'm going down the right road or if I've sort of missed something.

Or she adds

> I suppose now, for me, the majority of the time it is like that. If there is a case that isn't...like...something I haven't come across before...there's something different in it, then I'll go and ask other people's opinions

Holly's concern is to take advice from a scientist with experience to help her make decisions in how to approach certain aspects of her casework:

> whereas if something in a case that a victim has done something or vice versa that's where I would go and ask somebody else with experience what would you do, how would you approach the case, more I think like that as opposed to the technical aspects of the case

Ella would seek advice from somebody who has had the experience of already seeing the unusual part of a case:

> I just can't work out how possibly something could have happened given the circumstances. That's the little twist or something, yes, you might go ask somebody.

Melissa makes a clear choice in selecting the more experienced for her to receive knowledge from:

> No I usually go to people who have been here longer than me I suppose, and I would perceive as having more experience than me.

<u>Capability relationship amongst actors</u>

Jake speaks of his experience over a time period giving him the capability of being confident to be able to deal with requests from the police:

> I think with the experience gained over time, you certainly feel more competent and more secure in your knowledge of what you're doing and extend the knowledge around it so that if there are any queries [they can be answered].

Melissa observes that individuals have differing capabilities and that there are different rates of development:

> I think other people...I see them coming through and they're much more confident but maybe they're more confident people. I think I personal thing. Some people are more confident and other people need things to be reinforced a little bit more.

Kieran would like scientists to be cognisant of the measure of their own abilities to carry out processes or having the knowledge to be of assistance to others. He does not appreciate being led down the garden path to find that they cannot actually assist:

> I also believe that people when they haven't got knowledge should state clearly that they haven't got the knowledge and there isn't a stigma attached to that. I'm not so sure if that is essentially...that there is a strong support for that position where "I don't know it but I will find out for you if you think it's appropriate" or say "I'll pass you on to somebody else"

simply Kieran chooses:

> Whoever knows the answer best, I don't care who it is, it could be junior, it could be senior.

Brianna knows who to choose to help her in what she needs by evaluating the individual's performance in her previous consultations:

> Well it would depend on past experiences with them, if they have given me good answers in the past. Or if they have developed an expertise in an area and their knowledge the laboratory is the people with the experience in that area.

Brianna finds that if there is more than one scientist that can help her there is a further selection process that she instils.

> Well if it's just a single area that other people don't have an expertise in then you have no choice, but if you can choose between people in the same areas then you choose other people that you feel gave the most satisfactory answers and particularly it probably gives the most thought to the questions.

<u>Casual relationship amongst actors</u>

For Adam the casual meetings and informal discussions 'could be anytime, anywhere'.

Monique having served a long time at FSL remembers when she had her ears primed for that extra knowledge of the tacit nature:

> I would say in reality that, if I go back to my early days, almost always at coffee breaks and lunch breaks.

Melissa seems to be always bumping into colleagues and would be the very chatty type when she mingles, increasing her chances of gaining new insights:

> Sometimes it just happens [gaining knowledge]. Somebody's had this case and guess what happens and I had a case and I'm after getting DNA from such and such, or else people might come to you with a problem they have in their case and you're exposed to a totally different scenario that you wouldn't have seen before and then it would make you think about...so it happens in a number of different ways.

Julia a senior scientist who has decreased her case loads for other organisational needs finds that interactions are mostly formal with the staff and she observes that the:

> More junior staff develop through informal interaction.

Francis backs up the informal setting where she gains her knowledge from other people's events, or happenings:

> It would be mainly casual contact...by overhearing other people talking or getting knowledge.

Brianna one of the executive managers approves of such casual environment and is encouraged by the social intercourse that ensues from a down time such as the coffee break:

> kind of casually informal chat as well where people just have a cup of coffee and start talking about a case.

Jason captures the essence of how tacit knowledge is spread through the less formal channels of communication:

> There are a lot of other things that are just...you tend to hear them...people just discuss them at various times – over coffee or in a bit of a huddle somewhere – and its not written down...its not formal anywhere, but they're still important.

Shane picks up details through casual conversations:

Conversations with people – you know, who have come back from meetings, that might tell you something interesting that they heard.

Kieran recognises the innovative spirit that emerges from the informal chat, that would not necessarily become apparent in a formal setting:

> It happens most in an informal way whether that be the coffee situation or just generally going through the laboratory or in places like two people sitting down beside each other at the microscope looking at slides, there's time there where you can bounce ideas off others. The more formal ones are probably less heeded.

Francis speaks of the informal communications that happen within the Biology sphere of practice:

> And that's another way where you learn knowledge as well, people discussing cases at coffee or whatever and when interesting cases come in people do a lot of the time discuss it and you would always learn from those things as well like discussing and asking people "how did you get on, what did you do, what happened?"

Ella speaks of the dichotomy of informal/formal communication over an examination of an item when another forensic scientist is required to formally sign-off on a conclusion reached during a procedure such as damage assessment or blood pattern morphology analysis:

> I think that you can go and ask somebody and they will come and/or you will be able to chat back and forth about circumstances.

<u>Helping relationship amongst actors</u>

For Aaron, he prefers the straightforward practical way of thinking about things or dealing with problems, and would select individuals who are concerned with achieving the results required rather than getting caught up with theories:

> I perceive a degree of pragmatism about certain people and that would be very important.

Aaron had a case involving vehicular airbags and had heard Ella mention that she had done a similar case with airbags. On going to Ella for advice on how to deal with the case type Aaron found that her helpfulness gave him a good feeling about trying to find out some advice – no doubt he would go back to her for other instances of gainful knowledge in the future:

> so I came back [to her] and she was very happy to help.

Jake gets help in interpretation from others:

> [I] ask someone some details on the case that I might have, that would help in interpretation, say, for instance, you're doing an alcohol analysis and you might not have the information on how much was drank or when it was drank or the period between the incident occurring and the sample being taken – these kind of things.

Sophie describes that within the laboratory that knowledge is given freely and that:

> Generally it is just individuals helping each other.

Isabella works within a helpful environment, and can gain some advice or help in other areas when she already has helped them in her area of specialism:

> I like helping others. I find that people will help me in other ways...the people whom I'm giving knowledge to will then say – well, I covered your 'phone on Monday because you weren't in and you're always doing things for me – so I do find that I do get it back in other ways.

Holly will give others help if she can, thus gaining:

> A sense of achievement and moving up the ladder.

Francis continues, showing her own helpfulness with individuals:

> If somebody's doing a case and if you can help them in any way, isn't that a good thing.

Dylan also reflects on the helpful culture within the organisation:

> I've found people within the other sections just as easy to approach in relation to questions and helpful as in my own section.

And Dylan is not hung up on who he should seek help from:

> for me it would be anybody I feel would be able to help me out in relation to the case, it's non grade dependent, it's not experience dependent.

Aoife finds the eclectic notice board with many pieces of paper hanging from drawing pins a useful source of valuable knowledge:

> I think its [available]...well, we'd have notices up on the notice boards and that.

Laura who has employed at another organisation before she became integrated into FSL actively tries to meet others over breaks so as not to become cliquish:

> I would purposely go for coffee in the annexe to meet other people because otherwise its very easy to fall within this tiny group and people tend to stay very tightly.

Danielle realises the importance of keeping in the loop by being around for breaks – for fear of missing any knowledge nuggets or being distanced from her clique:

> Like if you go to coffee or lunch with people, that's where you get more of your information than if you don't, and to a certain extent you feel – I don't know, excluded is too strong a word but you feel like you're not part of that grouping, that you're not being given the information.

Monique captures incidences of learning when individuals come back from the Courts in their usually heightened state of awareness, coming down from proffering all their energies having been consumed from tough cross-examinations by senior counsel. Some of the most valuable knowledge such as how to deal with a question or how to deal with a barrister who is trying to belittle your case report can be gleaned by casual corridor debriefs:

> You might come back from Court which I think is another area of knowledge, and you might tell the people that you meet or the people you are sitting with a coffee, but it mightn't go beyond it.

<u>Openness/Sharing relationship amongst actors</u>

Laura regards the FSL as being very open where she glean her learning from being in face to face situations:

> but the actual tricks of the trade – if you wish – was very much from verbal communication. There's very open channels of communications to find out all of that information.

Jake senses the openness as some sort of dynamic within the organisation:

> I think there is a flow within the section, you know, as you're learning, certainly, you know.

> And if he wants to find out something he tends:
> to go up to the person and ask them.

Danielle too goes through the personal networks to gain knowledge:

> Basically go and ask people. Maybe ask somebody and question and they might say to me – oh, so-and-so had a case like that, talk to them. So it was just basically from asking people questions and talking to other people.

Jason gives an example of how knowledge can be effectively transferred from one colleague to others:

> Maybe if someone's been away and they've learned something, it goes by email – that would be the main way.

Ella also mentions another medium through which knowledge is spread:

> you've gone to a meeting and you've heard in this instance people have done this.

In addition Dylan who is relatively new to FSL shakes the apple cart in a refreshing way so much so that he realised:

> initially people didn't like the questioning.

But he genuinely feels that the populace of FSL are there for the asking in the advice one seeks:

> I believe the more you ask questions in relation to certain things they'll open up a little bit more.

Brianna recognises where the communication channels are open:

> And I think in biology people are very good about that in biology, I think there is a lot of dialogue there...they are interested in it and like the opportunity to talk. I would think that we are good at sharing knowledge here, there is a lot of discussion.

Brianna over the years of her experience attending meetings realises the import on how necessary it is to be able to muster dialogue with comparative strangers:

> Jim I had never met, but again the more you do it the more confident you get as you, you know, for new people coming in it is a bit intimidating but the more you do it the more you realise that this is the norm rather than it's unusual.

Approachability relationship amongst actors

Jason lists approachability as factor in those he selects knowledge from:

> Some people are more approachable than others but pretty much anyone would know the knowledge, so it would be a mix of who is approachable but then it could easily be just the first person who walks past.

Danielle supplements the definition of the helpful individual by judging at the strengths of individuals:

> I think the giving of information and even the receiving of information is very much dependent on the person. Some people are better at dissipating knowledge than others and its not that they're trying to keep it to themselves or anything its just that they're not that good at it.

Adam a very senior forensic scientist within FSL would still be worried about showing himself up in an informal way, being more relaxed with individuals he can approach to ask advice:

> Now if I've got some cross section matter where I want advice or something, you tend to go to the people, you're getting on well with [inaudible] because, you know, you're in quite a vulnerable position here – exposing yourself, showing how little knowledge you have.

Simply put Xavier states he would go to fellow forensic scientists:

> If I felt they were approachable. Some are, some aren't.

Melissa has a particular kernel in seeking knowledge from a fellow colleague:

> But the number one thing is that they are approachable – for me.

Kieran mentions the power-play phenomenon as a reason why an individual may not be as favourable to give knowledge to others:

> Some people do and some people don't [give knowledge]. There's still the old adage of knowledge being power and there's certain people who have maybe either personal defence mechanisms, I believe through lack of knowledge or lack of confidence in their knowledge and are reluctant to pass it on, maybe that they're not 100% confident that the knowledge that they have is correct so that when you do approach people like that you find that their reluctance is natural, probably self confidence or maybe they're a bit unsure of their position.

Holly being very self conscious of her position in the pecking order amongst her colleagues outlines her thoughts on those who she would feel comfortable to seek knowledge from, not turning to those who she knows would not help her

> Oh I think [knowledge] it's all over the place it just depends who you approach and who you feel comfortable approaching. It might be down to who you approach and then you know what their train of thought is, probably very much in line with yours and maybe that one bit further, there might be one or two that I mightn't bother with because they haven't got time for me.

Francis who herself is very approachable has some exacting words for those who are not team players:

> I'd go to somebody who I knew was amenable to answering questions and would be able to help…interested and not rushing to do their own work. There would be certain people I would go to more than other people within the section.

Brianna, the executive manager who appreciates how people really are chooses those that are interested as well as being approachable:

> But also they also need to be approachable and open to it, and I suppose people that are actually interested in challenges of new problems, but also be more inclined to go to because they are not, they don't regard it as an extra burden, they are interested in it and like the opportunity to talk, so that would all influence in who you picked.

Alice mentions that some individuals are just attuned to give knowledge in an approachable environment:

> Also some people are more open in how they share knowledge and experience with you, and I think that's regardless of who you are or what you are.

Jake would choose those that are easier to ask advice of:

> if people are more approachable you're going to go up and talk to them if they're perhaps easier to deal with or something like that, you know.

Ella, too points out those who show on the surface some elements of approachability but in the end are of no assistance to the greater cause of knowledge sharing:

> Well, I think everybody is approachable but the answer you might be told no, it doesn't suit, but you can approach them by all means – come and say hello and ask me but I might not go – so there's a difference between whether you can approach them – yes, everyone's approachable – but whether you think you're going to be successful in getting that person to do what you want to do is another matter.

<u>Respectful relationship amongst actors</u>

Danielle is conscious of the group dynamics in choosing the pecking order of individuals in a section or community of practice, a sense of respect prevails:

> its very obvious to me in things like when we have literature meetings in Chemistry and we'd maybe talk about if there's any papers coming up about glass, and straightaway everyone would direct their conversation to Noreen, because she's the person who goes to ENFSI for that and likewise for other areas. So to me its very obvious...there's a very obvious sort of recognition towards them people when it comes to them areas.

Melissa, in seeking advice would use respect as a deciding factor for whom she approaches:

> you would choose people that you would respect their opinion and you would respect their opinion because you would...they're just usually people who I would see as having a lot of experience and are good...I suppose just good forensic scientists and I respect them.

Alice the senior executive who has been at the pinnacle of FSL's interests for many years, knows who to choose based on a trust and judgement measure:

> I suppose I'd have to be perfectly honest and say that there are some people who's judgment I trust more than others.

<u>Proximal relationship amongst actors</u>

Francis logically finds who to go to for advice containing tacit dimensions:

> it's obvious that you go and ask advice of who's around. So my rule of thumb is if in doubt seek advice and because we're quite a small group and we work in quite a small building at the moment that it's quite easy to pop down the corridor and ask somebody for advice.

Ella too, being practical tells how she would seek advice in the first instance.

> If I come in and there's someone there, I would go and ask them.

<u>Cohort /Cliquish relationship amongst actors</u>

Harry exemplifies the cohort effect observing the different groupings and the way they work:

> Younger people seek knowledge moreso than the older people. All the time on going every day discussing something. Mostly newer people going to older people.

Danielle somewhat complains of the few forensic scientists who do not help her in giving advice, and finds some communities are worse than others:

> I think it's different circles....very much so. Like if you go to coffee or lunch with people, that's where you get more of your information than if you don't, and to a certain extent you feel – I don't know, excluded is too strong a word but you feel like you're not part of that grouping, that you're not being given the information. And I think that's very strong within the Chemistry section.

Danielle does feel excluded because of the obvious cliquish behaviours of certain cohorts.

> Well I felt when I joined here – that's 9 years ago now – I felt that there were people working in the lab for, like 10 years plus, and they had created their own way of working and they weren't prepared to take on anybody else's opinions. They were quite happy the way they were and they weren't prepared to listen to new ideas coming from the outside.

Monique a senior manager is aware of the different groups of scientists describing them as a circular process with no tangents outside to other scientists not in their group/circle:

> I'd say there are probably sub-groups within that and probably a cohort where it is kind of a circular system, you know they go to each other about things and they'll discuss things. And

then it may be a bit hierarchical whereas the more junior people, advice is not sought from them, so that tends to be a, you know it's going this way, sort of round in a circle.

Monique's thinking is quite clarified – so much so it could be taken as a recommendation for action at FSL:

> I would say, I think it should be broken down, because I think that myths grow up and a new reality forms for a new cohort, and I gauge that from listening to conversations or, you know, working across from a particular room or whatever. And things become fixed like the gospel. And the longer it stays like that the harder it is to break it down. But I can see the problem; I can see the people don't particularly want to share offices with people of different ages, anything. But I think, I think it is useful and I would be, we would need an advocate of people from different sections in offices because I do think that it is good. Even if it's not maybe your choice, but in terms of the job, what we should be thinking about is advancing the job.

Isabella from experience has made observations showing up the disadvantages of such cliques:

> I think probably there is a bit of a bottleneck in that people will tend to ask the same people for their opinion. So if you're not being asked for your opinion, you're not learning because you haven't been involved in that loop.

Georgina who herself has served a long time at FSL faced somewhat prejudice from a certain jaundiced cohort of fully trained scientists:

> The only barrier I had in terms of training was the ethos that was here then, I don't think it's here now so much that, "how can you be so stupid...it was a different culture then, there was an element of, "we've been doing this for so long and there's one way to do it" and it was silly, a lot of it was I think, there was just false view that it had to be done a particular way.

Ella complains of the lack of transparency:

> people go away for given talks and day meetings and you've no idea where they're going or what they're doing. Now you know what's happened is a manager has approached them and asked them to do something...but its not transparent and if that information was...say it was Kieran...if his role was to let everybody know such-and-such is going to give a talk this week...you know, you hear about it. You might hear about it in Alice's news thing or you hear Robert tell about it at tea, otherwise you've no idea.

As a result Ella thinks there are power plays when it comes down to people with knowledge over and above their normal expected reservoirs:

> but I definitely feel that, here, having information is felt as a power and the more information you have the more powerful you are perceived, and you might have the edge over someone.

And Dylan makes a guess on the changes that have now been adopted since the historic non-questioning attitudes of yesteryear:

> I think that may have stemmed historically again from the fact that the reports and the work which was done was very restrictive and the freedom of talk and expression was, I wouldn't say frowned upon, but it wasn't readily allowed to develop and I think you've got new people in there with a broad spectrum and they began to question things.

<u>Interpretative relationship amongst peer colleagues</u>

Aaron finds that peer review by his colleagues was of benefit to him:

> To my mind the peer review I found was most useful.

Jake too finds that the advice inherent in the peer review system do help him:

> Comments you get back from the checking process can also be useful.

Chloe too reflects on the safety net and comfort zone for those who are recently trained:

> You learn a lot from peer review. You learn an awful lot of training and shortly after training I think which is probably a non-defined area. But you are thinking for yourself but you are definitely within the safety net of asking people.

Dylan takes the view that any unsureness about a case should be dealt with before the peer review stage where you seek advice from colleagues whilst in the process of writing up the case report:

> Checking has its place yeah, but I think prior to checking I think the idea in the laboratory which was you do all your questioning prior to checking. I don't necessarily see that that fits because sometimes you might not get around to asking that particular scientist. I don't think that's a good way of learning, checking. I think it's a typing error, typos and stuff like that.

> I'm not saying it's not a good way to learn but there are better ways to learn prior to putting something into checking.

Continuing, Dylan shows the importance for looking for advice before you commit to writing the report

> Because during casework you haven't yet formed anything on paper, whereas with checking if you've never asked anybody you could be completely off mark.

Maturely, Troy with his many cases filed away thinks deeply about the case in question and does not stop at the simple process of just doing enough for the standard practices of process:

> In the course of an examination, it may strike you that – hey, there's something here I'm finding which is kind of not at all what I'm expecting so I'll go and explore that with whoever's investigating the case and say, look, I'm finding bits of red paint here – is there any possible source of red paint in the case.

Sophie's main concern for herself is how to take command of the interpretation part of casework, as she is in the middle of her training for dealing with the more complex cases:

> Interpretation, with a lot of the DNA stuff, the mixtures and stuff like that. If you get a particular result and you are unsure of which way to go with it, where the work needs to be done or not, I would normally go to another scientist, generally they would be senior to me and I would say if you had this what would you do and they would give me an answer. Now generally I would follow whatever they've said, sometimes I would question somebody else. I usually get a second opinion.

Brianna feels that when the case report is submitted for peer review that it is the final product and should be accurate both in interpretation and quality:

> I think the fact that you know ultimately when a scientist hands in their report for checking they are saying this is my opinion, I am prepared to stand over that.

<u>Adversarial relationship protectively instilled amongst actors</u>

Georgina, who has had her fair share of court cases to experience, warns of the need to prepare for court:

> I cannot understand the person who doesn't follow a piece of evidence right through knowing, maybe they don't realise the potential of it and they go to Court without having hammered it so that when they go to Court it'll be hammered, you know, maybe they're lucky and the prosecution don't realise the significance of it.

Jake focuses on the circumstances of court:

> When unusual things happen or you end up in the Court situation, never knowing what you're going to be asked, as well, and learning how to deal with that. Experience will help with that because you hear from people who are in the lab – oh what happened in Court, what kind of questions were you asked, how did you deal with that, you know.

And where he gives the steps he takes in order to get advice to help him with the case that he is to got to court with:

> Say there was a particular case type coming up maybe you hadn't been to Court on before, you could have a look and see who's been to Court on those cases and then ask them, to get some ideas or to prepare yourself, I suppose, as best you can when you go to Court.

Sophie touches that as well as the set procedures to carry out analysis you need to know the wide scope of background information for court:

> You can perform these protocols without knowing why, you know, that's, but to be able to perform in court you need to have the theory so you needed both at the same time.

Melissa speaks of the precedents laid down in court on the way procedures have to be carried out:

> Oh the reason is that things are done in a certain way because its been proved in Court that they are the best.

<u>Structural relationship amongst actors</u>

Nathan who has served a long time at FSL is presumptive of those who possess the required knowledge based on a seniority scale:

> I'd probably go to somebody level or higher because they would probably know more than the people under me about…stuff.

Jake would judge differences partly on a structural level:

> There are different grades, I think. People with different experiences. So I think there is some variation in the knowledge that people have.

Xavier, if he as any problems goes to his supervisor:

> Well I currently go to the Grade One in my area.

Monique reflects on the different groupings of individuals within FSL who go to each other on an informal basis. She weighs this against the more structured seniority based scale of advice where advice is sought in an upwards path as opposed to seeking advice from the more junior individuals:

> It may be a bit hierarchical whereas the more junior people, advice is not sought from them.

Sophie defers to those more senior to her for advice:

> So that's anybody senior to me basically I would go to.

Georgina speaks of the pitfalls of an advice system based on seniority/structure, preferring the informal system of knowledge exchange where everybody should be given the chance to participate in both receiving and giving advice

> I, for example, wrote the case up, you know, put a lot of work into it etc. etc. and Aaron was here and I trained Aaron and he was hanging around and I gave him the report and I said "read that for me and make it better". Now I think that's good for him and it's good for me and it then gives the message that I'm open to criticism, I'm open to making...do you know what I'm saying and I think that's important and I will do that because if you're always giving the knowledge and not accepting it...knowledge becomes like orders, you then establish a real authoritarian system and then you're not getting the exchange.

<u>**Tacit knowledge gained – as result of advice given**</u>

The presence of tacit knowledge gained can be implied by finding instances of learning which when described can be cited as tacit knowledge gained in the process of receiving advice. From the interviews such instances have been found.

Jason, picked up an instance of tacit learning that he put in the back of his head through some advice he had previously received:

> I mean if I open a bag and there's something in it, I might remember somebody mentioning something about these particular tablets. I might go back and ask them something about it.

Aaron captures exactly the concept of picking up tacit learning from some previous advice received:

> There's a case I had with airbags and I heard her mention that she had done a case with airbags so I came back and she was very happy to help, so I think you pick up things in the back of your mind that you store away basically and then when a relevant case or something comes up if you can't remember who it was exactly that had mentioned to you that they had done that and it kind of worked before then you go back to them.

Nathan tells us it is not written down but saved to the memory banks in his head. Time and time again this is the procedure he uses to store the valuable tacit learning he has acquired:

> In the job doing it, picking up bits and pieces along the way and remembering them. A lot of it you don't record...you don't write down...it's in your head. You come across stuff that's not covered by the SOP, you sort it out and then you log that in your memory so that when you come across that particular scenario again, you remember what to do, you don't have to go asking advice. And the longer you're doing it, the more of these things you're going to gather

Harry a section head, laconically says how he gains knowledge of the certain tacit types:

> Comes from practice in dealing with cases, failures, successes and learn from them. Connects up

Melissa speaks of getting tips from her colleagues in the advices she receives:

> but if you actually see people doing it, they have little tips on how to make the whole process a little bit easier and trying not to get the sellotape sticking back on one another – little things like that. So a lot of it was watching and a lot of them have little extra tips that wouldn't be written in any protocol.

<u>**Why forensic scientists seek advice from their colleagues**</u>

Wanda, one of the less experienced scientists who had only begun to report cases at the time or her interview, states why she needed to seek advice during the carrying out of processed case work:

> I suppose if I wasn't sure of maybe what my next step should be, so I'd look to a more experienced person who may have dealt with what I'm dealing with, and see what they would do in a similar situation.

Similarly a recent recruit to FSL, Laura, says that she seeks advice constantly where:

> The seeking of advice would be with regard to different sample types and there are issues that other people would have experience with. They would have handled them on several different times or there may be odd samples

Aaron a recent recruit like Wanda or Laura, would seek advice for the unusual or different incidences:

> If I came across an unusual kind of case...I wouldn't really bear the SOPs that much in mind, just if I came across an unusual...or something I hadn't seen before I'd ask, but if the person training was available, close to hand I'd just ask them what shall I do with that case or else I'd go to somebody else.

Aaron being reticent in anything different he comes across wants to be sure about the processes he carries out:

> What would trigger it would be there's something I've come across that I haven't come across before, I didn't know exactly how to...I wasn't sure, I didn't want to make an error particularly working on other people's cases, I didn't want to....so really if I came across a problem I'd never interfere with or move the sample, I'd just go back and ask the person and basically ask them a question and get them to talk me through it.

Jason, only recently promoted to the middle line-managent grade II [see i Formal organisational structure] would still seek advice 'on an almost hourly basis' because it:.

> Would be that something unusual has cropped up and you're not too sure how to process it; or, more commonly, would be that something's cropped up and there could be two or three ways of doing it – and if you've decided that you want to do it a certain way, you might want to ask someone

Jake feels that it is:

> extra knowledge in that what you gain from them then you would use that later on again if you encountered the same situation.

Simply put Xavier describes what he wants from advice when he makes a decision to go to seek it:

> If there was a particular interpretation or result that I needed a second opinion on.

Chloe an accomplished junior forensic scientist who has given lectures to other forensic organisations seeks advice:

> Sometimes it's for reassurance, sometimes it's because I haven't seen something before.

Aoife a well honed practicing forensic scientitst describes what is in the advice communication as the:

> little nuance in cases that you might have a doubt over.

Shane takes a managerial view on the giving of advice in weighing up the resourses that are spent in the efforts of giving advice:

> Well, I'd hope they're gaining from it. I mean, I don't have a problem if somebody asks me about something I'll certainly try and give them advice based on my own experience, if I have any in the area

According to Xavier the best method of giving of advice is if:

> it's given on a one to one basis.

Isabella, an equally experienced scientist to Robert adds details to the best situation where one can successfully get advice:

> It's face to face, because it's the sort of stuff you really need to see...the exhibits usually...to sit down and look at the exhibits or it's a report that somebody's writing and they'll want to know how to phrase it.

Francis steadfast in her approach to her casework, is sensible in the way she would approach her casework always seeking advice if she was in any doubt, and not second guessing anything she was unsure off – always better to seek somebody else's counsel rather than making an error in one's judgement:

> Well because every case is different, obviously things will crop up that you haven't come across before so my rule of thumb is if in doubt seek advice and because we're quite a small group and we work in quite a small building at the moment that it's quite easy to pop down the corridor and ask somebody for advice and everybody has been very helpful in that, there's never been an occasion that I can think of that somebody has told me to go away, usually people are very amenable to helping and are interested in your case and what you're doing and very helpful, so I think if I have a question about anything, because of the type of work we do, you don't go "shall I do it this way and see what happens", if in doubt I would always ask somebody's advice and how to proceed because people's experience in different areas, they might think of something you haven't thought of down the line, so I would seek advice from colleagues both senior and junior.

However Francis warns that there are efforts that need to be made in order to seek advice – that it is not a passive pathway:

> It's up to you that when it crops up that you come across something to ask somebody and then there's never a problem with getting help or advice.

Brianna echoes the need for forensic scientists to be proactive in seeking the knowledge required to help them to completion of their tasks:

> That means that they have to go and seek out the information actively, rather than hoping it is going to come to them passively.

Alice too differentiates between the advice needed over and above the more mundane operations at FSL.

> I nearly always sound out somebody else. Except the most routine things obviously

Brianna surmises how the forensic scientist chooses the individual that they seek to gain knowledge from – a step-wise selection selection process:

> If it were something, I suppose, I think an operating scientist develops their own framework within which they work and they can then make decisions, they make their day to day decisions kind of using that framework, so if it's something that's outside that framework, something you haven't come across before, or something that somebody else has, you know would have more knowledge on or who's opinion you'd respect and you are unsure, that would prompt me to go to them.

And when Brianna sought advice herself, she tells how she came to form the opinion that they were expert in the area:

> Watching them in action at the workshop.

Robert because of his deep maturity and analytical prowess captures exactly why he would seek advice without being hung up on whether he should be seen to seek help from others:

> If I was confronted by something that I hadn't done before, say, a particular tissue type or whatever and I knew that she had had one a few years ago, I'd certainly go and...before I set up, I say, look here, how did you do this, how did it work, would you do it in the same way again if you had to do it again now.

Kieran, a very astute and practical forensic scientist who has won competitively a head of section management position because of the keen understandings he can quickly get from developing situations, succinctly tells one why forensic scientists seek advice and what can be expected in the contents of that advice:

> [advice is] two things, there's some formal things where one needs someone to sign off, the SOPs dictate that we must have someone to sign off so that's either advice or corroboration. The other areas where you've more likely than not made up your mind, and you just need a second person to verify that or that you feel you've come to something maybe for the first time and you know someone because no matter how long you're here different cases can pose new problems

Alice an executive manager would seek advice with regard to the management decisions she makes daily because:

> I am not great at relying just on myself. I have realised the more opinions you have the better chance the richer is the decision in the end

<u>Knowledge Exchange</u>

Wanda speaks of the operationalisations of knowledge exchange:

> I think the knowledge is there and I think if you ask for it, there's no hassle getting it but I think, again, just because of the nature of the organisation – its so busy –people don't have time to, I suppose, formally deliver knowledge and I think that piles up over years and years and I think I matter of asking for the knowledge and you get it.

Jason reflects the open knowledge exchange culture at FSL:

> I've never experienced anyone sort of hiding something from me or keeping something quiet or not giving me the full answer.

As does Nathan, however he is aware of others holding back:

> I'd say in general in our section that [knowledge] is given freely. I can't think of any empire building or they wouldn't tell you. If you ask them a question, they will give you the answer. Maybe there are...I'm sure there are other individuals that have a lot of knowledge but decide to keep it to themselves unless they're particularly asked for it.

Francis is another scientist who feels that there is a relatively relaxed knowledge exchange culture, but feels also that one has to be proactive in getting it:

> I think it's given freely when you seek it. I think maybe there could be a better exchange of knowledge, it's kind of I think the way we work. It's up to you that when it crops up that you come across something to ask somebody and then there's never a problem with getting help or advice.

Jake speaks of the boundaried islands of knowledge:

> Its primarily within the section.

Ella too speaks of the boundaries of where the knowledge exchange meets:

> It's mainly within the section because it's usually biology issues.

Danielle is a working example of knowledge exchange within her community:

> If there was blood or DNA or something in the case, then I would go to some other section to ask them but, generally, it was just from within the section that I got my knowledge.

If Dylan has a need to ask others in other communities practicing different specialities to himself, he does not find any resistance on actively seeking advice:

> Mainly within my own section, although I've found people within the other sections just as easy to approach in relation to questions and helpful as in my own section.

Troy has noticed over the years that the culture of sharing knowledge has become more open:

> But others very much hang on to it because knowledge is power and you make yourself so indispensable and you make people kind of have to come to you to find out things as opposed to being much more open with it. But I think the situation is changing. I think it has improved quite a bit over years gone by where everything was kind of very secretive.

She speaks of the danger as the organisation gets bigger that knowledge will not flow as well:

> I have a slight fear, more than a slight fear I suppose to see as the place gets bigger, and not just the section gets bigger, but if the lab gets bigger, knowledge transfer becomes really really difficult...
>
> Monique does feel that the giving of knowledge is done as democratically as possible:
> I would feel it is free knowledge, I don't think, and I can only talk of my current situation now, I don't think there's a situation where somebody is forwarding knowledge because knowledge is you know strength and power and all the rest of it, but I know there are instances where that hasn't always been the case, where people have been unwilling to share knowledge because they feel it gives them an advantage.

Isabella reckons that knowledge is spread through personal networks:

> It's people to people contact. Now, there's a little bit of emailing with, say, [outside groups].

Holly in her conversation with the researcher was wondering could there be a measure in order to be part of the annual review of performance management. There are difficulties because of the informal knowledge exchange system:

> It's a very difficult thing to monitor and benchmark and measure, you know knowledge will always be passed down verbally and you either pick it up in your little brain or a computer and

sometimes you can write it down and sometimes not. I would say that would be a hard one to measure.

Francis feels that the giving of knowledge is done purely for altruistic reasons and for the betterment of the organisation:

> People just generally want to help you out and just do the best for everybody that's there so it's congeniality if you want to put it under that or just for the well-being of the organisation. If somebody's doing a case and if you can help them in any way, isn't that a good thing as opposed to somebody maybe inadvertently doing something incorrectly or not the best possible way, so I would imagine it's for those reasons.

Brianna feels the culture of sharing knowledge is apparent in all of the different internal communities:

> Yes, I would think that we are good at sharing knowledge here, there is a lot of discussion. In the drug sections where there's possibly less need for discussion they still, their section meetings do cover a lot of information sharing as well.

Alice is approving of the generosity of individuals:

> I think people are generous in their knowledge exchange.

Chloe reflects that the knowledge exchange is very non-structured:

> In the lab, in the main lab, that's where the discussions go. I think that's probably, that could be improved upon because I know other people could definitely get the information if that were shared amongst everybody as opposed to those people who were talking. But at the same time you can't call a meeting every day there's something interesting to talk about.

Interestingly, Alice really shows up the boundaries of the internal communities faced against intra-organisational forensic scientists who would prefer to go outside to their inter-organisational forensic science counterparts in other countries, for certain advices:

> And incidentally it is not confined, that lack of transfer is not confined to any ..., it can also be other things so you can also have appraisal situations where one section has information and knowledge about how to do something and another section or another group of people who more easily go outside of the laboratory to get that information than they will to go to their colleagues in another section.

<u>Knowledge Databases</u>

Nathan, a gatekeeper enters summary pointers of what he has learned onto the knowledge database:

> I'd definitely bring it back...well, now that we have the database, it would go there straightaway in the report. Some of the good points, I might suggest them.

However, Nathan does not think that the database is the best way to actually simulate the knowledge back into the lab (especially if he does not read the entries himself):

> Possibly not. To be honest I haven't read anybody's report when they've been back.

Jake seems to prefer the personable face to face option of gaining knowledge:

> I suppose nowadays its databases as well – the Court reports that you can have a look at. I tend to go up to the person and ask them.

And gives reasons why he does not think highly of such databases:

> I don't think it fully reflects what's happened – you know, how complete the reports are – and sometimes you'll get other information out from talking to someone about the case – what was it like, how did it go – than you might get from just reading the report on its own.

With the onset of knowledge databases Danielle feels that she is now more in tune with the developments taking place at FSL:

> I think up until we got the databases and things like that, you were only finding out about experiences in Court and scenes and that and even people going to ENFSI groups, when they were sitting on a social level at lunch time and coffee time, so if you weren't actually with that grouping of people you weren't finding out anything.

Eventhough there may be only proceedings or summary points, Danielle feels that at least she is now in the picture as opposed to the times two years previously when she only got the minimum of details:

> The only information that I would be aware of them bringing back would be you'd get the proceedings so it would be up to you to go and read it and, as I say, until the databases started up there a couple of years ago, you used to get trickles of information...you know, something

> might be decided and you'd ask why was that decided then you'd find out it was because something had been said in ENFSI, but you didn't necessarily get a full briefing of anything major that would implement on the organisation.

Adam as would be normal of a manager's role recognises that the purpose of the database is to open a store of knowledge available for the full complement of staff to peruse:

> I suppose in the [wider quality] there's some attempt to capture that on the establishment of the databases in terms of Court...experience and the... defence scientists'. That knowledge is available to a wider selection of people...it might be just by chance that I got a copy of a particular group whereas everybody has access to the internet and can look it up and go back and ask the person who wrote the report if there isn't enough detail there...what were the circumstances and what was the outcome?

However for Troy having the different kinds of knowledge available on the intranet is an advantage, acting as an introduction to pursuing the scientist personally:

> But now within the lab there's much more free access to other people's statements and reports and from that point of view it's certainly opening things up. In terms of knowledge, technical knowledge and scientific expertise, I suppose the availability of things on the intranet again has probably helped, not alone the accreditation documents and so on but also the presentation and things, which might of themselves not be illuminating, the old PowerPoint things for meetings and so on but at least the fact that somebody has put it there, you might feel freer to go and look and perhaps approach that person and say I see there's a presentation meeting about such and such, can you fill me in about it or even give me the details of the person presenting so that I can go and contact them. So it has opened the door in that way.

Alice as an executive manager has a clear idea as to what the knowledge databases should provide:

> they attempt to try and get people to identify their learning from different experiences and have that available to all, that's the purpose behind that.

However, she states that 'the knowledge databases...haven't hit it right at all.

<u>Expert</u>

Jason within his discipline believes if you have the role of a duty scientist – one that can answer queries from the police and is experienced enough in the scope of analytical tests – is sufficient:

> Well I find for somebody to be fully trained in the Drug section area is when they can be duty scientists. To me that's the mark and for that you need a skills set of what you can analyse but you also need certain attributes, personal attributes as to how to deal with guards, how to explain to someone – this is an 'A' case – you're only going to do one part of it today...you're going to get a result but it might not necessarily be the result they want.

Aaron thinks that knowing how to interpret and make case findings is the sign of an expert:

> Knowing the protocols would be one thing but to actually interpret the result, I would think is the most important thing. You would assume everybody would know the protocols.

Nathan mentions that although one might be fully competent, it is the case experience that makes the way to become fully expert:

> Well, somebody who's passed all the competency tests...well, they've received the training first as prescribed and have passed all the competency tests that would give them the authority to write up a report but I think you'd still want a bit of experience... you'd still have to go back and ask after that to build up your experience. You can't really learn the experience but you can learn the techniques and the processes up to a point then you're signed off but its from then from there on experience of training starts. I'd say the SOP training would bring you up to basic survival level as a forensic scientist but to become a good one or to get to the top of your field, you would have to incorporate the experience. There's no way, based on learning every SOP in the lab, you'd be seen as an expert in the field.

Jake feels there is always more than being competent for one to be seen as an expert:

> Like you can become fully competent in all the SOPs in the lab and how to do the analysis and how to report it but I think there is an ongoing need to read up materials relating to what you are doing and I don't know if you can ever say you're fully – you know – competent. There's always going to be something that you can learn or that you don't know, or maybe you don't realise you didn't know but then later on you find – oh God, I didn't realise. You know, something might come up as a question somebody asks you and you think – Oh I don't really know that. So, from the point of view of functioning in the lab and doing the analysis and

> reporting – okay, that's one issue, but then just a knowledge base that's complete understanding...I think sometimes you will always find that there is something else that you can learn.

Harry, a senior manager puts the expert to the task of his/her effectiveness in the organisation:

> In practical terms there is a difference; there are levels of effectiveness.

Aoife takes a fulsome holistic view of what is expected when one is labelled as a fully trained expert:

> Somebody who can practically do the work they're asked to do, who can follow procedures, who can check cases. But the fundamental thing in a way, is to have confidence and to understand their full responsibilities and to accept those responsibilities, to be able to stand by what they say with no equivocation. Also I think to understand their own role in the justice system is quite important, which comes with experience.

Shane a senior grade scientist also lists a wholesome view such as knowledge, judgement and experience that makes-up the fully trained expert:

> Well, I'd say you're looking at technical competencies in a number of areas. You need to have a theoretical knowledge of your area because you can't really be an expert in it unless you have a good background knowledge of the area, and I think you also need – I don't know how to describe it – maybe judgement or experience because a lot of the situation that we or I always deal with are sort of unprecedented in the sense that we, personally, or maybe even the section hasn't seen something exactly like that before. So you have to use judgement to decide what to do about it or how to report it or what kind of phraseology to use or whatever...what tests to carry out.

Danielle covers both bases, stating that one needs to be both competent in the procedures and able to interpret the results:

> I suppose if you're shown to be competent in both the bench side and the interpretation of your findings that would be what I would class as a fully trained forensic scientist.

Reflecting on how long it takes to get to the stage of being a fully trained expert, Danielle feels it is relative to one's own comfort zone:

> I think you know yourself when you're sort of happier doing the work. You get to a point where you sort of realise that...its like you get to a point when you suddenly realise that you're doing it almost automatically without having to think about it and then the person who's training you is obviously deciding when they feel you're at that stage and then they give you the competency test.

Troy too views that being fully trained is a combination of competency and assessment skills:

> I'd say somebody who either has already got the required technical scientific skills in terms of examining various types of material or has acquired them in the course of training in a particular laboratory and who is sufficiently competent in their knowledge and skills to examine cases for a variety of kinds and competent enough to assess the results in order to write accurate and helpful reports for the recipients.

Adam in his usual wisdomed thinking-guise feels that there is never a stage of being fully trained:

> You could argue that they're never fully trained – you're always learning.

Robert too, touches on the premise that one is never fully trained and looks at confidence as a measure:

> Well, I don't know how you can even define fully trained because techniques are always changing and new ones coming on-stream. I suppose there's an element of being fully confident in what you're doing that comes with experience and so on, but I don't know that I would define myself as fully trained in that in other labs they would use different ... techniques...that are slightly different.

Francis also feels being an expert is a continuous learning process:

> Well once you've passed your competency test in certain areas you're deemed a competent, fully trained forensic scientist and because of the type of work we do with the Court system that's the way we officially have to work but I think you obviously need experience in working in cases as well so when you start off, although you're deemed fully competent, you would...things would crop up where you'd have to seek advice of others so I suppose officially you're a fully trained forensic scientist but I think you're always learning and gaining experience and talking to others as you go along.

Dylan reflects in the same way speaking of the experiential learning process:

> I don't think you'll ever be a fully trained forensic scientist so just like any scientist I think you'll always be learning and that's the ethos in any science, be it forensic or other science.

Sophie considers the need to be fully competent and also be positioned to be able to carry out other organisational type duties:

> For the time we spend on non-lab work your development continues for quite a while after that. Because you start off trying to manage your case work first and once you've done that then you can find time for other things and that continues your development as a forensic scientist. It's not just about the lab work and the court work, there's other areas as well.

Melissa puts a timeline picture on what is a fully trained forensic scientist as well as contemplating the confidence factor:

> I think it actually takes a number of years, five or six years, before you're fully competent and I honestly believe that's because...I think...well, I'm speaking for myself and I think it took me that long to be confident and I think when your confident enough to make decisions on what work has to be done and what work you won't do and you are able to stick by your decisions as to why you didn't do something and stand over it. I think when you get to that stage and you're able to defend why you didn't do something, I think then you're well on your way to being a fully fledged forensic scientist and I think another area is when you're confident enough to ask somebody if you're not sure rather than going alone – that's another way you can measure that you've arrived.

Isabella puts it down to experience:

> I feel that experience has a lot to do with it, so it's not just being signed off to be able to do the techniques. I think there's more involved than that. I think you do need a couple of year's experience. Because the job is not just a scientist's job. There's an awful lot of very subjective stuff involved and there's a lot of decision making, I think, involved.

According to Isabella, the basal level of competencies required for all forensic scientists is not enough:

> I mean they could do all the tests, they could take out the [protocol] and they could follow all the tests but its in the selection process and deciding what to test and how much to test and how to write it up afterwards and how to present it in Court.

Holly too touches on the additional skills needed over and above competencies:

> Somebody obviously has the ability to comply with the protocols laid down and then obviously somebody has the ability to approach in the logic manner that they've been trained to do, because at the end of the day it is logic, you're putting yourself into the frame mind work of the victim or the suspect and how you might approach it.

Chloe looks at the big picture when outlining what an expert should be able to do:

> I think there's a lot more. I think understanding is probably the big thing. Checking procedures are basic and can be learnt very quickly, it doesn't make you competent. So it's the understanding and the interpretation of what you are doing. Yes, assessment, or judgement, all those things I think make a proper fully trained person.

Brianna looks at the expert needing a multi-faceted approach to their casework:

> For the forensic aspect they need to get into the thinking of a forensic scientist and the thinking of the investigator and aware of what the courts need as well, so there's very different demands other than the science.

Alice as an executive manager has thought of what is expected for a forensic scientist to be deemed a fully trained expert, either in the analytical/quantitative or eclectic trace evidence/qualitative areas:

> Somebody who has a good knowledge of analytical tests available, and who has the judgement to know when and how to use those tests. So maybe tests are a bit distracting, but we could put examination options as well as tests. I consider that it is quite different for scientist who are involved in complete analytical schemes and scientists who are involved in trace evidence schemes, so for the analytical it would be to know the limits and detection and the suitability of the instruments that they are using. Know what might prevent positive or negative results. For the trace evidence, it's a knowledge of the types of material, how they transfer, circumstances of which they expect to find them. Sufficient knowledge to enable a scientist to have expected results in their minds before they start an examination. And the judgement to know when to follow up if all expected results are not achieved.

Sophie in her mindset has an understanding of what a fully trained forensic scientist is – outlining the change in her thinking from novice to that of having more experience:

> Well you think in a different mindset because you are following on how people have taught you and you continue to ask them questions but it is, you don't think like them at the beginning, and it's not that you start to tow the party line or anything like that, although there is an element of that. But you just start to think differently and start to analyse things differently, within the context of forensic science and that within science you push things whereas in forensic science you can't do that. You can't be, you can't be enthusiastic about your results, you always have to be conservative.

Ella uses decision tree analysis in weighing up her expectations versus the results – revealing the way she approaches her case work as an expert:

> You take your file, you say well what's my expectations for finding semen in this case, what's my expectations for finding blood, and then, depending on what you find, that leads you down another kind of tree and so that's how I think.

<u>Experience – View held by Individuals</u>

Wanda defined experience as:

> I think it's having knowledge of a broad range of different cases because the nature of the work is that not everything...no one case is the same as the next.

Jason in looking at the duty scientist role would consider somebody experienced when they juggle:

> You know, someone could be a duty scientist but you wouldn't necessarily consider them experienced at first, but someone else has done it for a certain amount of time that you wouldn't have any qualms about work coming through the door as you know they can simply handle it so they've sort of demonstrated that they can handle the unexpected. One of the differences would be...an indication would be that...we always get something unexpected and there's always a question of how to deal with it. Somebody who is inexperienced would say – what do I do. Somebody who's experienced would say – this is it, I think I'm going to do it this way – does that seem reasonable to you? And that would be an indication of someone's experience that they've already thought it out, what they want to do and they may be just looking to bounce it off someone.

Aaron sees that a scientist should have processed a portfolio of case types to be classed as having the nomenclature as an experienced scientist:

> Well you can't just measure the time somebody has worked on it, so it has to be the range of kind of cases they've worked on.

Shane too, speaks of a case portfolio over time:

> I suppose experience means having seen a variety of case work over a period of time.

Nathan a senior grade scientist speaks of the tacit knowledge gleaned from the years of being a practitioner:

> It's got to be length of time in the job doing it, picking up bits and pieces along the way and remembering them. A lot of it you don't record...you don't write down...it's in your head.

Harry speaks of the tacit learning that the experience forensic scientist has gained:

> Comes from practice in dealing with cases, failures, successes and learn from them. Connects up.

Danielle believes that an experienced scientist has worked over a number of years:

> Just the knowledge, the amount of knowledge that they've gained over whatever number of years. I think the more experience you have, the more knowledge, the more years you've been working in an area.

Adam has conceptualised an experienced scientist as needing a perspective wide in scope:

> I think somebody with a specialised knowledge and, I would expect, knowledge in limited areas where they're competent to examine and test materials recovered and report and interpret the outcome. But I think they would probably need a bit broader knowledge than that. That confines it to a box. So I would say you need a broad knowledge of what the other areas within the laboratory are doing, so that if you do get a case in, your perspective is a bit wider than the little bit you are expert in yourself. I think I kind of ability to be able to reflect on the knowledge you've gained and adapt that to new circumstances or changed circumstances.

Troy takes a different tack, arguing that an experienced forensic scientist should know his/her limits of interpretation:

> I would say probably confidence in your own knowledge and ability, and knowledge of limits of how far you can go in terms of not overstepping the mark or overstepping your area which is what some people who maybe are less experienced are slightly more inclined to do.

In addition Troy suggested that the experienced individual should have latitude in their approach of their casework:

> I think you need to be able to do some lateral thinking and be inventive and I suppose just have an investigative kind of a mind or twist, when you want to figure out how something works or what something is or what has happened in a different situation. Rather than just analysing things or doing what's asked of you. I mean quite often a case comes into us and the request is very straightforward – maybe do such and such – is there evidence of contact between A and B or what have you – but you know when you're looking at it that maybe that isn't really what they need to know or that maybe more information could be gleaned from this stuff which they've submitted and its up to you then to sort of identify and pursue that because its going to add something to what they've already asked.

In being asked could a forensic scientist work without that experience, Melissa replies

> No. I don't think so. I think he'd be a technician then or an analyst.

Kieran feels that to be experienced that time needs to be served along with a curiosity factor that would complement the scientist's scope of understanding of all the different types of cases at FSL:

> Experience comes with time, it comes with serving your time, but also being open to wanting to know more, being curious, the nosey, almost being awkward to say "I want to know how this works, I want to know how that works" even to the point of something isn't within your own remit and to stuff that might go on in another section, say that it's appropriate that you know that, there might be gaps there, but people will gain more experience by gaining knowledge of what happens in other sections because that happens in other places that it might be appropriate to take on board.

Isabella speaks of a personal tacit knowledge repository having been built up by the scientist who has become experienced:

> You're sort of relying on similar cases that you may have worked on and the results that you got from them because the feedback is really, really important. The results that you got in the past are what trains you for the future, because you're going back and saying – yes, that worked that time – or – this is the stain that gave me the right results the last time, so I'll stick to that – or – I never get a result from that kind of thing so I won't do that one.

Francis reckons it is a combinative set of actions that makes one experienced:

> I think it's a combination of all of those things, it's definitely doing casework and different scenarios and things cropping up and you know what to do in those cases, so it's basically working through cases, but it's also using a bit of common sense and logic and following through the procedures so it's kind of a combination of things.

Ella thinks that experience is gained through practice:

> I think experience is just by doing. I don't think...you can read journals and you can read papers but I don't think they...because every...well, the thing about a forensic scientist's caseload is the cases themselves. They all have some unique identifier in them. So just a little quirk or a twist on the circumstances and that's what makes you stop and think, and that's what not...you know...what you've experienced before. So it is experience on each case that you do and you've come across before or you've gone to a meeting and you've heard in this instance people have done this and, so there's a certain amount of knowledge that you gain by references and literature and by conferences and by networking with other forensic scientists but the majority of it is actually in doing, I would say.

Chloe speaks of the tacit reserves of knowledge that an experienced scientist has accrued.

> I think it is how you do your, how you approach your work and how you carry out your personal interactions based on your previous interactions or based on your previous work, so if you've learnt anything from doing it once, that gives you some sort of experience for the next time.

Melissa puts experience as that which one has ingested over time – the tacit elements floating within your head:

I suppose experience is being able to use all the techniques that you've learnt and all the information you've gathered and read in papers and being able to apply it to a particular case, because no two cases are the same. And I think experience then is being able to draw from all the information that's floating around in your head and being able to draw the parts that you need to help you to assess a case and to examine it critically and effectively.

SOPs – a baseline of standard practice: an inherent shortfall of tacit Knowledge

In touching on the advantages of the quality system, Adam speaks of it as a platform to make improvements in the organisation's procedures and practice:

> There are other aspects, I think, that are picked up through practice. Again, the SOP's aren't meant to be dead and once and for all documents. I mean practice does change, improvements do come about by people suggesting things or by people spotting somebody doing something that isn't in the SOP. The whole point of discussion is felt to be a good idea, so there is this ongoing learning.

He mentions the shortcomings of such a system, where fit for purpose or streamlining of steps considerations that may need to be contemplated do not take place:

> The disadvantage to SOPs is that maybe we do things right and we may not be doing the right things. They may to some extent repress the top process of saying, are we doing the right things? To question efficiencies, to question need for certain tests or what we do, and the other system doesn't capture that, the other system captures "are we doing what we say we're doing?" and should we be doing this at all.

Aoife reflects on the tacit gap between working straight from SOPs and the work an experienced forensic scientist carries out:

> You probably can work without that experience but you're not going to be performing to the same level. You're not going to be dedicated to such a level. You're going to be in some way disassociated from what you're doing. You're going to have a very inorganic mechanistic machine-like operation, which can be good for some things but destroys ultimately the heart and goodwill, knowledge, the whole thing.

In addition Aoife adds to her opinions of the quality system, fearful of the autonomous thinking and responsible role of the junior level forensic scientist grade being dumbed down to an operant level analyst:

> It suits the current management in that things are done properly and they're done efficiently but the person who's doing them, who hasn't been fully exposed to Court etc., there are gains in efficiency and there are equal standards applied to everybody but you lose out ultimately because you get people who aren't fully taking responsibility for what they're doing and what they're signing because they're following an SOP rather than engaging any or on a higher level or any other level with what they're doing. But I think that their role is becoming more and more and more limited and from what I've seen, the new Grade 3's who are scientists are now the new technicians. So there's a limiting, a continued limiting of the role.

Shane identifies the tacit gap as judgement, experience and assessment:

> No, I don't think so because I don't think the SOP's can capture the judgement and experience and assessment aspect. The SOPs really only cover the technical competence and, to some extent, interpretation. I mean it is very difficult to, I don't know, describe or convey how you interpret something in an SOP. You can give guidelines and so on, but you can't be too rigid in how you do it. But the SOP's on their own are not going to do the job, because as we've said already, SOPs can't answer some difficult questions for you about, you know, which items will I analyse, which ones do I not need to analyse, how do I interpret these results and so on.

For Danielle the tacit gap is the skill set involved in interpretation:

> It would reflect the practical side of it, like the bench-work, fully but it doesn't reflect the interpretation which I think is a large portion of forensic scientist work. I mean anyone can be trained and shown how to do bench-work but the interpretation is the main difference between us and analysts if you like. So I don't think the documentation covers that side of it. Its something you have to gain.

> She adds:
>
> There'd still be areas because none of the cases are the exact same all of the time – there is always something small...different and although the SOP's will give you that guidelines of what to follow, there will always be some point where you'll think – oh, this doesn't fit exactly into what this says here, what do I have to do.

Robert shows that tacit gap by painting a picture of a working example:

> I think the SOPs define certain situations but there's always something coming down or coming in through the door that is slightly different. No, I mean we have standard procedures for dealing with blood stains, for example, but there is no SOP that would rigidly define how you would deal with a piece of human skin caught in the undercarriage of a car for example. There might be a choice of methods for something like that.

Isabella on being an auditor who judges whether a set of procedures reflect the way process is actually carried out reaffirms that SOPs are just baseline in the knowledge required to proceed:

> Yes. Well...I mean I work as an auditor as well so I go into other sections and look at Standard Operating Procedures and I know that I couldn't follow them in other sections. Now I probably could do it here because I have the background knowledge but I know that I could not follow a Drugs Standard Operating Procedure.

Francis identifies the gap and outlines the tacit steps that an experienced scientist takes:

> I think it reflects the majority of what we do but there will always be things that crop up that won't be covered in the procedures or you'll have to use your own judgement, you know, your common sense, logic to decide what we to approach a case, you can't cover every eventuality in the SOP's. So sometimes you'll have to use common sense, or you'll have to use judgement to seek advice.

Francis feels the SOPs are written in a vague way to allow for the tacit process steps to be carried out:

> Well I think because of the nature of the work we do and every case is different, that there's SOP's have been written in such a way that it's not too defined or too tightly outlined exactly what you have to do, that there'll always be cases where you have to use your judgement, so I think they're written to cover that and I don't think there's been any major problem with them being, you know, too defined that they have been left open deliberately like that so you can use your judgement in different cases.

Ella identifies that the gap is due to the quality standard [ISO 17025] that FSL is accredited for, because it is limited to standards and competencies:

> Well they don't cover the writing...the report writing or the interpretation really. They cover...they're very much based on 'can do' but that's because of the standard that we're geared to, which is the Laboratory Measurement Standards 17025. It's all about standards, about measurements and stuff. So when we're putting down our competency, we're being measured against that standard.

Dylan practically identifies the tacit gap:

> Well, SOP's cover 70% possibly of your case work but the other 30% requires initiative, lateral thinking, as some people say it, thinking outside the box.

Chloe too observes the tacit gap:

> I think again it goes back to judgement, that you can't, it's very hard to capture that in a document. The documents will tell you how to do it, it might not tell you the whys or when to do it. The SOP's tell you how to look at something but they won't tell you necessarily what you are looking at, you might see a different pattern or a different type of damage that you haven't come across before.

Wanda a recent recruit recognises the virtues in knowing more than basal level of competencies inherent in the documented SOP's:

> No, there's a lot more to it than knowing the SOP's. The SOP's are important to get the basis, to get a set of results. Then you need to know the theory and you need to be familiar with studies so that you can interpret what you find and actually apply it to the case that you are working on.

And is appreciative of the vast scope of procedures that would need to be recorded if every eventuality were to be captured:

> I think there's too much to actually fit into...I think the SOP's are fine for laying out procedures and for a fairly general view of how to go about something or how to use an instrument or something like that, but I think just the nature of the work is so diverse that its not possible to capture it and write it all down – you'll be writing forever.

When something atypical is submitted into FSL, Jake details that an SOP can be used as a basal set of guidelines:

There may be some other drugs that come in that perhaps aren't covered by SOP's – unusual kind of things that I've seen come into the lab that wouldn't be covered by SOP's. Referring to that drug specifically – no – but as a way of working towards it you might use a SOP as a model to approach it, but certainly there would be things that have come into the lab occasionally that I may not have seen before, you know. Someone has to do the analysis on it. We'd use the SOPs as a guide.

Melissa identifies the tacit gap as judgement and experience:

Oh I think there is a lot more, because the SOP – that's like doing cookery and following the recipe and you can still get a very flat cake, even though you've done everything, but I think as well as the SOPs you have to have judgement, you have to have experience, you have to have...and the SOPs don't have all those extra things that you need to work effectively. I suppose its because a lot of our work as forensic scientists...I mean, we're the experts and a lot of it is very subjective and it is based on your opinions. You know, whether something is damaged or whatever. You'd have a lot of guidelines to guide you to the answer but its only, I would feel, in a lot of cases, where its your experience plus the SOP plus even maybe one or two other person's opinion that would help you judge whether something is damaged or wear and tear – something like that. So I think I combination of all those things.

Georgina with all her years of experience judges SOP's as the baseline:

The SOPs again are the procedures which give you the skill base which bring you up to that number two or three [out of five] I was talking about, that's all it does and then to get the person who's going to have the insight to think out of the box, to find a piece of evidence that is going to exonerate or convict, you won't find them in an SOP and in fact I would even say, SOPs are very important because we have to be accredited but that's more for Court's sake. I think there's a balance between putting too much weight, if you put too much weight on these, you actually discourage the out of the box thinker but if you think too much out of the box and you're always wanting to change things then you run the risk of not being able to stay with the SOPs, do you know what I mean, it's a balance, so you need the both.

Harry a senior manager and head of section speaks of the less experienced forensic scientists who have been indoctrinated in the culture of functioning through SOP routines:

They are doing things by the book. But who would not go beyond that. They are likely to draw the line at the minimum, not exert themselves to solve a problem themselves.

Isabella reflects on those scientists who would work through SOP's alone without the resource of experience:

I think they could do a passable job but I'm not sure they would be doing justice to the case.

<u>Disadvantage as result of SOP conditioning</u>

Monique is confident if there is a problem with the lack of initiative of the new entrants who may use the SOPs as a crutch that the quality audit system will pick up what is wanting:

so I would say that the newer people would probably follow them [SOPs] more closely, but in, it is a bit early to tell, a few more audits I'd say on new people might be what's needed.

Adam is worried that they may have become so focussed in carrying out the procedures and completing them that maybe down the road as time go on, they may still be ignoring the less obvious factors is a case that may be instrumental to interpretation. He took thinks that this simplistic reasoning will be picked up by others:

I'd say that there is a danger and that it should probably be reflected by the mentoring or monitoring of the process.

Julia is of the opinion that individuals may rely on the SOP's to heavily not allowing them to be open to tangential conditions that may arise in casework:

Danger on relying on SOP and not use their heads when something anomalous comes up. People over rely on them.

Alice does not want the FSL to fall into the trap of the straight process vision, in which some of the other European forensic laboratories have developed into:

A surgeon doesn't start from first principles against going to carry out an operation, and that SOP's per say are not a bad thing, but we can't afford to fall into the trap that it's the only way. I mean if the SOP is all that was needed, well then we could take the lowest common denominator and just set people to work, that's not my vision.

LPP – a qualitative insight

For Aaron, Julia, Isabella, Holly and Chloe, during their learning, they all experienced the mentoring process.

Jason gives a clear picture of the process of his learning gradually gathering the competencies and practical skills to carry out his casework:

> Your exposure to the cases would be staged as you went along. You'd start off with simpler cases and then, as you added another sort of test to your list you could do, you'd start getting cases of that. And then, as you start to have two or three different types of drugs you could analyse, well then you might get a case that involved two or three of them. So there was a slow, ramp-up of complexities of cases.

For Aaron as he moved from the peripherality of his community began to receive more complex work as he became more competent of what he had learned:

> The cases given to me were very… started out pretty simple and the pressure put on me was specifically to encourage me to take my time on them and not rush and do them right.

> His experiences of learning were positive, feeling he was in a nurtured learning environment:
> To be honest I did feel as if I was being a nuisance sometimes, constantly plaguing my trainer but I never felt that back, to be honest I thought they were very very patient.

Jake's learning regime was through practice with an added set of theories to be evaluated:

> From hands-on practice in the lab and with the people who were training you – you know – giving you some background to what you were doing, so that you'd also have the theory behind what you were doing. But it would generally be hands-on – you know – with the background given to you as you were working through it.

Danielle is another example of where a forensic scientist along with reading up the background of the techniques and theories learned through practice:

> Well it was working with other scientists in the section and they would have gone through the practical side of it and they directed me to various papers and books and things to do background reading on, so it was both practice and...like bench-work...and reading.

Robert had the combinative learning regime of learning through practice and assimilation of theoretical principles both at FSL and another forensic laboratory in a different jurisdiction where he had worked previously:

> It would be a combination. I spent a lot of time watching the quite experienced people and learning the techniques from them. In my previous job there was an enormous reading list – reference papers going back over a fair number of years

In addition Jake spoke of learning his skill sets by working on less complex cases in the beginning:

> The way I did the training... what they did with me, I was started off on kind of easier casework, just to get you used to – I suppose – working with cases and how you took notes and how you reported cases and then moved on to more complex cases later. That's how it worked. I was generally doing fairly easy cases in the beginning and then once you became competent of doing those, they kind of gave me more complex material to work on.

Danielle too, recants how she was brought from the periphery of reporting relatively simple case types to those of a more complex nature as she gradually became more central in the pool of capable caseworkers:

> I was told at the time that I would be getting the less complex ones to gain my experience and to get more familiar with the reporting and then, as time went on, you'd get the more complex cases.

Sophie, Kieran, Holly, and Francis are all forensic scientists who as newcomers learned their skills for casework through practice, as well as perusing the background literature for completeness.

For Aoife her learning occurred in a non-formal way:

> There was some introduction to the various drugs and abuse, both from the legal side and how we would practically analysis them so it wasn't structured...the learning wasn't structured. You kind of went to an individual to, say, talk about cannabis and then you were given cannabis cases and you did them.

Shane as a senior scientist now, spoke of his early days where he learned through observation of others and did not have the benefit of standard operating procedures:

> No, there were no SOPs. It was mainly by watching what other people did and by doing whatever they did and, I mean, I was trained to do certain things certain ways and I did it that way.

Adam because of the length of time he has been at FSL did not have the benefit of SOP's during his training, where he learned through practice, partly over in the UK at another forensic science laboratory:

> Through practice alone almost. There were no protocols to be followed. A group of us did, at one stage, ask for some formal training or an idea of what happened in other forensic science laboratories. And it was arranged that some of us would go and spend some time in the Met Lab.

Adam had found that it was beneficial to actually see people operate as he was able to see practice in context as opposed to just to be able to carry out analytical procedures removed from a forensic environment:

> Previous to that we kind of operated in a vacuum. I come from an analytical and chemistry background so I could do analysis.

In her days training, Melissa was fortunate to be within the sheltered learning environment affording her the luxury of working on less complex cases. However, now she feels that the newer trainees may not be able to benefit from such a comfortable situated learning domain:

> I'd say initially that I was sheltered a little bit and, you know, I was given cases that, for example, wouldn't be coming to Court for ages... your know... I didn't get to go to Court until I was about three years here, which was fantastic. So I was sheltered in that respect but now I don't think you can shelter people as much because now with DNA...I mean the simplest case, *you might think*, with one cigarette butt can end up with having two or three people on it or a mixture and its suddenly a very *complicated case. So I don't think* now, because the techniques we use are more sensitive, that you can shelter people as *much and, as well as that,* cases are coming to Court really, really quickly. I was sheltered I do think but I don't think you can do that anymore.

Isabella speaks highly of the system of trainee scientists receiving less complex cases:

> Because it gives you a time to sort of become assimilated into the place and also it means that you're not going to end up in Court within the first six months, because if you don't get any cases for a year, there's a good chance you won't get to Court for two years. So you're well established by then.

In learning how to carry out case analyses, Isabella explains the comfort zone provided for trainees when they can work on mock-ups:

> I think that's very important that they get trained in doing sexual assault and that they get trained in doing a blood case and that means they read the background literature, they watch somebody else doing it and then they do it for themselves, and they do mock cases first so that they're free to make mistakes.

Troy, Sophie, and speak of the process of moving from working on less complex cases to those of a more complex type.

<u>View of previous experience held by organisation</u>

Aoife has personal reflections on those in the organisation who do not have regard or are not bothered about the novice's previous experiences:

> I was talking to the person who was mentoring me, a very senior person, about, ... a lot of work ... in my previous job...and you come with all your previous job, that's what's in your head...and I just mentioned to this person and they looked at me and they said – you know more about that than I do and they ran away. So when you're here for a week, you're saying, well...what do they say, its like...its very odd...its like that there is a block of knowledge that you need to know when you work here and you almost need to know nothing else. That I find very poor.

Aoife suggests why do these supposedly senior people all of a sudden not want to know about one's past experiences:

> Because they're afraid. I think it's a matter of control. I think they're concerned that they are seen as experts – which they are – but that doesn't mean...like, for me, scientific knowledge doesn't belong to the person who owns it. Scientific knowledge belongs to mankind and the

kind of retaining of knowledge for your own...I suppose your own self-interest, I find objectionable.

Danielle believes that "they weren't open" to hearing about her previous experiences.

Sophie feels that the presentation of the not interested culture is a conditioning tool:

I feel they tend to quash them to a certain extent because they want you to think as a forensic scientist, and their thinking becomes very inward looking.

Her displeasure of the dismissal of one's experience is apparent:

I think they should stop saying when you come in, "you are no use to use because you know nothing and you have to learn our way". I think that's totally wrong way to treat people. I think you need to explore the experiences that people have had before and not be threatened by them if they have more experience in certain areas than you do. Because I do feel people feel threatened by experience.

She reflects why some of the oldtimers are so dismissive:

Because they've been here for so long...people have been in their jobs too long to change, they don't know what's going on really outside this place.

Dylan does not think the dismissive attitude of previous experience is appropriate:

Yeah I didn't...when you came in here first you got the idea of the first impression for the first six months was you knew nothing and therefore you learn everything from us and then the whole idea we will rebuild you. I actually think that's a very negative thing to say to a new person and in actual fact they have life experience, they have scientific qualifications, they obviously sat through the interview and were recognised as being people to be able to develop into good forensic scientists and then when you come in it's a case of you know nothing and everything you say isn't worth anything, and in actual fact it can be very negative and unless you're a very strong character and over time people tend to look at you and say "well, actually this person's quite a good idea" but I think it's a very negative. I think all opinions should be taken and especially with a new person, you wanna make them feel confident they are a valued member of the laboratory and that any opinion they have will be discussed and acknowledged and it....

Melissa too expresses her dismay:

Well it wasn't plain sailing because a lot of it...I mean before you come into the lab you are trained to think independently and, you know, you do your PhD or whatever and this is...you're independent, you come up with your own ideas and straightaway you're into this culture of where it has to be done a certain way by the protocols accredited – well they weren't accredited – but it had to be done in a certain way and I found that extremely difficult. You felt like you were back in day one in school and people telling you what to do and now, with hindsight, I know there was a reason why.

But on reflection she opines why the oldtimers act in such a way:

The reason is that things are done in a certain way because it's been proved in Court that they are the best...its the best way to write something or you don't do it this way because this is a better way of doing it and there are reasons why it is a better way of doing it. So its just from other people's experiences and the fact that they've been to Court and things like that. They knew how to do things differently and even though I might have come up with different ideas how you could do things, they'd probably already tried them out and found that there was a reason why it couldn't be done like that.

Isabella a senior scientist experienced the disinterest herself and still sees it today:

Yes. It was – forget everything you've ever learned – was the attitude. And I even see it now when new people come in and they feel that they have a lot to offer the place or maybe we should try doing this a different way, they're slapped down straightaway and told – this is the way we do it...you know...we're not really open to doing things...

Francis, relatively new to the organisation does not see the dismissal of prior experience as a problem. She reflects that the work is very different from her own previous work and as a result it is like starting all over again:

But the new people who started in the last while I wouldn't even know what they did beforehand, I don't think it's a huge issue, I mean you're in here starting from scratch. Deep down was "things here are done a certain way so just do it the way we do it", but then again if

I thought something needed to be changed I'd not let that stop me from saying...speaking up on something so I didn't see that as being a huge issue.

Ella also is in the frame of mind that this type of initially supposed dismissive culture is correct:

> No, I don't think there's anything wrong with that, because essentially, yes, you can pull on your experiences and you will pull on your experiences to do your job, but doing the casework and report writing is very specific to this job so you do need to say, right, we're learning, we're starting from scratch again now and you may well have trained in a certain area or certain status in your last job – I bit like going from primary school to secondary school. You're the top of that school and then all of a sudden you go into a new school and you're the bottom of that school – so that's the way I tend to think about it. So, yeah, you're coming in and we know you have all this experience but now you have to act at a different level in a different way. So I think that's a good system because it's telling people you have to think in a certain way and that we do have to think in a certain way – so I way of training people to think like that.

<u>Learning & Training</u>

During certain instances of his daily practice, Robert learns tacit tips that may assist him in the future:

> I mean a lot of it is certainly routine and assembly-line, like, so you know a bloodstain is a bloodstain for example for the most part. But when something more unusual comes down, I mean you tend to remember the unusual and so if you get something similar three years from now, it's likely that you would remember.

Nathan even at his senior grade still is very much open to new ways of carrying out process:

> If ever anybody comes up with a better way of doing what I'm doing, I've no problems or hang-ups about dropping what I'm doing and doing it another way.

Jake is always open to attaining new knowledge:

> There's always going to be something that you can learn or that you don't know, or maybe you don't realise you didn't know but then later on you find – oh God, I didn't realise. You know, something might come up as a question somebody asks you and you think – Oh I don't really know that. So, from the point of view of functioning in the lab and doing the analysis and reporting – okay, that's one issue, but then just a knowledge base that's complete understanding...I think sometimes you will always find that there is something else that you can learn.

Chloe had a lot of personal contact with individuals when learning:

> Mostly mentor/mentee when I was definitely starting. And it was only as time went on that I started to talk to others. I think by experience, by actually doing it and learning from it, being told is one thing but I think you actually have to go through it.

Brianna feels that learning can only happen in an open knowledge-giving environment:

> Well I think mentoring which people have in the early days, the, an environment where people feel it's easy to ask questions and feel they can approach people with the knowledge and that, people with the knowledge are open and will share that, and an environment where it is an incentive, not necessarily incentive but the people are willing to share their knowledge in general whether it be section meetings or filling in the knowledge databases. So if there isn't a willingness to share in the first place you have got a problem.

Laura speaks of conferences as an area where she can get invaluable learning:

> Conferences – I haven't been on any but from my previous experience of conferences I think they're invaluable in making connections with other people and in learning new things and opening up new avenues.

Isabella in her training learned by face to face contact and careful observation:

> There was time given to me. That was part of their job to train me but also you sat in a lot and watched them doing their own cases. You'd see what sort of selections they'd make and how they'd interpret things.

Georgina is adamant that one's mentor is so important in the first steps of training a forensic scientist:

> I think your mentor would be the greatest influence depending on your mentor and how good your mentor is.

During her training by watching individuals carrying out their case work, Melissa learned some tacit nuances of process not documented in the protocols:

> Well, something a simple as searching clothes – that was watching people how they did it, how they took them out of the bag, how they wrote the form. I mean a lot of the protocols don't tell you exactly how you do things correctly, so a lot of it was watching people – how they did it – and yes, picking up things like how to sellotape lift on clothes. Somebody will tell you how to do it and its in the notes
>
> Also Melissa in keeping her ear to the ground gained new knowledge:
>
> And also from listening to other people and what they say when they come back from conferences. And the other way you learn, I find, is from listening to what people were asked in Court and wondering would you be able to come up with the same ideas and defences and things like that.

Dylan learned as a forensic scientist newcomer through practice:

> Mainly practice in my opinion.

<u>Learning through practice</u>

Forensic scientists mention on how they learn, mirroring what has been reflected in the literature. According to Nonaka & Konno (1998), learning by doing, training and exercises allow the individual to access the knowledge realm of both the group and entire organisation.

Laura was able to gain knowledge of certain procedures within FSL by watching her colleagues carry out their analyses:

> Because you're witnessing – you know – somebody's doing an extraction or a reaction and you're witnessing it and, as I say, early on I would have...every time, I would have said – look, can I hang around and watch the rest of it – not just what needed to be witnessed for information gain. And again, then with the computer analysis end of it, that's all second analysed and certainly the more of the second analysis that you do, the more you see of the rarely used or the rare scenarios with the mixtures and the complex things, and again at that point...because you're bring up – you know – nonconformities with some of their work and then you have to discuss it, but that's indexed into our system because everybody has to agree on what they're calling at the end of the day. So it allows a lot of one on one time with other people and a lot of questioning to take place. So it is a very good kind of practice within the system.

Aaron speaks of gaining knowledge during the two stages of the career forensic scientist: learning from the contents of other scientist's files when a novice; and picking up tacit tips when perusing case files during peer review when a fully trained expert:

> I looked at other cases similar to the ones I was doing to see the wording those were the biggest issues I had and still have, how to word something concisely and follow the protocols for wording and I think when people start....when your experience, when you're involved in the case checking so you can see exactly what everybody else is writing and what they're doing, but when you're sat with a trainer you're kind of isolated from that so you actually have to go and seek out cases or, say the people who were training me gave me, a copy here is an example of a case and got me to read through them.

Shane gained knowledge through observing practice:

> Watching what people did and more or less doing the same as they did.
>
> He is of the opinion that:
>
> I doubt if it's possible to learn forensic science from theory. I think, in my experience, theory tends to follow practice or support it rather than precede it.

Danielle feels that it is better to experience the gaining of knowledge through practice, observing those carrying out their procedures:

> I think it's better if you're watching somebody do something and they're giving you the experience to do it because its like reading the SOI's that we have now. You can sit and read them but unless you're actually doing it sometimes it doesn't actually make full sense and you don't remember as much as if you were actually physically doing it. So it certainly was more on the practical side of things, my initial training.

Isabella, already comfortable with her technical background, learned how to become a forensic scientist by observing others:

I think it was from watching other people because I already had all the sort of scientific background and all the technique, so really the forensic science aspect was just from watching over people do the work and taking on a case and doing it from start to finish.

Georgina gained her wealth of forensic knowledge by watching others as they went about their practice:

Actually it was through practice, being trained by another forensic scientist, there obviously was theory as well, because you had to read the literature but actually doing it hands-on.

Ella maintains that in the main you learn by doing:

So there's a certain amount of knowledge that you gain by references and literature and by conferences and by networking with other forensic scientists but the majority of it is actually in doing, I would say.

Qualifications for the Job

There is a distinction between academic intelligence and practical intelligence (Sternberg 2001). There is a school of thought that success of an individual in an organisation can be predicted by one's practical intelligence, in which tacit knowledge has a major part, as opposed to the academic form of intelligence (Sternberg 2000). Here is exposed how practitioners think what qualifies them, where they themselves had channelled all their energies into academic qualifications which ultimately allowed each to enter FSL through national competitions based on their academic records.

When asked about the qualifications that she felt qualified her for the role of a forensic scientist Wanda spoke of her academic and previous employment experience:

I've a degree in Biochemistry so I would have that...chemistry with some biology background...so I'd be familiar with a lot of the theory for the different processes. As well as that then, my previous experience...I've worked in analytical labs and diagnostic labs as well, where I've come across different processes.

Jason too speaks of the same:

I would say the academic qualifications and experience.

Aaron concentrates more on his practical experience at FSL that now qualifies him for the forensic scientist position he holds:

Well I suppose it would be a certain element but very little of the academic qualification side of it because you learn a lot of stuff early on and work in the laboratory so it's really down to your personal attributes.

Jake sides with the practical hands-on experience that qualifies him for his position of forensic scientist:

I think that the lab training and the experience that I've had over the years. The paper qualifications themselves, okay, reflect what you should perhaps know or the level of competency that you may have reached. But I think the experience of hands-on working in the lab really.

Francis a junior grade scientist along with Jason, Aaron and Jake, lists her academic background as that which qualifies her:

I suppose it's my scientific background so you've got a general science background, we are forensic scientists so there is a science aspect to it.

Aoife a middle grade forensic scientist focuses her thoughts on court when asked about her qualifications:

Being able to speak in Court, being able to convince a jury, being able to answer questions, being able to be responsible. I mean, in Court it's very much a role that you're playing and to know what your role is and to play it well. There's a confidence element to it, and I think that if you have your degree or your Masters or your PhD or whatever, that keeps adding layers of confidence and that is actually of benefit to you ultimately in Court.

Brianna with her long years of service attributes in part her knowledge of the court system as one of her qualifiers:

The familiarity with the legal system, the relevant parts of the legal system and the familiarity with the operation.

Danielle albeit a middle grade forensic scientist only attributes her academic background to qualify her:

I would have my paper qualifications.

Robert takes the middle road as he sits in his middle grade position:

> Well it would be a combination. As I said, most of my academic background had to do with DNA in one way or another so obviously that's a help when I'm still working with DNA. No, apart from that, its just back to the experience.

Sophie bases her qualifications as practical:

> Well obviously my technical experience, experience of presenting scientific results. And again the experience of managing yourself. You gain that as you go along as a scientist, you gain that.

Melissa sees her actual practical years of experience as being her chief qualification for her job:

> Well, actually, when I'm sitting in Court and I'm sitting in the box, the key thing that I like to get in is that I'm eleven years working as a forensic scientist because they always ask you what are your qualifications and I spelt them out but I think it kind of goes over people's head but if you say to the jury that I'm eleven years working, they think – God, she must be there forever and she must know so much and have seen so much – so I think years experience is the most important thing.

Isabella too is concerned with experience:

> Well, everybody when they go to Court has to list their previous education so I always refer back to it in Court as a matter of course. Now I don't think that that's the most important thing. I think the important thing is the experience in the forensic science lab, which is something I always list – how long I've been here – as well. I think that's most important.

Dylan puts his qualification down as being a good communicator:

> You've got a good foundation in science and you have the wherewithal to be able to think of alternative situations…you need to be a good communicator.

Shane a senior grade forensic scientist sees the academic qualifications as a basic requirement with experience being required:

> Well I think that obviously they're a foundation. I mean you have to have a degree level to be...a degree to be recognised as an expert any how and to be credible as a scientist; degree plus experience.

Adam as a very senior scientist within the organisation shows his maturity when he reflects on the qualifications he needs for his post:

> I think...an element of curiosity about life, I think, is a good attribute. The ability to gather knowledge...go out and find out about things in a structured way...I think that's an extension of the curiosity...and then a logical frame of mind – you know, if these are the circumstances, this is what I should expect to find...what's the most likely material transferred in here...I look for that first and when I find that...I don't need to go on to the end...I mean there's other things. They are the qualities I think help me do the work. The other side I suppose are the formal qualifications…expert in Court, which is educational and experience.

Troy too cites curiosity that qualifies him for his senior grade forensic scientist position:

> I would say its probably curiosity in terms of...you know...I've always liked to figure out how things work or why something has happened – that kind of thing and I think in a sense that's what I'm doing here – presented with a problem or a puzzle which you're trying to solve given certain bits which may help and certain bits which may not and you're trying to kind of reconstruct what's actually happened and sometimes that will suit one side in a case and sometimes it will suit the other and sometimes it won't suit anyone or you might not be able to make any gist of it at all, but I think its just kind of inquisitiveness about how things have happened or what has happened and how things work more than anything.

Monique as a manager seeks the formal credentials as the suitable qualifier for the role:

> I think there has to be a formal qualification because I think there has to be a demonstration of some kind of knowledge, acquisition and processing, and some level of organisation, particularly you know if you have written up projects or written up pieces, seeing things through to completion. But you know how to use resources, information, resources, all that kind of stuff.

Harry a senior manager discusses his path of experiences that qualify him for his role as a forensic scientist within management:

> Academic long ceased to be of any consequence. Its what I have been doing here that matters. Experience in court now redundant.

## *Appendix: Deviations from SOPs*

| Text | Code | Preview |
|---|---|---|
| DNA\FSLBTP016-R3 | Divergence from SOP | For some samples extracted in large volumes it may be necessary to concentrate the epithel |
| DNA\FSLBTS004-R2 | Divergence from SOP\pulling from case experience | Fst value of 3% may be more appropriate for some small isolated populations (e.g. Travellers |
| DNA\FSLBTS004-R2 | Divergence from SOP\pulling from case experience | These are clearly not the only possible explanations, in certain circumstances it may be more |
| DNA\FSLBTS016-R2 | Divergence from SOP\pulling from case experience | In practical terms the decisions taken...when dealing with low-level DNA samples are govern case |
| DNA\FSLBTS016-R2 | Divergence from SOP\pulling from case experience | The analyst following a qualitative assessment of the profile and duplication of the peaks may |
| Drugs Cannabis\FSLDTP001-R5 | Divergence from SOP\pulling from case experience | Establish whether a substance which looks like cannabis resin is present...Use an episcope i |
| Drugs Cannabis\FSLDTP001-R5 | Divergence from SOP\pulling from case experience | Where large pieces of plant material are present a visual examination may indicate it to be ca |
| Drugs Non Cannabis\FSLDTS101-R5 | Divergence from SOP\pulling from case experience | However in certain cases, circumstances may dictate that you will have to analyse more thar |
| Drugs Non Cannabis\FSLDTP101-R4 | Divergence from SOP\pulling from case experience | Establish whether a substance which merits analysis is present...information associated with |
| Chem Fibres\FSLCTP152-R1 | Divergence from SOP\pulling from case experience | In these instances the scientist forms the opinion that an exhaustive search and recovery is r |
| Chem Fibres\FSLCTS151-R1 | Divergence from SOP\pulling from case experience | In selecting most suitable donor items, consideration should be given given to the sheddabilit |
| Chem Fibres\FSLCTP150-R3 | Divergence from SOP\pulling from case experience | Particular attention should be paid to areas of damage which may affect the sheddability |
| Chem Fibres\FSLCTP154-R1 | Divergence from SOP\pulling from case experience | In general a minimum number of five control fibres are measured. More may be needed depe |
| Chem Fibres\FSLCTS152-R1 | Divergence from SOP\pulling from case experience | denim fibres are generally not suitable as a target fibre...in certain circumstances...of value tc fibres |
| Chem Accel\FSLCTP102-R4 | Divergence from SOP\pulling from case experience | There may be exceptions when it may not be appropriate to heat a sample |
| Chem Accel\FSLCTP102-R4 | Divergence from SOP\pulling from case experience | A scientist may decide to analyse a number of samples from the same case simultaneously |
| Chem Footwear\FSLCTP050-R1 | Divergence from SOP\pulling from case experience | A number of possible conclusions are open to the examiner ranging from a unique identificati |
| Chem Footwear\FSLCTP052-R2 | Divergence from SOP\pulling from case experience | In interpreting the results of a footwear comparison, there are three broad conclusions possib |
| Chem Glass\FSLCTP008-R4 | Divergence from SOP\pulling from case experience | The number of fragments to be examined depends on the number recovered, the case circur |
| Chem Glass\FSLCTP008-R4 | Divergence from SOP\pulling from case experience | at least six recovered glass fragments per suspect should be examined...In some instances t |

| | | |
|---|---|---|
| Biol Damage\FSLBTP201-R3 | Divergence from SOP\pulling from case experience | To carry out interpretation, reconstruction experiments may be required |
| Biol Damage\FSLBTP201-R3 | Divergence from SOP\pulling from case experience | Significant damage...made with force...case circumstances are taken into account when dete |
| Biol Damage\FSLBTP202-R1 | Divergence from SOP\pulling from case experience | On rare occasions, it may be required to determine if a particular weapon caused the damag |
| Biol Damage\FSLBTP201-R3 | Divergence from SOP\pulling from case experience | Where the type of damage cannot be characterised, a full interpretation may not be possible. |
| Biol Blood\FSLBTP157-R3 | Divergence from SOP\pulling from case experience | Due consideration is given to the type of fabric or material the bloodstain pattern is on |
| Quality Manual\FSLQM004-R6 | Divergence from SOP\pulling from case experience | The information is used in assigning a priority to cases...elucidating what contribution the lab |
| Quality Manual\FSLQM024-R8 | Divergence from SOP\pulling from case experience | where a scientist considers...the interpretation of the results of casework...should be include |
| Biol Damage\FSLBTP201-R3 | Divergence from SOP\Advice seeking | If the assessment indicates that the damage is significant...another scientist is required to ex |
| Chem Accel\FSLCTP102-R4 | Divergence from SOP\Advice seeking | If item is melted...and scientist is in doubt [about] fingerprint examination, a member of the Fi consulted |
| Chem Accel\FSLCTP102-R4 | Divergence from SOP\Advice seeking | if fingerprint examination has not been specifically requested...consult...to ascertain if fingerp |
| Admin\FSLGS031-R4 | Divergence from SOP\Advice seeking | Laboratory staff...will seek additional information in relation to cases submitted to establish th |
| Admin\FSLGS043-R1 | Divergence from SOP\Advice seeking | If you feel it is warranted, call another scientist of a different discipline to the scene |
| Chem Fibres\FSLCTS151-R1 | Divergence from SOP\Advice seeking | When items in a case are to be examined for other types of evidence consultation with other |
| Quality Manual\FSLQM021-R3 | Divergence from SOP\Advice seeking | On occasions at scenes of crime laboratory personnel may offer advice to investigating office |
| Chem Footwear\FSLCTP057-R1 | Divergence from SOP\Advice seeking | For impressions...known to have been made in blood...the Biology scientist...should be cons |
| Admin\FSLGS005-R4 | Divergence from SOP\Advice seeking | A second competent scientist reviews each report and associated file [and] makes suggestio |
| Admin\FSLGS029-R9 | Divergence from SOP\Advice seeking | If...apparent that the items need...to be stored outside the normal manner the receptionist ca |
| Admin\FSLGS043-R1 | Divergence from SOP\assessment | Look at the body for stains...deposited by the assailant. Consider whether these need to be r |
| Biol SAS\FSLBTS100-R1 | Divergence from SOP\assessment | [if] reason to believe that...complainant...unable to communicate or remember...a swab from |
| Biol SAS\FSLBTS101-R1 | Divergence from SOP\assessment | further screening of the clothing is unnecessary, unless there is reason to believe that semin |
| Biol SAS\FSLBTS101-R1 | Divergence from SOP\assessment | If the panties are AP positive, further screening is unnecessary, unless there is reason to beli |
| Biol Blood\FSLBTP156-R1 | Divergence from SOP\assessment | information can assist in the selection of appropriate stain(s) [such as] How many people ble |
| Chem Fibres\FSLCTS151-R1 | Divergence from SOP\assessment | In selecting most suitable donor items, consideration should be given to the sheddability of re |
| Drugs Non Cannabis\FSLDTP101-R4 | Divergence from SOP\assessment | [in circumstances] such as a case where information indicates...Certain substances...may be |
| Drugs Non Cannabis\FSLDTP101-R4 | Divergence from SOP\assessment | If a conclusion that the sample contained a controlled drug is not reached following the analy required |

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| Admin\FSLGS043-R1 | Divergence from SOP\cognisant of other casework reqd | The Forensic Scientist advises on the most appropriate samples or items to be taken to adva |
| Biol Damage\FSLBTP202-R1 | Divergence from SOP\cognisant of other casework reqd | Prior to damage examination, preserve any trace evidence such as fibres |
| Chem Footwear\FSLCTP064-R1 | Divergence from SOP\cognisant of other casework reqd | footwear may be submitted...a particular class of trace evidence may also be requested e.g. |
| Chem Glass\FSLCTP003-R3 | Divergence from SOP\cognisant of other casework reqd | to examine for glass fragments...as well as considering the order if other types of trace evide |
| Admin\FSLGS036-R1 | LPP | The potential trainees knowledge requirement as outlined...to be checked by means of an or |
| Admin\FSLGS036-R1 | LPP\peripheral participation process | The program for trainees is a mentoring process. |
| Admin\FSLGS036-R1 | LPP\peripheral participation process | Heads of section must make available to the trainee...less complex cases |
| Admin\FSLGS012-R2 | LPP\peripheral participation process | Training can extend over a long period of time as different areas of work within the laborator |
| Admin\FSLGS023-R4 | LPP\peripheral participation process | competency may be maintained by peer reviewing a number of cases (minimum 3) of the cor |
| Chem Accel\FSLCTP106-R2 | LPP\peripheral participation process | At an appropriate stage, the trainee may undertake the analysis and preparation of draft repc |
| Drugs Cannabis\FSLDTP009-R3 | LPP\peripheral participation process | During the training period, the work performed by new trainees will be monitored |
| Quality Manual\FSLQM016-R5 | LPP\peripheral participation process | train personnel to be competent to carry out procedures...to test this competence before...un |
| Admin\FSLGS021-R3 | LPP\full experience criteria | Scientists are authorised by head of section to take responsibility and report cases when...cri |
| Biol Blood\FSLBTP157-R3 | LPP\full experience criteria | Full interpretation may only be carried out by scientists who have completed their training |
| Chem Accel\FSLCTP106-R2 | LPP\full experience criteria | To be deemed competent...the trainee shall have completed a test where the expected outcc |
| Quality Manual\FSLQM001-R8 | LPP\full experience criteria | Scientists when trained and authorised as competent are responsible for carrying out the cas |