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Discourses of knowledge across global networks: What can be learnt about knowledge leadership from the ATLAS collaboration?

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ABSTRACT

Writing on knowledge management (KM) and leadership studies tends to take place in parallel; both fields are prolific yet they rarely inform each other. A KM view tends to take a positional view of leaders and a functionalist view of firms: so it regards those with the ascription or status of leaders as pivotal, and knowledge as a commodity to be leveraged with the help of leaders to improve firm performance. But as the global reach of organizations in the knowledge-based economy become more stretched, as their operations become more networked and as their workforces become more mobile, the task of deploying and deriving value from knowledge becomes ever more challenging and calls for a qualitatively different approach which is termed knowledge leadership. In contrast to the instrumentalist approach of KM we offer some alternative discourses of knowledge and explore the implications of these for knowledge leadership. We then use interpretive discourse to examine the way knowledge activists enact and experience the exchange of knowledge in the ATLAS collaboration, part of the largest scientific experiment in the world at the Large Hadron Collider, near Geneva. We find this apparently democratic and homogeneous global network to be populated by quite different perceptions concerning the way knowledge is viewed, the way knowledge leadership is exercised and the impact of this on the global collaboration. We discuss the wider significance of these findings for knowledge leadership in other international knowledge-based enterprises and R&D businesses.
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1. Introduction

Knowledge management (KM) is concerned with the processes or practices of creation, acquisition, capturing, sharing and usage of knowledge, wherever it resides, to enhance learning and performance in organizations (Scarbrough & Swan, 2001). The need for KM has resulted from a revolution in computing and communications technology (Venters, 2001) and KM systems have been identified as key to improving the efficiency of business processes (Vorakulpipat & Rezgui, 2008). Studies suggest that actions can be taken to help create the social capital necessary to effectively transfer knowledge (Gooderham, 2007; Teigland, 2000; Tsang, 2001), and there is a growing assertion that formal organizational design can facilitate innovation and knowledge exchange (Adenfelt & Lagerstrom, 2006; Foss & Michailova, 2009); this is despite evidence that mechanisms like intranet can paradoxically inhibit knowledge exchange (Newell, Scarborough, & Swan, 2001). We argue in this paper that knowledge leadership is more likely to be an emergent property of horizontal network interactions rather than a manifestation of traditional 'top-down' hierarchical mechanisms.

The role of leadership as a factor in successful knowledge management is receiving more attention. For example, quantitative studies have found consulting and delegating styles of leadership to be significantly related to effective KM in a software firm (Singh, 2008), leaders with an 'adaptor' cognitive style had a positive impact on KM within an Indian organization (Jain & Jeppeson, 2013) and leadership practices are found to be among organizational enablers of innovation in 111 Spanish firms (Donate & Guadamillas, 2011). In surveys of students, knowledge sharing was positively associated with an empowering leadership style (Xue, Bradley, Liang, 2011) and transformational leadership behaviours (Crawford, 2005). A literature based study by Birasnav, Rangnekar and Dalpati (2011) and an analysis of CEO interviews in Harvard Business Review (Lackshman, 2009) also point to the crucial role of leaders in leveraging human capital benefits and improving performance respectively. The difficulty with such studies is that they tend to take a positional view, assuming that leadership is typically invested in a single person (or group) and that the designated leader(s) should be the focus of study (as an independent or mediating variable).

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There is a subtle, but important, difference between the role of a leader in knowledge management (which is a legitimate field of study) and knowledge leadership. The latter focuses on relational – rather than positional – influence, generative learning processes and the climate that supports the exchange of knowledge, especially that which is more intuitive, tacit and emergent over time (Peet, 2012; Viitala, 2004). In the context of networked organizations, leadership has been conceptualized as a means of enabling emergent bottom-up organizational practice (Marion & Uhl Bein, 2001), as being co-determined by a range of actors (Gronn, 2002) and as a shared activity appropriate for tasks that are highly interdependent, complex and requiring high levels of creativity. As the literature on communities and networks of practice demonstrates (Balkundi & Kilduff, 2005; Orlikowski, 2002; Ormrod, Ferlie, Warren, & Norton, 2007; Swan & Scarborough, 2005), much of what is considered tacit knowledge remains embedded within the fluid social structures of networks and organizations. The leadership processes required to channel such mercurial knowledge are quite different from the articulation of leadership in more hierarchical settings.

Without rehearsing the arid management-leadership debate, we suggest that the distinctive characteristics of large, networked organizations call for a qualitatively different approach to KM, which may be termed 'knowledge leadership'. With the break-down of paternalist bureaucracy on the one hand and the inability of the market mechanism to optimize the production and distribution of knowledge on the other, a fresh approach is needed. Furthermore, global collaborative science experiments like ATLAS, may provide some clues as to what knowledge leadership looks like. Adler and Heckscher (2006: 37) go as far as to claim that: "without a rebuilding of community institutions, the potential of a knowledge economy cannot be realized". This paper seeks to deepen our understanding of knowledge leadership in international networked organizations and we return to this bold claim towards the end of the paper. In the first section we briefly examine *knowledge leadership* in the context of current literature; given the embedded nature of tacit knowledge flow, we move on to propose that discourse is a particularly apt analytic lens for exploring this process. In the Section 2 we describe the unique setting of the ATLAS collaboration and report the narrative of scientists as they describe their perceptions and experience of knowledge leadership. Finally in the last section, we examine the lessons learnt for the way knowledge leadership might be conducted in other networked, collaborative organizations.

2. Knowledge leadership

Knowledge leadership has been defined as "any attitude or action – joint or individual, observed or imputed – that prompts new and important knowledge to be created, elicited, shared and utilized in a way that ultimately brings a shift in thinking and collective outcomes" (Mabey, Kulich, & Lorenzi-Cioldi, 2012). The two words deserve a little more attention. First, we consider *leadership.* For organizations in the post-bureaucratic knowledge economy, leadership has been conceptualized as a means of enabling emerging bottom-up organizational practice (Uhl-Bien, Marion, & McKelvey, 2007) and as being co-determined by leaders *and* followers. An increase in team-based knowledge work has led to the devolving of leadership to a range of individuals with key skills for addressing particular issues at a given time: "Knowledge work increasingly takes place as a collaboration from different and changing workplaces due to mobility, multilocational and geographical distribution of participants", with a heavy reliance "on ICT infrastructure" (Bosch-Sijtsema et al., 2013: 275). Shared leadership thus becomes more appropriate for tasks that are highly interdependent, complex and requiring high levels of creativity (Stocker, Looise, Fisscher, & de Jong, 2001). Balkundi and Kilduff (2005) suggest that leadership is tied to social networks, which emphasize the building of trust, respect and friendship, enabling shared interpretations and systems of meaning (Nahapiet & Ghoshal, 1998). Furthermore, in networked organizations, the notion of leadership being invested in a single individual is untenable due to several factors: high degrees of uncertainty, goals are discovered rather than predetermined, any single individual lacks total knowledge and the absence of standard operating procedures implies that leadership cannot be exercised by authoritative fiat (Boisot, Nordberg, Yami, & Nicquevert, 2011). It is not unusual for the leadership baton to be frequently passed around, for there to be times when it is not clear where leadership is emanating from and, indeed, it may well be attributed after the event (Grint, 2005: 38).

Second, what is meant by *knowledge*? Far from being self-evident and easily classified, Alvesson (2011) argues that knowledge is actually a highly ambiguous, uncertain and controversial concept. This is especially the case for tacit knowledge (Styhre, 2004). The significance of 'new and important knowledge' cannot necessarily be predetermined as it emerges from the mutual interaction between agency and structure, the daily collision of the momentous and the mundane, the merging of micro-behaviour and macro-context. Schultze and Stabell (2004) helpfully explore some of this uncertainty by distinguishing four discourses of KM research, drawing upon the work of Deetz (1996).[1] In this section we adopt these discourses[2] in order to examine what they begin to tell us about knowledge *leadership* in organizations. The intention is not to privilege one discourse, or 'reading' above another, but rather to demonstrate that the notion of knowledge leadership is quite different from that of knowledge management. As Schultze and Stabell (2004:568) point out: "An awareness of other discourses and a dialogue across them surfaces the blind spots in the individual discourses and it is this that will generate advances in an area of research".

3. Knowledge leadership as enhancing performance (functionalist discourse)

In seeking to understand KM, a functionalist discourse has tended to prevail (see Baruch, Ghobadian, & Özbilgin, 2013). So the knowledge leadership task becomes one of identifying the nature of knowledge itself (the degree of tacitness, ambiguity and complexity), teasing out the motive for learning (exploratory or exploitative), determining the absorptive capacity of both donors and recipients, the nature of networks and the strength of ties.

[1] We prefer the use of discourse to that of paradigms. Probably the most influential attempt to delineate contrasting paradigms (and liberate researchers from the confines of functionalist assumptions) in the field of social theory and organizational analysis is that of Burrell and Morgan (1979). The four paradigms they proposed were very similar to the four discourses described in this paper: functionalism, interpretivism, radical humanism and radical structuralism. However their view was that these paradigms were mutually exclusive, and by accepting one set of meta-theoretical assumptions the researcher denies the alternative. We agree with Johnson and Duberley (2000: 80) who remark: "Because the meta-theoretical norms of one paradigm are not translatable into those of an alternative" that this "removes the opportunity for debate or for deciding upon which paradigm has the better problem-solving capacity", and with Willmott (1993) who argues that regarding the four paradigms as polarized sets of assumptions is probably not sustainable in practice.

[2] In their book *Doing Critical Management Research* (2000), Alvesson and Deetz contrast two bipolar dimensions of meta-theory: these are relation to dominant social discourse (consensus – dissensus) and origin of concepts and problems (local/emergent – elite/a priori). From these they derive four discourses for guiding research: normative, interpretive, dialogic and critical. Following Schultze and Stabell (2004), it is these four discourses (using the term functionalist rather than normative) we refer to in this paper. For a more detailed account of the derivation of these discourses see Mabey and Finch-Lees (2008) and their application to leadership development (Mabey, 2013).

Typically the emphasis is upon choosing appropriate governance systems (Easterby-Smith, Lyles, & Tsang, 2008; Ivory, Alderman, Thwaites, McLoughlin, & Vaughan, 2007; Un & Cuervo-Cazurra, 2004) in order to positively impact organizational performance, (Garcia-Morales, Llorens-Montes, & Verdu-Jover, 2008; Gonzalez-Padron, Chabowski, Hult, & Ketchen, 2010) or competitive advantage (Easterby-Smith & Prieto, 2008). Valuable though this and other work on KM is, there remain a number of difficulties when trying to identify how international enterprises exchange knowledge. First the tendency to objectify knowledge as something to be captured, categorized and classified; the premise being that knowledge can be separated from the knower. This leads researchers to ask questions about the conditions under which certain types of KM technology is more appropriate than another and the implications of each. Second is the assumption that, being an asset, knowledge is primarily, if not exclusively, prized to serve the competitive agenda of the organization concerned. This emphasis on corporate performance neglects important socio-political aspects of knowledge flow in organizations (see below). Third, the belief that such principles of effective KM, once discovered, can then be applied universally across all organizations. Yet, conventional management processes are confounded by most knowledge-based enterprises, which are by nature, highly diverse, comprise loose networks, and have diffused boundaries, lines of authority and responsibilities. By contrast a more subjectivist approach, which we consider next, sees knowledge as "inherently identified and linked to human experience and the social practice of knowing" (Vorakulpipat & Rezgui, 2008:18).

4. Knowledge leadership as facilitating know-how (interpretive discourse)

Interpretive discourse pre-supposes idealist ontological assumptions about the nature of reality, based on the human capacity to reflect on situations (Williams & May, 1996). Epistemologically, it is premised on knowledge not being observable as a neutral fact (Law, 2004), but drawn from socially constructed accounts of what actors say and do (Yanow, 1996, 2000); and, because people differ in their beliefs, this knowledge is contestable and open to multiple interpretations (Fischer & Forrester, 1993; Hajer, 1993). The focus is therefore less on what knowledge is and more on when knowledge arises according to different actors. This requires several things: surfacing the symbolic language, objects and acts used (Yanow, 1996); listening to the stories actors tell to build on their moral claims (Fischer & Forrester, 1993); noting how these stories come to be shared over time and incorporated into the institutional machinery (Hajer, 1993); and observing how this has the potential to frame the way that knowledge is understood and exchanged (Atkinson, 2000).

The transfer of knowledge between individuals is a shared experience in which participants make sense of certain events and construct meaning. The evolving web of social relations, therefore, rather than the intervention from appointed leaders or management systems, determines the knowledge contribution to the group. It would be unwise as well as futile for a single leader to attempt mandate the sharing of knowledge as it may be "personal, subjective, socially determined, primarily tacit and related to daily practice" (Van den Hooff & Huysen, 2009:1). Nevertheless leadership, perhaps exercised by a variety of actors, can be articulated by influencing and facilitating the flow of know-how. This can be done by providing a common interest and environment of mutual trust (Li, 2005), generating shared goals (Chow & Chan, 2008) and enabling access to those with relevant knowledge and the sharing of 'a common ability' that aids the understanding, interpretation and assessment of the knowledge (Newell & Swan, 2000). For some theorists, however, this conceptualization of knowledge is still too consensual.

5. Knowledge leadership as ongoing dialogue (dialogic discourse)

While sharing the interpretive emphasis on duality, dialogic approaches emphasize differences in understanding rather than consensus, and conceive of power as local, relational and embedded in technologies governed by discourse (Fairhurst, 2009). In his work on organizational discourse, Deetz (1996) was an early adopter of the term 'dialogic', pointing out that discourse can only exist in relation to prior discourse and in anticipation of future discourse (Fairclough, 1992). What this suggests is that leadership identity can be ascribed and regulated by others' in the context of past and future assessments of performance (Mabey, 2013). Here, any text or utterance is therefore inherently inter-textual (Kristeva, 1986) in that it forms part of a dialogue that establishes the conditions of, and the potential for, all meaning (Wehrle, 1982). So, knowledge might be seen as a multi-layered, fragmented and discursive accomplishment, one that is continually in a state of becoming as opposed to anything more fixed or stable. This deconstruction, not dissimilar to the less precise idea of post-modernist thinking, points to a very different understanding of the activities associated with knowledge leadership.

Such approaches point to a better understanding of the way that context shapes and constructs leadership identity. For example, Knorr-Cetina (1999) observed the way scientists at CERN procured knowledge differently depending on their investment in different systems, objects and technologies (Knorr-Cetina, 1999). Given the dialogic interest in how subjectivities (or identities) are constructed in and performed through texts (spoken and written) and other artefacts associated with 'big science', we might ask: what are the processes by which leadership becomes ascribed or known? And how are individuals and events made visible and measurable by their leadership? This is in keeping with Grint (2005) who rejects leadership as a concrete natural phenomenon; his constitutive theory of leadership argues instead for the socially constructed and contested nature of a multiplicity of *accounts* of both leader and context. So knowledge leadership needs to be seen as constructed within the confines of particular social institutions, unable to exist independently of a given context and as attributed (or ascribed) by others. At best, leaders are those who provide a persuasive account of knowledge in a given context, but ultimately they merely enact the behaviours and messages required by those able to confer leadership status. However, for all the emergent richness that this perspective provides, it might be argued that dialogic discourse underestimates some of the institutional and political realities which shape and constrain how these ascriptions might occur. This leads us to consider the critical discourse, which we move onto next.

6. Knowledge leadership as power-broking (critical discourse)

An in-depth discussion of the ontological and epistemological nature of critical discourse is beyond the scope of this paper (see Howarth & Torfing, 2005:6 for a fuller discussion about the nature of first generation (i.e., rational-scientific); second generation (i.e., structuralist); and third generation (i.e., post-structuralist) discourse). However, what such approaches agree on is the impossibility of any claim to the objective existence of ultimate and singular truths about the social world, stating that our means of accessing such truths will always be socially, historically and politically mediated (via, among other things, competing ideologies) (Carr, 2000). By taking an interest in the way that societal

structures shape and constrain discourse (Howarth, 2000: 3) it is possible to examine the dualisms in language in the sense that they tend to represent the world in terms of *analytically distinct divisions* like truth and falsity, oppressors and oppressed, agency and structure, individual and collective. Although idealist accounts of critical discourse do not necessarily deny processes of social construction (Rusaw, 2000; Brookfield, 2001) they tend to treat these as no more than *images constructed in the minds of individuals*. This, of course is in further contrast to the dialogic discourse which makes no distinction between *images of* reality and what it considers to be the inherently multiple *nature of* reality in itself. This gives rise to one of the main interests of structuralist approaches to critical discourse, to expose what it sees as the false consciousness of individuals whenever they acquiesce to social dynamics or ideologies that do not serve their own 'true' or 'real' interests (Garrick & Clegg, 2001; Rusaw, 2000).

By applying critical discourse to knowledge leadership in global networks, we can become more alert to at least two power-broking issues. The first concerns the largely unquestioned assumption that organizational knowledge equates to the top team's beliefs about the viability and validity of information and ideas (Gourlay, 2006). As Von Krogh, Nonaka and Rechsteiner (2012: 251) state: "Knowledge as 'justified true belief' means ideas and plans have been sanctioned by leaders because they fit with criteria such as budget constraints, timing of product innovation, technological challenges. By adopting a more critical stance we can see that this sanction is not only rooted in the beliefs of a privileged few, but it also contrasts with knowledge based on objective, scientific criteria". The second issue is the potentially disempowering presence of boundaries. These may be socio-cultural in nature, such as the boundary between different disciplines (physicists, technologists, engineers), geographical (face to face or virtual working), personal difference (like gender, age and national culture) or the disparate economic contribution of partners (Hong, Snell, & Easterby-Smithy, 2009; Makela, Andersson, & Seppala, 2012). A functionalist take on knowledge leadership would see such boundaries as issues to be minimized and managed, whereas structuralist accounts of critical discourse would seek to unmask the discrimination they create by exposing the dualisms that appear in the discourse of those being studied.

In summary, we can see that the quest to understand more fully the process of knowledge leadership in and across organizations can be usefully informed by different discourses, each of which is fuelled by contrasting assumptions about the nature of knowledge and how it is shared. Here we take up this challenge by drawing upon one of these discourses (interpretive) to examine the research question: *how is knowledge leadership enacted and experienced by ATLAS scientists?* In the next section we provide more detail about the research site and outline our methodology, before reporting our preliminary findings arising from ATLAS scientists based on their experiences of leading within a knowledge intensive environment. By addressing this question it is anticipated that we will learn lessons for the way global collaborations both within and outside the science community might develop their leadership of knowledge.

7. Research design and findings

7.1. Research site

We explored knowledge leadership via an in-depth case study of scientists involved in the ATLAS experiment, for three reasons. First, it is one of four particle physics experiments being conducted in the Large Hadron Collider (LHC) at CERN, and designed to investigate the nature of matter at higher levels of energy than has ever been attempted before. These experiments are generating technologies that will be seminal in their impact and are at the frontier of knowledge leadership. Second, with the cancellation of the U.S.'s supercollider project in 1993, intellectual leadership of the particle physics community migrated from the U.S. to Europe. This research will hopefully provide clues as to how the European scientific community can retain their knowledge leadership in this field. Third, the ATLAS collaboration involves a network of 3500 physicists located in 175 institutions in 38 countries. Given the distributed nature of the network and its global dispersal, it is proto-typical of many international, knowledge-based enterprises and provides an ideal research site for observing the emergence and impact of knowledge leadership.

In-depth interviews were conducted with a sample of particle physics scientists working in the ATLAS collaboration. They were chosen because they are actively engaged in the exchange of tacit knowledge and, secondly, they constitute a multi-level, international network comprising different nationalities working in one of two networks: either part of an ATLAS project team in CERN or participating in the Calorimeter Trigger project comprising a number of European Institutes. 17 semi-structured interviews were conducted with a wide cross-section of scientists in each of these two ATLAS networks (see Appendix for more detail). We recognize that this is a small number of respondents and that it is unlikely that we have reached saturation point, either of the data (Corbin & Strauss, 2008) or of the analytic categories used (Suddaby, 2006). However, the intention was more to explore the variety of ways in which knowledge leadership is enacted, experienced, interpreted and re-constructed by participants, rather than to seek a representative sample. Following the main research question: *how is knowledge leadership enacted and experienced by ATLAS scientists?* an initial first level coding of the data identified common themes, utilizing template analysis (King, 2004) within a 'contextual constructivist' discourse (Madill, Jordan, & Shirley, 2000). Four broad codes arose, namely: (i) how is knowledge described by our respondents, (ii) how is knowledge leadership exercised, (iii) what expectations do scientists experience and (iv) what does effective knowledge leadership look like? A second level analysis was then conducted on each transcript and this yielded a number of constituent sub-themes, indicated in bold in the Results section. Of the three non-functionalist discourses discussed above, we chose to adopt an interpretive reading of the transcripts; however in the Discussion section we reflect on what dialogic and critical readings of the data might tell us. Interpretive discourse is driven by an interest in the way that scientists construe knowledge, particularly tacit knowledge, and how they make sense of the events around them (Van den Hooff & Huysen, 2009). This discourse also highlights the importance of examining the *language* that scientists use, the knowledge *objects* they invest in and the *acts* that they perform to generate and exchange knowledge as part of their everyday experience (Yanow, 1996, 2000).

7.2. Research results

7.2.1. (i) How is knowledge described?

We find scientists referring to knowledge differently depending on their intrinsic motivations for participating in the ATLAS collaboration, but also in how they make use of tacit knowledge depending on their need to either explore or exploit this knowledge. For some, especially the more senior scientists, their motivation is to develop an **open form of tacit knowledge** based on contributing to the greater good of science:

> "No …this is really open science and it's so much more powerful. The world is full of challenges, of problems which are way too complex to be solved in a corner by people who want to make money" (Senior Physicist, CERN)

Surprisingly perhaps, they nevertheless see themselves as making a collective investment in the "*day to day, nitty gritty tasks*" of running the Large Hadron Collider (LHC), through calibration, data preparation, logging results and so on; this is on the basis of egalitarian values rooted in good will and friendship, in an attempt to "*keep the machine running as best as it can*" (Senior Physicist, CERN). This open form of knowledge leadership is generated through the **informal exchange** of knowledge rather than in formal meetings:

> "It's the gathering that matters and it's the sort of having coffees and having a beer, that sort of thing, rather than during the meeting, is when things start to crystallise" (Project Leader, UK)

Here, tacit knowledge appears to be useful in managing both the high volume of data produced by the LHC and need for precise calibration, based on the "*high level of system dependency that the LHC machine relies upon in terms of garbage in – garbage out*" (Senior Physicist, CERN). This suggests a **highly distributed** approach to knowledge leadership involving every level of scientist, ranging from team leaders right through to PhD students:

> "So the idea is everybody can see everything. The challenge is rather more to do with information handling and how to make it available in an easily accessible way. The information is supposed to be shared, but then of course if it's in the head of one expert and they haven't written it down, haven't documented it, that's where the problem is.... And occasionally there's a slightly human nature thing that if someone's got a clever idea they want to keep it to themselves. But on the other hand, before they can publish a physics paper they have to convince the rest of the community, so at a certain point they have to share it" (Applied Physicist, UK).

For some respondents, their intrinsic motivation is to contribute towards academic outputs within ATLAS. Here it is necessary to explore what knowledge means and this is done by constant and largely informal dialogue, an ongoing filtering process via face to face meetings, email, phone and electronic conferencing to generate tacit knowledge:

> "but as the Trigger got into place we were still having meetings, still talking to each other, and I think that seeds of ideas were planted in different places, something that you take from a talk or something that comes up over coffee, or a discussion over dinner or an email exchange, and those ideas get planted and take on a life, And very often it's the person who just happens to have the time to think about something and come up with a new answer who contributes and then that adds on. I don't think anything happens in a formal meeting where somebody stands up, gives a 15 minute talk and sits down again. The best meetings in the world are the ones where there is the informality, the coffee breaks where people put down the formal mindset and relax" (Senior Physicist, CERN).

However, an overriding ambition of most, if not all the scientists we interviewed was a pioneering desire to **extend the knowledge of society**, a focus on active theory-building rather than 'mere' academic modelling. The respondents in our sample emerge as a highly autonomous group driven by personal interest to pursue the highest form of scientific endeavour. They use terms like the "*high risk*" involved in funding the development of a systems architecture and the "*leap of faith*" that is required to produce a tool that can actually capture such cutting edge knowledge as the Higgs' boson. As one scientist puts it: "*It's basic science, curiosity, pushing boundaries, observing new things*" (Coordinator, UK).

7.2.2. (ii) How is knowledge leadership exercised?

Of course this portrayal of a global network where knowledge is freely available and accessible for the greater good is both idealistic and unworkable. First, there is the likelihood of information overload, with individuals drowning in a deluge of intranet messages, emails, conference calls and the like. Second, there is a need for scientists to give attention to their own **personal career** prospects. Over and above the knowledge leadership required to keep the experiment running efficiently, where science is the common objective, the need to secure an income serves as another driving force: "*The passion is driven by some personal consideration that really the element to human life...you know... your bread and butter*" (Software Specialist, USA). For instance, this is revealed in some descriptions about "*what it means to get ahead at ATLAS*" and the ways they have **made themselves visible** (and/or measurable) within ATLAS. They do this by developing specialist skills associated with the maintenance, calibration, data preparation or modelling of the detector:

> "I am an expert in calibrations which is a specific aspect of something that everyone needs here. Basically okay, I measure standard model QCD and I'm also interested in looking for exotics" (Post Doc, USA)

These so called "exotics" represent the outlier knowledge, the ability to spot anomalies in welter of data they are examining; it is noteworthy that such skills would have little currency outside of the ATLAS community. This shows how ATLAS scientists have come to define their roles in terms of the way that they interface with the different parts of the ATLAS detector and how this in turn **shapes their identity** as particular types of scientists in the ATLAS community:

> "This group will build this part and that group will build that part. Because its built it'll be a system where part of it is built by several groups and you have to read very carefully exactly what has to be built and the interfaces between them" (Project Leader, UK).

This results in acts to "*play down the people side of things*" and a reliance on more formal network-building with a close network of contacts. This more expert form of tacit knowledge helps them to **navigate their way around** the ATLAS collaboration by "*knowing their place*" and "*knowing their contribution*". In this sense, knowledge leadership represents a more hierarchical form of tacit knowledge generation on the basis of exploiting "*what you know*" to secure future paid work within ATLAS: "*My place is quite low down in the hierarchy because we have a different kind of physics*" (Software Specialist, USA).

So despite earlier reference to a relational approach to leadership arising from social capital between scientists and *informal* exchange of knowledge, there is also evidence of competition in scientists' narratives. This is built around the dualist objective that in order to get ahead there is also a need to work independently too. This sets up a **tension** around healthy competition in which individuals are forced to explore knowledge through collaboration at the same time as compete to exploit it:

> "There were more conflicts of interest; say for example we had to conduct analysis of an equation. There were 40 something people working in the same group, which I thought is crazy. In my own opinion only 3–4 people would be sufficient to work things out. It was a sign of competition.... and that's quite natural because physics is like in sport, we have to win." (Senior Researcher, China)

7.2.3. (iii) What expectations do scientists experience?

Taken from this very different perspective, what we begin to see is how the supposed intrinsic motivations of the communities of meaning surfaced in the previous reading might actually be more in keeping with Knorr-Cetina's (1999) *epistemic communities*,

suggesting that the choices scientists make about the type of work they do, and how they derive their identity at ATLAS may not lie at the level of individual control, but at the level of the institution.

This power is observable in the form of normative practices which scientists use in order to downplay any identities which are not considered to be in keeping with the perceived ATLAS culture. One scientist remarked on requests to "*tone down*" the written language used in emails in order to demonstrate one's commitment to a cooperative and collaborative approach. Another reported:

> "We have a common dressing code and we have a common sense of politeness and especially because we use a lot of email communication there is a way you need to write those emails to not. . .because of we ask favours from each other" (Post Doc, USA)

There was evidence that this causes some people to minimize aspects of their socio-cultural background in line with the expected norms and behaviours at ATLAS:

> "So people are a little bit, I think in this environment, they're a little bit reserved or guarded so you don't see too much of their real personality or what their real cultural heritage is" (Software Specialist, USA)

Repeatedly, respondents referred to ATLAS researchers, regardless of their origins, as speaking and understanding a clear common language to communicate about physics. Some said that this makes them feel closer to another physicist from a foreign country than a non-physicist from their own country. Yet for all this, we noticed that fluency in English is a pre-requisite for meaningful engagement.

Several scientists claimed to have changed their behaviour by suppressing certain personal differences and preferences (like gender, ethnicity, language and personal faith) to ensure that they fitted in to the ATLAS culture. By surfacing the way that scientists utilize different aspects of their identity in this way we can discern not only the hidden power that the machinery of the ATLAS experiment exerts but, in keeping with Knorr-Cetina, the way it determines who succeeds at ATLAS and who does not. This is a perspective on knowledge leadership rarely touched on in the literature.

The potential for such disadvantage can be found in the narratives of younger post-docs or students, several of whom mentioned work overload, long working hours and the expectation that this included the "*need to go for a beer after work*". This results in a further tension associated with gender (much of the social activity is male-oriented) and also wealth. This is because the capacity to take part in ATLAS is not always based on ability to contribute technically but the capacity of one's home Institute to contribute financially (and therefore fund longer tenure at CERN). This confers privilege in the way that scientists and PhD students from such institutions can maintain a stronger physical presence at CERN.

> "I mean the member states are the people who supply the CERN operating budget and they're the ones who say what the rules are. Ultimately it's council who's setting the rules." (Applied Physicist, UK)

7.2.4. (iv) What does effective knowledge leadership look like?

In keeping with the idea that actors seek to frame and articulate knowledge (or their lack of it) differently depending on their institutional, social or political context (Howarth, 2000), it is possible to further examine these different subject positions to see how certain contributions might become privileged or de-emphasized within ATLAS. This is revealed in tensions within the narratives of scientists as they seek to grapple with some of the unspoken rules of the game and make sense of what is valued at ATLAS.

In the context of ATLAS scientists, age and ethnicity seemingly play the greatest role in determining who has voice and subsequently power. This appears to be determined by the length of time spent at CERN, which is itself partly a function of the financial contribution the home Institution is able to make. Surfacing such tensions is important because of its influence on knowledge flow and knowledge leadership. For instance we find evidence that the tacit knowledge of older scientists holds greater sway than that of younger scientists, not only because of the length of time they have worked at ATLAS and the experience this brings, but also because of the informal networks they have built too. This commands respect of older scientists by their younger counterparts based on the advice they can offer:

> "[older physicists] have different skills. The generation who are now, I would say 45, 50 years or older, they have an excellent knowledge of hardware, of detectors. They have seen a lot of experiments before, they have seen discoveries happen" (Post Doc, USA)

> ". . .what happens critically is that the people who have experience of trying to make these complicated systems work, they know what the intricacies are, [they] know what the dependencies are intuitively without having to look at a manual because it's actually nigh on impossible to really document in a very explicit format what the tendencies are. It maybe shouldn't be but it somehow is. So we to some extent rely on expertise being passed on and using the expertise that exist in order to make systems work. So actually you become very valuable as an expert because of that tacit knowledge. It's quite difficult to do a brain dump into somebody else and just expect them to get up to speed. . .. Because you can read some documentation and it says this is what you do, it doesn't really tell you why or the philosophy behind it. You can try and document that but it's much easier to talk face to face with someone in order to develop a real understanding of that" (Senior Physicist, CERN).

What this second quote demonstrates is that even in the rational world of particle physics, there is no substitute for intuitive feel for what knowledge is important and how best to diffuse it. With such respect also comes greater status, conferring advantage to older scientists not only because of the contribution they have already made to knowledge generation but also the power they have over decision making:

> "You don't want to piss them off. They are very powerful. And now those are their skills, they have a power of authority. . .their authority of course comes from their knowledge, they are professors, they know a lot of things" (Post Doc, USA)

However, this sets up a tension around age versus experience because of the decreasing likelihood of older scientists to continue to be involved in the process of generating data (i.e., the writing of code or algorithms) over time. This implies that the knowledge of younger scientists has the potential to be exploited because of their apparent lack of status or voice:

> "Now you have the majority of people here who are not professors, who are post-docs or students. These people are younger than 40, younger than 30 I would say in most cases. They are good at doing stuff. They are the executioners. I know how to write code. I know how to dig out the data. My boss doesn't know that. My boss wouldn't be able to write a line of code. But I do all that, and of course come up with new ideas" (Post Doc, USA)

Hence despite a public rhetoric of democratic decision-making and consensual, distributed leadership in the ATLAS collaboration, we find the social machinery which is at play actually promotes the charismatic style of leadership which confers status on individuals displaying particular traits. This can be seen in respondents' explanations that decisions about who will lead are not always made according to whom is the "*best scientist*" but rather someone who is perceived to have the social skills to manage:

> "You see, to get a position within ATLAS it's not only because you are good but also you are able to deal with many people, to organise the work of many people, and to have the respect of many people. That is, I would say, equally important. My experience, not only in particle physics but also in other fields, is you know, you have to be good to come to the top but really the other factors like social skills actually at the end are the deciding factor" (Senior Physicist, Germany).

When it comes to knowledge leadership there is a recognition among our respondents that informal meetings, astute networking and interpersonal skills all play their part, but there also comes a moment when intentional leadership is required:

> "Getting this idea was one thing, but then there's the question of, once the idea has grown actually doing it, and I think that's why we have elected leaders like XX, who actually have the authority to say, you've got until now to do it, who actually push things through. It's fun to sit around and come up with the ideas and build these ideas, but I think that everybody needs a little bit of prodding to actually go forward and I think that that's what the higher level leadership does. To engage themselves in the discussions, see how things are going, guide them, and say, this is when you need to have it done, and make sure it happens." (Senior Physicist, CERN).

8. Implications for the study of knowledge leadership

So how does this exploratory analysis advance our understanding of knowledge leadership for firms in the wider knowledge-based economy? Here we propose two answers. First, theoretically, the insights gained underline the value of adopting more than one discourse. Second, the study begins to provide some pointers for a neglected field of research, the role of knowledge leadership in networked organizations. In this final section we examine each of these in turn.

8.1. The value of multi-discourse analysis

Encouraged by previous theorists' writing about tacit knowledge (Alvesson, 2011) and knowledge exchange (Schultz & Leidner, 2002) this study adopts a non-functionalist approach to surface different theories of knowledge and knowledge leadership. Our chosen discourse (interpretive) reveals that in order to get the best from individuals it is necessary to acknowledge the intrinsic motivations that various actors hold, making explicit what drives people to undertake the (often sacrificial) work in the knowledge economy (Bouty, 2000; Gooderham, Minbaeva, & Pederson, 2011). In the context of knowledge leadership, this is crucial because if people feel marginalized due to their social or cultural background, they are likely to behave in such a way as to exploit knowledge for personal gain as portfolio workers rather than to work collectively to enhance collective learning (Kamoche, Pang, & Wong, 2011). It is here that dialogic and critical analyses of the data highlight may help to illuminate not only the different subject positions that various actors hold but the way that socio-political context might serve to shape and constrain behaviour on a micro level (dialogic reading) and how this might confer dis/advantage because of macro level influences (critical reading). For example, the highly competitive context in which scientists operate, is not consistent with the collaborative public rhetoric of ATLAS. A post-structuralist reading of scientists' narratives suggests, on the one hand, a strong, intrinsic motivation, and on the other, respondents signal that their choices are limited by the hegemonic context in which they operate. Some seek to manage this tension by aligning themselves to an altruistic, scientific endeavour since this satisfies their ideological belief in a strong work ethic in the absence of a more meaningful reward for personal recognition. Foucault (1980) maintained that discourse is not just a form of representation (as with an interpretive reading) but that it also acts as a powerful form of action. So it is important to the context in which knowledge leadership is articulated. In the case of ATLAS that power is embedded within the machineries employed in knowledge production, in the form of both the people involved as well as the technical artefacts they interact with (Knorr-Cetina, 1999).

So for future studies of knowledge leadership, we recommend the adoption of interpretive, dialogic or critical discourses. From a research design perspective, this will help confront several assumptions associated with the ontological nature of knowledge leadership. First, it questions the functionalist assumption that, ideologically, *all knowledge generated* in highly collaborative, non-competitive environments, is based on norms of strong reciprocity and is necessarily harnessed for the benefit of the organization. We found evidence from an interpretive reading to suggest that the way knowledge exchange processes are led is based upon a range of – sometimes conflicting – motivations. Second, the assumption that socio-politically *all actors have equal access* to resources for knowledge exchange is found to be suspect because a more critical reading of the case tells us that the amount, nature and flow of knowledge leadership is dependent upon many socio-cultural factors, not least the prosperity of one's host-Institution. Third, it challenges the assumption that culturally *all actors share the same 'fixed' view* about the network in which they participate. For example, the espoused view, voiced by many respondents, is that ATLAS comprises "*world citizens*" bound by physics irrespective of diverse backgrounds pursuing their careers in a work-hard and play-hard culture in which it is possible to progress through dedication and recognition. Yet dialogic and critical discourse suggest something quite different. We note that those engaged in knowledge leadership have to negotiate carefully their 'initiation' into the ATLAS community observing the strong norms and 'code of conduct', recognizing that knowledge "orders and produces rather than mirrors. . .the world 'out there'" (Alvesson, 2011:1645). In particular, what a critical reading might also show is how scientists' behaviour is energized by higher level discourse in the form of a dominant ideology, which has the power to confer status on some forms of knowledge over and above others. Because this discourse regards knowledge as an entity separate from the individual knower and knowledgeable action, it can be extracted from one social grouping and appropriated by another, thus becoming a means of exercising power and control. For example, in her study of a multinational subsidiary, Moore (2012) found knowledge management playing a key part in strategic self-presentation and thus in power relations. In short, knowledge is power. An emancipatory application of critical discourse might reveal how any knowledge activists (including those in positions of seniority) can themselves be subject to the exploitative side of organizations.

8.2. Knowledge leadership in networked organizations

In their book, Adler and Heckscher (2006) advance a fascinating thesis maintaining that modern economic theory has shown that

Table 1
Knowledge leadership in collaborative, networked organizations.

Features of a scientific communities (e.g., ATLAS)	Requirements for *knowledge leadership*[*] in collaborative organizations	Features of market-based organizations (e.g., MNCs)
LEVEL 1. Where is knowledge found? Knowledge is generously shared, it is complex, multi-layered and difficult to track and disseminate but danger of overload or missed opportunities	*Sets overall direction and gaining coalitional support via light-touch governance which facilitates fair and fast knowledge flow*	Knowledge is embedded in formal systems and disseminated according to rational governance systems but danger of knowledge hoarding and untapped tacit knowledge
LEVEL 2. How is knowledge shared? Reliance on informal networks and voluntary association around longer-term goals but strong norms and socialization can lead to homogenization	*Sets up formal and informal social structures to ensure interdependence of contributions, whereby all are needed and valued*	Authority for knowledge sharing invested in hierarchy. but deference and bureaucracy can stifle bottom-up ideas and more radical solutions
LEVEL 3. How is knowledge controlled? Knowledge is socially sanctioned and flows via communal groups with shared values, proximity, language, etc. but this can lead to in-groups, discrimination and 'lost' knowledge	*Establishes an ethos where the value of knowledge is internalized; ensures this is reflected in the way resources are allocated and knowledge-sharing is collaboratively esteemed*	Knowledge is externally constrained, regarded as a commodity to be traded across the organization but this can lead to an instrumental and arid approach to knowledge sharing
LEVEL 4. How is knowledge used? Strong reliance on collectivist values and knowledge activists with high autonomy but danger of slow and inefficient decision-making (org level) and overwork (individual level)	*Creates an environment that values diverse views, pushes peers to resolve conflicts on their own and concentrates on galvanizing energy around the big picture*	Strong reliance on rational individualism and organic division of labour but knowledge stays in silos and leaks when key members move on

[*] NB Leadership is distributed and not the exclusive province of the top team.

neither markets nor hierarchies (in the form of central planning) optimize the production and distribution of knowledge. As an alternative organizational form they propose the *collaborative community* since: "it makes possible an enlarged scope for simultaneous knowledge generation and sharing. Community can dramatically reduce both transaction costs – replacing contracts with handshakes – and agency risks – replacing the fear of shirking and misrepresentation with mutual confidence. . .. And insofar as knowledge takes a tacit form, community is an essential precondition for effective knowledge transfer" (2006:29–30). This is a bold claim with reference to *effective* knowledge transfer (which belies a functionalist mindset) is one they seek to support by reference to several case studies. However the case organizations they cite are primarily from the fields of banking, manufacturing and IT. With some exceptions, like Knorr-Cetina (1999) whose commentary of the scientific world of high energy physics also refers to a "post-traditional communitarian culture", less has been reported from the world of science. In this paper, we have sought to build on Adler and Heckscher's argument and, in particular, to propose what knowledge leadership looks like in collaborative communities. In Table 1, we depict some of the characteristics of knowledge and its exchange in scientific communities (see the left hand column) and the corresponding features of market-based organizations, typified by MNCs (right hand column). Undoubtedly both organizational forms have something to tell us about four levels of knowledge leadership: where it is found, how it is shared, how it is controlled and how it is used. Scientific communities typically exhibit highly complex, multi-layered knowledge and unusually high generosity in the sharing of knowledge (level 1). To achieve this, they rely upon informal social structures and high levels of trust channelled towards higher, longer term goals (level 2); strong social norms govern the way knowledge is exchanged, often based on communities of practice and/or virtual teams linked by technology (level 3); despite their strong autonomy scientists galvanize their knowledge sharing efforts around a strong sense of shared values (level 4). In our study of ATLAS we discovered highly democratic decision-making, the avoidance of any 'overmighty' individual or group (possibly borne of uncomfortable experiences in the past history at CERN, see Taubes, 1986) and scientists in the experiment reliant upon accurate and timely knowledge from all the other participants. Our interviews revealed that this was less about formal mechanisms and sets of practices, and more about a strong ethic of active collaboration. Individuals took delight in their intensive immersion into the scientific community at CERN. Although electronic communication underscored all they did and produced, the face-to-face proximity, both informal and more formally at meetings and presentations, was an integral aspect of validating results and knowledge-sharing. As Table 1 demonstrates, there are downsides to this approach to knowledge leadership, however. In our study, we noted frequent reference to information overload, workaholic tendencies, inefficient decision-making and the need for new scientists to navigate powerful norms and an unwritten code of conduct, leading to a more homogenized and less creative workforce than might be desired.

In contrast, multinational companies are renowned for their well-prescribed knowledge governance systems (level 1) which tend to invest the authority and responsibility for knowledge exchange hierarchically (level 2). As a prized internal asset, knowledge is traded across the organization via rational value-chains (level 3), with an emphasis on competence, integrity, diligence and deference to authority and status, all of which are deemed to contribute to the efficient handling of knowledge (level 4). However, again as the Table illustrates, each level is accompanied by potential drawbacks like the failure to exploit tacit knowledge, the stifling of bottom-up creativity and an instrumental and/or silo mentality. In short, the admirable features of both organizational forms are countered by a series of 'buts' which are theoretically rooted in the limitations of *gemeinschaft* and *gesellescahft* respectively (Adler and Heckscher, 2006). Yet, by systematically drawing upon the best, and minimizing the risks, of each, we can begin to identify some key requirements of knowledge leadership, designated by the shaded central column in the Table.

From this we are able to offer a number of recommendations for international businesses in the knowledge-based economy. First, effective knowledge leadership is neither laissez-faire nor highly prescriptive, it is *intentional in terms of setting the overall direction*

but resists interfering and micro-management, both of which backfire with knowledge workers. Too often, the very mechanisms set up by international networked organizations to facilitate knowledge flow militate against it. This is because they are instituted in a top-down way, they are burdensome to manage and the bridges of trust across which prized know-how travels fail to get built. As a result, staff are drowned in a deluge of mundane intranet messages, while off-the-wall ideas and important insights are routinely missed.

Second, knowledge leadership designs-in interdependent, modular working where each unit has an important piece of the overall knowledge puzzle, but recognizes the mercurial nature of knowledge (especially tacit) and allows the mode of achieving this to bubble up organically. It is professional peer pressure rather than corporate compliance, that shapes such ideas and this leads to highly motivated and energized workforce. Individuals are willing to invest time and energy in fostering networks across a complex organization because they feel psychologically involved and have a personal stake in the future success of the organization.

Third, knowledge leadership is 'light-touch', instilling and modelling a strong ethos (of generosity and trust matched by accountability and transparency) and backs this up with the appropriate allocation of resources and rewards. Effective businesses are adept at building cognitive capital where shared mental schema and strong working relationships – built on a day-to-day level – allow for the fast uptake of important, intuitive knowledge. Sadly, in many international organizations and strategic alliances, important know-how remains locked in. Competitive-minded cabals dilute or sanitize what they are willing to share with others, project groups jealously guard their knowledge assets and autonomous individuals take it with them to the next job. In each case, the collective benefit does not materialize and organizational learning is impaired. This contrasts markedly with the ATLAS scientists, whose enthusiasm for and identification with the shared project is palpable. For many, the ATLAS collaboration will outlast their personal career, yet they remain intent on preserving the integrity of their contribution and passing on their legacy intact to the next generation. This sense of continuity, future-focus and ongoing community transcends parochialism, and is salutary for the short-termism of many private multinationals.

Fourth, knowledge leadership facilitates critical scrutiny of data *and* process (the 'know-what' as well as the 'know-how'), and encourages full-blooded debate and constructive deviance, all in the interests of arriving at more robust, informed and ground-breaking knowledge. Multicultural networks offer immense learning and – often uncomfortable – opportunities for surfacing radically different know-how. Benefits include unfreezing the cognitive maps of participants, loosening conservative structures and processes, preserving healthy levels of doubt and debate, confronting negative stereotyping and prejudice. However for such learning to be exploited, and to avoid the familiar marginalizing and excluding of 'out-groups', relentless and rigorous self-scrutiny is required. What this tells us is that knowledge leadership is not confined to the ascribed leader or senior team but needs to operate at all levels if it is to be effective in an international, networked environment (Liyanage & Boisot, 2011).

Our findings help to advance understanding of the highly nuanced ways in which knowledge leadership emerges and evolves during the life cycle of research networks and its contribution to effective knowledge exchange in international settings. Furthermore, by providing empirical analysis conducted in a global R&D community, this paper also begins to address a gap in current theorizing, given that much of the work in this field is still conceptual and/or tends to focus on MNEs (Choi & Johanson, 2012; Ferner, Edwards, & Tempel, 2012; Kasper, Lehrer, Muhlbacher, & Mulle, 2013; Tallman & Chacar, 2011) or professional consultancies (Alvesson, 2011; Donnelly, 2008). Whilst the immediate application of the results reported in this paper relate to the ATLAS project itself, they begin to address the call by Champalov, Genuth and Shrum (2002) for more studies of scientific, inter-organizational collaborations as objects of enquiry.

9. Conclusions

We began this paper with a brief discussion concerning the nature of leadership in knowledge intensive organizations, before examining four quite different conceptualizations of knowledge, depending upon the presiding discourse. Focusing on an archetypal knowledge-based global network, we then adopted interpretive discourse to explore perceptions of knowledge leadership in the context of the ATLAS collaboration. Despite the appearance of being an egalitarian and harmonious community of knowledge activists, this analysis reveals a more finessed understanding of the way knowledge leadership is enacted and experienced. Although our sample is small and the nature of our study is exploratory, we suggest that the insights begin to delineate the kind of leadership required for community-based organizations and networks in the knowledge-based economy. Fleming and Waguespack (2007: 165) observe that "despite their bizarre-like, egalitarian, argumentative, unplanned, chaotic appearance, open innovation communities rely heavily on strong leadership to function effectively and to resist splintering, forking, and Balkanization". On the basis of our findings, we would take issue with the notion of strong leadership in such organizations if this equates to a top down, 'one-size-fits-all' knowledge management with prescribed knowledge governance systems, a style favoured by functionalist discourse. However, a *laissez-faire*, anarchic approach would be equally damaging for effective leadership of knowledge exchange. For international knowledge-intensive enterprises and R&D institutes, a more sophisticated understanding of knowledge is called for; rather than regarding it simply as a material asset to be commodified, translated and exploited, it is necessary to view valuable knowledge as socially constructed, as continually negotiated and as interwoven with the nexus of organizational power. Paradoxically, it seems that while such networked organizations are typified by fluid exchange of knowledge, informal relationships and non-hierarchical structures, this actually requires intentional knowledge leadership, but crucially, of a distributed and light-touch variety.

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Appendix 1

Description of respondents

Gender	Job role	Home institution
M	Coordinator	UK
M	Senior physicist	CERN
M	Senior physicist	Russia
M	Doctoral student	Greece
M	Software specialist	USA
M	Post-Doc	USA
F	Senior physicist	Sweden
M	Senior physicist	Germany

Gender	Job role	Home institution
M	Physicist (Convenor)	Japan
M	Physicist (Data analyst)	Russia
F	Physicist (Data analyst)	France
F	Doctoral student	Sweden
M	Project leader	UK
M	Applied physicist	UK
M	Senior physicist	CERN
M	Senior physicist	CERN
M	Senior researcher	China

Appendix 2

Initial template of four codes arising from main research question

1. HOW IS KNOWLEDGE DESCRIBED?
   - 1.1 Communication and knowledge sharing
   - 1.2 Collaboration ethos
   - 1.3 Cultural issues
   - 1.4 ATLAS history
   - 1.5 Physicists' mindset
   - 1.6 Working with other groups

2. HOW IS KNOWLEDGE LEADERSHIP EXERCISED?
   - 2.1 Barriers to communication
   - 2.2 Barriers to knowledge sharing
   - 2.3 Competencies, skills required or owned
   - 2.4 Decision-making
   - 2.5 Hierarchy
   - 2.6 Mechanism of K sharing
   - 2.7 Meetings
   - 2.8 Social relationships

3. WHAT EXPECTATIONS DO SCIENTISTS EXPERIENCE?
   - 3.1 Barriers to progress
   - 3.2 Career progression and recognition
   - 3.3 Competition
   - 3.4 Conflict
   - 3.5 Funding issues
   - 3.6 Gender
   - 3.7 Job role
   - 3.8 Publications

4. WHAT DOES EFFECTIVE KNOWLEDGE LEADERSHIP LOOK LIKE?
   - 4.1 CERN relationships
   - 4.2 Challenges
   - 4.3 Home institute influence
   - 4.4 How the work gets done
   - 4.5 Position
   - 4.6 Power and leadership
   - 4.7 Trust

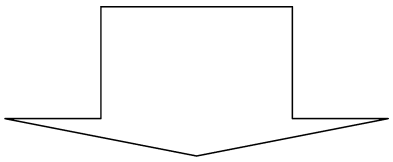
Appendix 3

A table showing an example of emerging codes from raw data and final themes

1. HOW IS KNOWLEDGE DESCRIBED?

1.1 communication and knowledge sharing: an extract of emerging codes

1.1.1 Channels of communication	1.1.2 Informal contact and discussion	1.1.3 Information flows
'*Yeah, that's the sort of thing, yeah. I mean often the technical stuff will come from the combined performance group into the analysis at the early stage and of course someone doing the analysis… It can be two ways. Someone [could start that] and in doing the analysis they refine something for their process and they feed that back in saying "Well actually, you know, this recipe was good, but actually for some purposes you should be aware that I could make improvements doing this".*' (Post Doc, USA)	'*Let's be honest, the major reason for going to a meeting at CERN is not usually to sit in the auditorium and listen to the talks because, barring other distractions, you can do that perfectly well from here, although asking questions is harder. No, I mean when I go to collaboration meetings at CERN I often find it difficult to actually fit in going to the formal meetings because of a number of appointments. You get "Oh, you're in town? Right, can I have a chat with you about such and such?"*' (Senior Physicist, Russia)	'…, he will present it at working groups, he'll take comments and feedback from other people… other people who might want to work with him or who might have ideas will… you know, they'll share information there. And then that loops out into the collaboration when it's a little bit more fully fledged and you've got something you feel is substantive enough for the collaboration to listen to.' (Senior Physicist, CERN)



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