RELATIONAL AGENCY IN SOFTWARE DEVELOPMENT COLLABORATIONS: THE CASE OF THE e-DEMON PROJECT TEAM IN THE UK e-SCIENCE PROGRAMME

Research full-length paper

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This paper presents evidence from a two-year multistage case study of an inter-organisational collaboration involving actors from universities, manufacturers and hospitals seeking to develop a prototype for digital mammography. Using ethnographic methods, the paper illustrates how developing a productive team of experts involves an ongoing struggle to overcome the ambiguity generated during the course of the innovation process. In particular, it focuses on how actors with different cultural drivers, derived from different disciplines and institutional backgrounds, resolve (or not) the contradictions that emerge as they orientate themselves towards the object of their collective activity. Key finding is the deployment of relational agency, a joint and more powerful form of individual agency, as a central process to manage the ambiguity, uncertainty and low visibility of this mode of work. Management practice to foster relational agency, then, involves engaging actors to recognize and reflect on the link between motivation and object formation, enabling actors to develop tools for boundary crossing, and encouraging them to learn to work with contradictions, rather than attempt to manage those away, by constructing inclusive boundary objects to enable creative collaboration.

Keywords: collaboration, teams, inter-organizational, relational agency

Short title in five words: Relational agency in inter-organizational collaborations

1. Introduction

Project teams designed to develop and share expertise in order to solve poorly defined problems are likely to be characterized by high levels of uncertainty, tension, conflict and contradiction[1]. Rather than being seen as problems to be managed away, such characteristics, when used as potential sources of change and development (Engeström, 2004), can be actually central to the development of this type of work activity. However, the evidence to date indicates that such expansive moments of learning can be quite rare and of short duration in work systems designed with the aim to integrate knowledge between experts from different backgrounds, domains and functions (cf.Majchrzak, More and Faraj, 2012). As a consequence the full potential of the project team cannot be easily reached, a phenomenon akin to *process*

[1] We use the term "contradiction" as in Engestrom (2004, 150) to mean sources of change and development. Contradictions are not the same as problems or conflicts. Contradictions are historically accumulating structural tensions within and between work systems.

loss (Steiner 1972) and *coordination decrement* – "the invariant of difficulty arising when all members attempt to work together at their full potential" (Fiore et al., 2003, p. 341).

In this paper, we aim to take forward this discussion to explore the challenges of constructing work systems where the goal of the activity is either not given or is very poorly defined. It is our contention that such work situations, characterized by ambiguity due to the existence of blurred boundaries (Alvesson, 1993), are common during processes of innovation, and stand in contrast to other types of work situation where the goal of the activity is usually more clearly defined and typically given, and where employees work within, and are socialised into, pre-existing practices with their associated rules, tools and divisions of labour. In our case, individuals from different organisations have to establish and develop a new work system. The research questions we wish to explore, in particular, in this paper is: (a) what is the nature of such innovatory collaborative working; and (b) what does management practice involve in teams designed to share and develop cross-organizational expertise. To achieve this, we focus on the e-Demon project, part of the larger e-Science innovation in the UK, to follow *in situ* the project team in the design of a prototype for a digital mammography computer system.

The e-Demon project, a flagship project of the e-Science initiative in the UK, was a two-year collaborative research project aiming to prove the benefits of grid computing in the domain of *eHealth*, in particular for Breast Imaging in the UK. The need for this project was derived from the professional recognition that the stresses upon the national Breast Screening Programme and for Breast Imaging in general were increasing, putting an already stretched service under more pressure (Department of Health, Social Service and Public Safety, 2002)[2]. Specifically, the project was set up to design a large distributed database of mammograms which, using grid computing power, could be accessed from many different hospitals and research centres nationwide. By enabling clinicians to retrieve and examine mammograms on their computer screen through the grid instead of using the film, as in their current practice, the e-Demon prototype was intended as the first step towards developing a potential tool to assists radiologists in the UK in earlier and better diagnosis of breast cancer.

2. Theoretical background

Information systems research indicates that such project teams need to activate additional mechanisms of social interaction to ensure reciprocity as a means to achieve knowledge integration between actors (Robert, Dennis and Ahuja, 2008). This is, we argue, for three main reasons. First, these project teams are having to deal with an ill-defined or poorly defined problem and so actors need to be equipped with an additional sensitivity to engage in creative interaction with project peers as a means to navigatethe project competently in the midst of ambiguity, uncertainty and low visibility. Second, these conditions easily give rise to tension and conflict, inherent features of multiparty collaboration (Levina, 2005), as actors operate from within different regimes of value (Barrett, Oborn and Orlikowski, 2016; Appadurai, 1996). Third, because of the 'decentralized' mode of work in such collaborations – it can be more complex to sustain actors' ties – as actors find it more difficult to respond to what counts as *obligations*, feelings of mutual responsibility that exist among team members in view of how to do work for the team (Robert, Dennis and Ahuja, 2008). This, however, can attenuate members' longer term *identification* with the purpose, the goals and the knowledge object of the project team. The challenge for the project team, therefore, is how to keep *energized* the team's trust, norms, obligations and goal identification, i.e. the team's relational capital (Nahapiet and Ghosal, 1996; Robert, Dennis and Ahuja, 2008) to ensure enhanced reciprocity in task delivery, when requested.

[2] Comprehensive Review of the Radiography Workforce, Department of Health, Social Service and Public Safety, April 2002, http://www.dhsspsni.gov.uk/publications/ahp-docs/radiography_workforce.pdf

Keeping energized the project team's relational capital can be achieved if actors learn to work with an augmented sense of agency –beyond individual agency– necessary to operate creatively in a collaboration. This is a form of joint agency conceptualized as *relational agency* (Edwards 2005, 2007, 2011). As a concept, relational agency originates in research on inter-professional working and inter-professional collaboration (Edwards, 2011). Relational agency is defined as the ability to work with others to expand the object of activity – the horizon of possible actions- or task being worked on (Engeström, 2004) by recognizing the motives and the resources that others bring to bear as they too, interpret it, *and* to align one's own responses to the newly enhanced interpretations with the responses being made by the other professionals while acting on the expanded object (Edwards, 2005, 2007, 2011).

Following this definition by Edwards, in this paper, we conceptualise the ability to work with relational agency as a key mechanism for achieving enhanced reciprocity in multiparty collaborations. We see the exercise of relational agency between actors in a team as a key mechanism to foster a multiparty collaboration because multiparty collaborations as work systems s need – and often struggle - to integrate knowledge between actors and stakeholders with varied interests, motives and incentives (Pouloudi, Currie and Whitley, 2016) as they work together to co-create value (cf. Rai, Pavlou, Im and Du, 2012) and generate the desirable collaborative advantage (Dyer and Singh 1998).

As a concept, relational agency finds resonance within current organizational analysis of cross-functional teams where scholars voice a need for practices that foster actors' personal responsibility to translate personal knowledge in to collective knowledge (Majchrzak, More and Faraj, 2012). In this way, relational agency, as a concept, adds to Nonaka and Takeuchi's (1995) knowledge creation framework by enhancing our understanding of how conversion from implicit to explicit knowledge occurs as actors develop the meditational means necessary to enable knowledge negotiation and to achieve knowledge sharing between them (Kinti, 2008).

In particular, our findings in this research indicate that working with relational agency is a **key skill** that enables the project team, this new boundary organization, to cope with the anticipated ambiguity surrounding the project work. Actors become more able to discern how to move the work forward because they, now, work responsibly, responsively and resourcefully vis-à-vis each other and towards the project outcome. Through the exercise and deployment of relational agency, the team can produce the necessary boundary organization practices of shared organizing to negotiate, to contain and to sustain (Yeow, Shia, Soh and Chua, 2018) the infrastructure necessary to integrate and co-create new knowledge. The next section presents the research context in which we study relational agency.

3. Collaborative Working in e-Science: the case of the e-Demon Solution Team

In 2000, the Department of Trade and Industry (DTI) of the UK Government defined e-Science as:

> Science increasingly performed through distributed global collaborations enabled by the Internet using very large data collections, terascale computing resources and high performance visualisations[3]

To achieve these ends involves the use of a new type of computer technology, grid computing, developed and applied within the context of a range of e-Science pilot projects. The long-term objective of the e-Science Programme in the UK has been to draw lessons from these pilot projects in order to build the electronic platform that will enable the desired

[3] https://www.oerc.ox.ac.uk/our-history, last accessed 1st June 2019

large-scale scientific collaborations using the Internet. Through this emergent e-Science Grid, collaboration amongst scientists and other actors from across universities, research and development labs of manufacturing corporations, hospitals, research institutes, government agencies etc would result in a combination of their expertise to help tackle the big scientific questions hitherto unexplorable (David, 2004).

The potential implications of the restructuring of work practices inherent in the e-Science initiative is explored in this paper using a case study of one pilot e-Science project: the e-Demon project. The e-Demon project group comprised partners from: a) five university computer labs; b) two manufacturing firms, M1 and M2 and c) four hospitals. Almost forty scientists specialising in software engineering, technology management, computer systems development and integration, digital imaging, radiology, epidemiology, and ethnographic analysis of medical work, came to work for e-Demon in the course of two years. During that time, these actors liaised in the context of multiple face-to-face and video-mediated work meetings in order to deliver the new system.

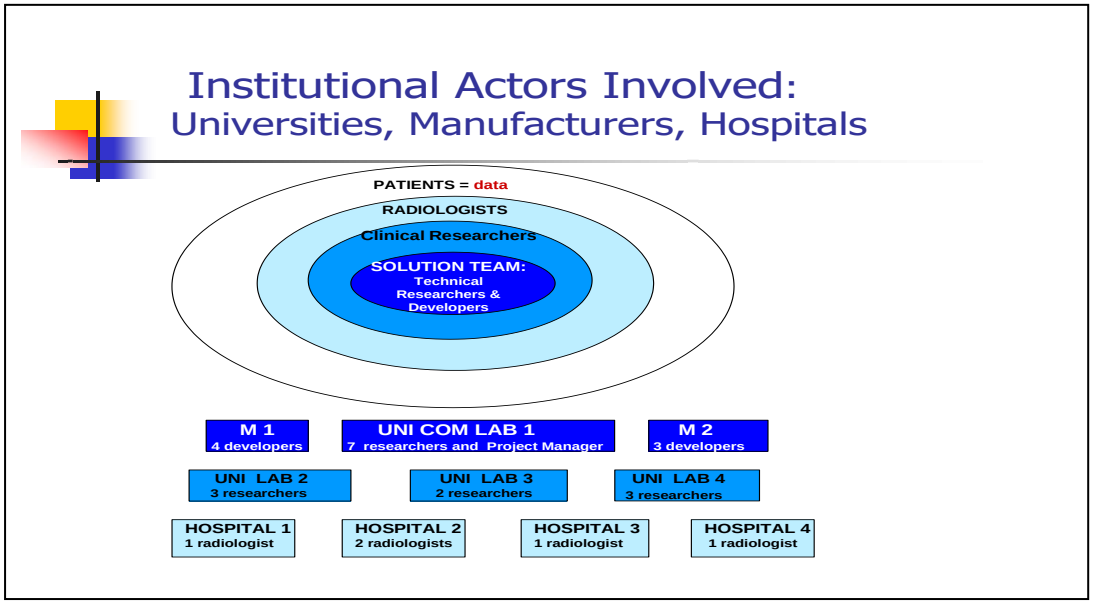

Figure 1. Prototype design was organised around collaborative expert teams

At the centre of this newly created project organisation, a core R&D group was set up and this was responsible to deliver the digital mammography prototype. The Project Solution Team, the focus of this research, was formed by university researchers from the central "Com Lab"[4], systems developers from the two manufacturers M1 and M2, and a project manager who had been specifically recruited for e-Demon by "Com Lab". As Figure 1 illustrates, there was a slightly more dispersed group of clinical researchers around the Solution Team, from four other university labs and hospitals, whose task was to assist the Solution Team in the technical development of a clinically useful prototype. Around that team, there was a group of hospital radiologists, involved to act as end-users. The radiologists and supporting staff of radiographers and nurses, liaised with clinical researchers and Solution Team designers for a variety of purposes: mainly to provide consultation and to test the prototype's developing functions in practice but also to help with digitising and inserting patient data into this computer system. The radiologists, and other hospital staff, were the most peripheral of the actors involved in the design and development of the digital mammography prototype. Thus, the expertise needed to develop e-Demon was distributed across the whole of this inter-organisational network. In addition, there was also a Management Board to oversee the

[4] The University Computing Laboratory – who had applied for and was awarded the e-Demon project.

project, including university principle investigators, other lead academics and top management executives from the two manufacturers.

While bringing all these experts to work together, each one of the parties involved in the Solution Team was charged with delivering a different component of the final prototype (Figure 2): "Com Lab" was responsible for designing the distributed database of the new system; M1, a large international hardware manufacturer, was responsible for designing the architecture and developing the grid infrastructure of the distributed database. The grid services, screening, training and epidemiology, were developed with the assistance of clinical researchers. The developers from M2 - a university spin-off company who had developed into a digital imaging champion- had to work closely with the clinical team in order to develop the software for the radiologists' workstation.

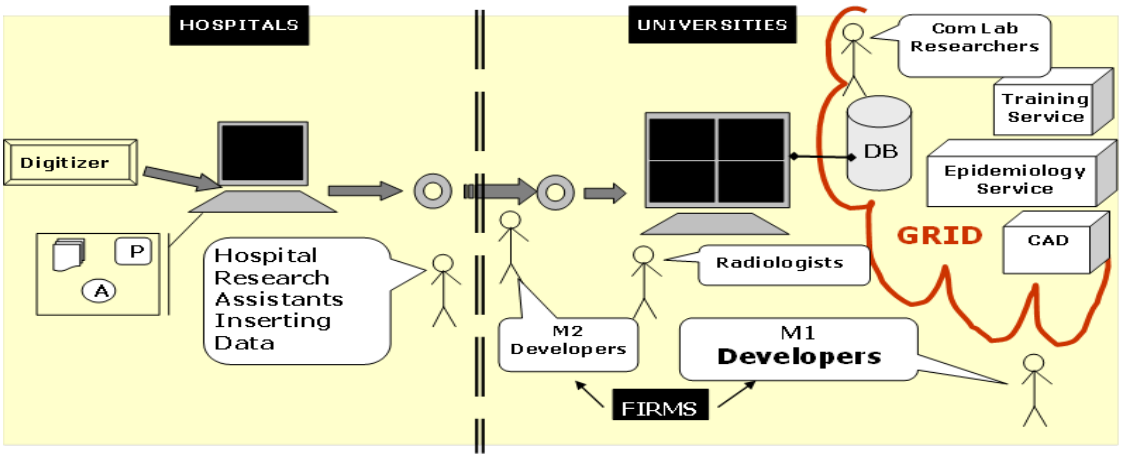

Figure 2. Collaborative working in the e-Demon Team

Applying grid technology for diagnostic use in healthcare is still generally regarded as innovative. In this case, it implies the capability of Solution Team designers to draw upon and to coordinate different streams of expertise from delivering ethnographic analyses of clinicians' workflows, converting those to requirements specifications, architecting, designing and developing the system, programming to fix applications, interfaces etc, and testing system's performance with radiologists. Thus, the work of such a team can be considered an example of collaborative expertise as proposed by Engeström (2004, 1):

> *"There is a new generation of expertise around, not based on supreme and supposedly stable individual knowledge and ability but on the capacity of working communities to cross boundaries, negotiate and improvise "knots" of collaboration in meeting constantly changing challenges and reshaping their own activities".*

An insight into the challenges experienced by the e-Demon project team is provided by the project manager in the following excerpt. As Sienna, the project manager, indicates these challenges or "complexities" revolved around: a) the experts' individual drivers; b) their employment contracts; and c) the multi-institutional composition of the team.

A challenge in delivering this prototype was in the individual partner drivers. Clearly, a commercial partner would want to push for their technology to be adopted as part of the solution as any potential exploitation would result in higher sales for their organisation. The project had a technical architecture team struggling several entities and had a technical architect working for the main

commercial organisation. This resulted in difficulty in making technical decisions on the architecture, as the committee argued extensively over decisions.

A further complexity resulted in the nature of research funding which required the universities to employ research assistants on these projects. These research assistants are expected to publish papers but are often tasked with fast track development to ensure delivery of these prototypes. The University research staff not only had to manage the design of data management systems but also the systems administration of a complex and novel grid architecture.

This aspect of the project could be aligned to the management of normal projects but proved to be difficult in that: there was no real customer, but several competing users, it had research staff performing development, and experienced conflicts with cross-organisational decision making. While the project team followed the process of gathering requirements, designing an architecture and planning multiple phases of deliverables, this process was more like product management than project management due to the need to align the development with known constraints and potential markets.

The e-Science initiative in general, and the e-Demon project in particular, could be conceptualised as involving just technological innovation. However, as the narrative of the project manager suggests, it can also be seen as an organisational, socio-political and psychological challenge in that developing the grid infrastructure was likely to involve new forms of collaborative working, at least, for these particular computer scientists. However, whilst UK Government policy, for example, extols the innovatory potential of such new ways of working, there is little insight into the challenges of how such teams might be constructed and how the development of collaborative expert teams might be fostered. In the case of e-Demon, these challenges were amplified by the inter-disciplinary nature of the team; its inter-institutional constitution which led to debates, for example, about cutting edge research versus commercialisation; its mixed mode of working (distributed and face-to-face); and the inherent problems of its object of activity: human health care systems.

4. Research Methods

The study adopted a developmental case study research design to follow the Solution Team during the evolution of its work. Case study methodology (Yin, 1994; Stake, 1995; Punch, 1998) was particularly well suited to unraveling the development of what was considered a poorly understood phenomenon, experts' interactions at the boundaries of organisations. To acquire this understanding, data sources included: a) direct observations to generate thick descriptions of how the team accomplishes work; b) tape-recording of meetings that provided a view of how expertise is practically, collaboratively and discursively constructed; c) explorative conversations to understand the nature of IT work and how participants experienced their work; d) semi-structured interviews to triangulate the data collected through observation of work activity. The team was observed throughout its project life time, for eighteen months, including observation of forty (n= 40) project meetings, lasting at least one hour each, and seventy interviews (70), with research participants.

Data analysis involved first inductive then deductive processes analyzing both the data and the literature where the emergence and development of work practices could be explored in relation to specific theoretical constructs, such as, for example, the object of activity (Miettinen, 2005), actors' motivations (Hyysalo, 2005) and relational agency (Edwards, 2007). First, the work of the team was divided in four phases based upon a qualitative measure that emerged from data analysis: a significant turning point in the organization of the team's work (Table 1).

After the periodisation of the team's work was completed, an iterative process of within and across phase analysis was adopted to produce a rich descriptive account of how work was

organized and developed at the different phases of the project. This descriptive account, the Work Development Report (WDR), was used as a basis for identifying how collaborative practices emerged, developed, and changed. Such identification led to a return to the raw data to examine in detail the nature of change (breakdowns, external interventions, innovations) in the team's practice, especially during the three qualitative turning points (Table 1).

Work Phase	Intended technical development	Socio-political Problems encountered	Qualitative shifts in practice enabling the Solution Team to move the work to the next phase
Phase 1 Jan 1 - May 28 2003	Establishment of Project specification - - specify User requirements	Stasis – Difficulty to move the work forward due to high levels of ambiguity	The decision to do Phase Zero, a 'learning to work together' phase and adoption of Phase Zero in the team's practice
Phase 2 June 2- Sep 17 2003	Designing the system's infrastructure	Delays – Difficulty to maintain Organizational commitment / change of M2 engagement strategy	Reorganization of the technical activities to provide more structure for coordination
Phase 3 Oct 3 – Dec 31 2003	Development of the system's infrastructure	Conflict – Difficulty to coordinate parallel work activity to deliver tasks as agreed	Re-definition of the main deliverables towards a more feasible project outcome.
Phase 4 Jan 1-Sep 3 2004	Development of grid services aligned with clinical team and radiologists	Coping with Polycontextuality – Difficulty to sustain creative effort and coordination across multiple contexts of work activity.	Demonstration of the e-Demon prototype at the Annual 'All Hands' e-Science Conference - end of the Solution Team's work.

Table 1. Periodisation of the team's work according to qualitative shifts in practice development

Progressive focusing of the analysis led to identifying instances indicating disruptions in actors' interactions. This was a key aspect of the research process where socio-cultural and cultural historical theory of learning (Edwards, 2005, Engeström, 2004), with its emphasis on tensions as sources of practice change and development, was identified as a particularly useful lens to further analyze the challenges and theorize the mediation of creative interaction. Such empirical focus on disruptions and breakdowns, as actors attempt to interact creatively across boundaries, reflects a recent focus on organizational discontinuity echoing Mallone & Crowston (1994) advice that coordination is experienced in an implicit way by actors working together. It is when coordination breaks down that experience becomes available for reflection, so providing opportunities for researchers to understand more, in this case, about the complexities of knowledge integration in inter-organizational collaboration. Especially because during collaborative prototyping 'parties respecify, in and through the prototyping process, their own work's practices' (Suchman et al., 2002:167).

5. Research findings: the experience of coordinating this inter-organizational team of experts

The first part of this section provides an insight into the challenges of developing and coordinating this particular type of work system drawn from the experiences of project members. The ambiguity experienced during the effort to coordinate the work of the team is identified as the major challenge for this particular project team to cope with. The second part of this section reports on the sources of ambiguity in the team's work. In the next section, we will respond to this challenge and the issues that raises, using the notion of relational agency in an attempt to theorise the problems identified, from which potential solutions might arise.

4. a. The e-Demon Solution Team: the experts from within

According to Sienna, the project manager, projects such as e-Demon are characterised as follows:

> "*They often have multiple stakeholders with different visions and different drivers; they have a complex mix of research and non-research staff who are used to working in different ways and with different project approaches; there are disparate teams so it is likely that the project team rarely meet as a group; there is a disparate user community, all with different requirements and views".*

While experienced in practice, these organisational conditions left the designers perplexed, even confused, with the problem in hand. For example, after the first four months, a growing feeling of disappointment amongst developers, researchers and their team leaders culminated in Dennis, the "Com Lab" technical leader, stating "we have not been able to build anything so far" and Alex, the M1 architect said: "the scene is not being well settled at all here because there is no real client". Team members were not able to move on as fast as they initially anticipated because of the new way of working in this project. This mode of working was something new, for them, to learn: it differed from their current practices of "knowing how" to do systems development. Normally, the designers were used to: (a) having a clearly recognisable client for whom they were working and (b) having a clear a priori specification of the system's user requirements.

However, in the new context, the possibilities for exercising qualified judgment of "know how", drawing upon (a) and (b) as above, were seriously reduced because of the need to negotiate continuously the outcome of the work. The issue faced was not so much the need to develop technical knowledge, "know that", but the need to develop new forms of "know how" (Ryle, 1949). This uncertainty regarding the technical outcome of the team's work resulted in the designers experiencing a significant degree of ambiguity (Alvesson, 1993) in order to move the work on. The argument that we wish to make in this section is that such ambiguity was a characteristic feature of the collaborative experts' team work and process of development in this setting. To illustrate the point, Jonathan, the M1 systems integration specialist, noted in a project meeting before the end of Phase 1:

> **"***The problem here is that things do not come down to a straight technical choice. There is a flip side to every decision and so we are contesting all the time and this is so infuriating".*

The technical progress of the team was challenged by ambiguity caused by: a) the nature of the technical task which meant that the work outcomes were uncertain. At the beginning of Phase 3, Matt, the systems administrator at "Com Lab", characterised the team's work as a "moving target"; b) the reduced commitment of actors in order to fulfil their work roles on the project; c) the emergence of different types of coordination problems, some of which emerged due to the reduced commitment of actors; and d) the tensions generated due to conflicting motivations or unforeseen contingencies. However, as Martin and Meyerson (1988) say, it is

vital to acknowledge rather than deny ambiguity as an essential element of work in organisations (Alvesson, p. 1002, 1993). According to Alvesson, ambiguity involves:

"…uncertainty, contradictions that cannot be resolved or reconciled, absence on agreement on boundaries, clear principles or solutions. Ambiguity is different from uncertainty while it cannot be clarified just through gathering more facts. Ambiguity means that the possibility of rationality – clarifying means-ends relationships or exercising qualified judgement becomes seriously reduced" (1002, 1993).

A rather important yet neglected or unnoticed part, of the team's work, therefore, was **the management of ambiguity**. The next section identifies specific sources of ambiguity in the Solution Team's work. Then, consideration is given to the factors that were found to contribute towards managing the ambiguity inherent in the knowledge creation process within this particular setting.

4. b. Sources of ambiguity in the team's work: towards a classification

The first source of ambiguity in the Solution team's work was found in the existence of blurred boundaries in the technical development of the work. Specifically, the designers experienced: a) *absence of agreement on clear principles in the development of user requirements* in terms of "do we begin to design with or without user requirements" and b) *absence of clear direction in the design of the architecture* in terms of "do we begin to architect on the basis of innovation or feasibility?" These boundaries were not obvious to the designers until the end of Phase 1.

Designing the Application Programming Interfaces (APIs) was another example of how the team's technical work was underpinned by *uncertainty* in the sense that the *possibility for clarifying means-ends relationships was seriously reduced.* APIs were agreed bits of code defining how the different components of the system should connect together. In order to design the APIs the designers had to agree to define together the input and the output of the applications at the network's interfaces so that, for instance, the database could "talk" (send messages / connect) to the grid. But, the designers did not know exactly, at that stage, how the design of the APIs would work in practice because not a single part of the system was built yet. So the APIs could not be tested at that stage of the work. In that sense, designing the APIs was an exercise for the designers in disciplined imagination (Weick, 1989), i.e. they would do their best to meet certain criteria while designing but they could not guarantee that these criteria would be fulfilled by the system in practice. This is an indication of the ambiguity surrounding their work: they could not clearly estimate the effect of that part of the designing process on the system's development.

The second source of ambiguity experienced at the level of the team was found in relation to individual actors' uncertainty about the new roles they needed to adopt in order to commit themselves to the work of the team. Specifically, it was hard for certain key actors to recognise the boundaries between the relational and the non-relational elements of their work roles (Barley, 1990). Such boundaries were subject to negotiation. For example, participating in the Solution Team required certain actors to engage in a process of boundary crossing, from their home institutions to the new team. Here, they were requested to "unlearn" the taken for granted, non-relational elements of the practices that they exercised within their home organisations, in order to be able to participate in the Solution Team. For example, Frederick, the M1 team leader who was a senior advisor in the Emerging Technologies department of M1, was criticised for approaching Com Lab researchers and requesting them to produce certain documents to very strict deadlines. This caused Anthony, the Com Lab team leader, to openly disagree with Frederick and voice a concern about who is to manage technically the Solution Team. This can be interpreted as an indication of *absence of agreement on boundaries in relation to work roles*.

The third source of ambiguity was the absence of principles for coordination and communication. Our data indicate that this is an ongoing task, that could not be dealt with just in the earlier phases of the work. This, in turn, indicates that actors in projects such as e-Demon have to learn to live with this source of ambiguity as an essential part of the work.

Poor organisation and no clear goals breeds de-motivation and often results in a team that is frustrating to work for. The building of an effective team is crucial where there are expectations for cross-organisational delivery. The Project Solution team required development from both the University and the main commercial partner. The process of understanding what impacts the way resources work and what enables career enhancement in their organisations is critical to ensuring that resources are able to contribute and benefit from their involvement. These drivers may be the need to publish papers in their research field, or to promote technologies or to develop patents. Rarely are collaborators in a position of seeing all their partners' cards before a project commences and rarely are these details captured in any collaboration agreement. It is clear from experience that this activity needs to be addressed in the early stages of a project. By understanding these drivers, the team begins to both trust their colleagues more by understanding their actions, but also develop a more open and effective working relationship resulting in a more harmonious working environment.

This would involve engaging the designers in a continuous dialogue to explicitly articulate objectives and expectations and also to monitor pertinent changes in their objectives overtime.

The fourth source of ambiguity in the Solution Team's work was the emergence of contradictions that were hard to resolve or to reconcile, arising from partners' conflicting motivations. During Phase 4, such tension tended to produce a disturbing "noise" that prevented Solution Team designers from being able to concentrate on their work. **Table 2** summarises the sources of ambiguity and the symptoms of ambiguity in the Solution Team's different areas of work. The reported areas of work were selected to incorporate: a) building commitment; b) team coordination; and c) actors' co-participation.

Area of Work	Source of Ambiguity	Symptom on the work	Time Period
Technical Development	• Absence of agreement on clear principles in the development of user requirements • Absence of clear direction in the design of the architecture • Reduced possibility to clarify means-ends relationships in the design of the APIs	• Confusion and lack of direction • Lack of progress • Difficulty to reduce equivocality	Phase 1 Phase 2
Building Commitment	• Absence of agreement on boundaries between the relational and non-relational elements of work roles	• Reduced commitment	All Phases by different actors
Team Coordination	• Insufficiency of processes to explicitly articulate actors' objectives and expectations • Insufficiency of processes to explicitly articulate work dependencies	• De-motivation • Not delivering on time	All Phases except Phase 2 Phase 3
Actors' co-participation	• Contradictions that could not be easily reconciled due to actors' conflicting motivations	• Toxicity in linguistic interaction • Continuous • "noise"	Phase 3 Phase 4

Table 2. A classification of sources and symptoms of ambiguity according to area of work

6. Discussion

The analysis provided highlights the huge problems of sharing and integrating knowledge in this particular inter-organizational team. The problem in this work system is how to coordinate expertise across these various institutional actors, how to motivate them towards sharing and achieving common goals, whilst remaining sensitive to their personal drivers and the commercial/research needs of the organisations employing them. The experts involved provided us with a helpful set of categories of problems - motivation, time pressures, conflicts and contradictions - which are, however, essentially descriptive. The issue addressed in this section is how we might move from such a description to a more theoretical conceptualisation of these problems in order to understand how such teams might be enabled to better coordinate their activities. Our findings indicate that the Solution Team became able to move the work forward and cope with the ambiguity surrounding the project task when actors deployed relational agency in their team practice. First, we provide an example of relational agency deployment and how this enables the team to cope with ambiguity. Subsequently, we, briefly, outline an initial conceptualization of what the deployment of relational agency involves to assist management practice in such a cross-organizational collaboration.

The deployment of relational agency in the Solution Team

A concern that permeated the project team's organisation in Phase 4 was the integration of the work between the two collaborative teams: the Solution Team and the Clinical Team. In particular, one of the problems was how to manage the clinical partners' expectations. Communication with the clinical side about what the project was supposed to deliver was occurring through "Chinese whispers", as the project manager noticed in the middle of the phase. Specifically, she described the effort to strike a balance between technical and clinical demands as an "uphill struggle". When interviewed, she used the following metaphor to explain the mismatch in partners' expectations: "the project started off as a Mini and at the end of it clinicians are expecting a Rolls Royce". The actors, at this point are not working with relational agency; they are not sensitized to each other's motives and incentives vis-à-vis the project outcome. Contradictions in partners' expectations prevail and ambiguity for how to move on surrounds the work and the team falls into inertia.

Dealing in practice with such problems in project scope, however, raises the concern of how to re-define the division of labour: what would each designer need to do on the system and how they would all move on in parallel activity, without interfering with each other, so as to clarify and reach the project scope on time. In this way, the team could somehow move forward. Jonathan, the M1 team leader came up with the idea to use "a set of 5 Buckets" as a mental model to structure and divide the team's work. The researchers at 'Com Lab' agreed.

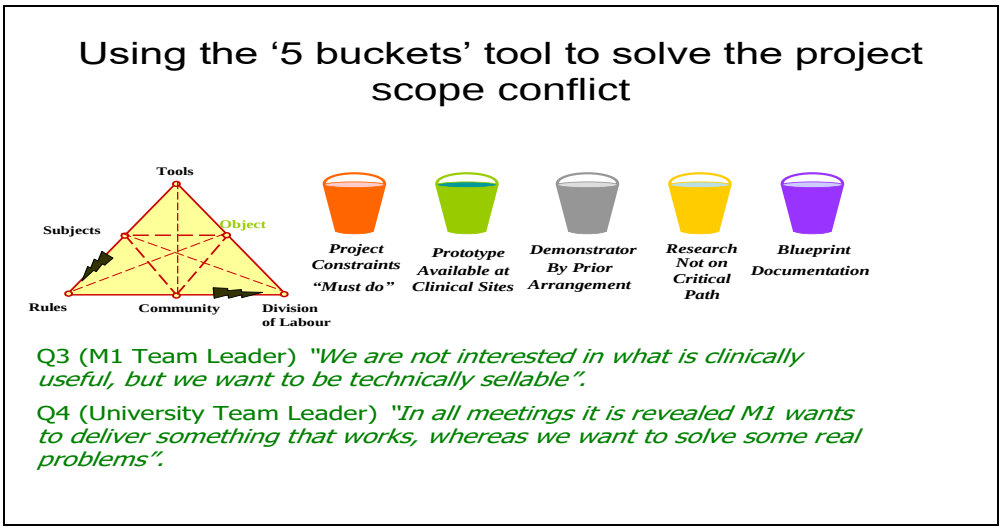

Figure 3. The 5 Buckets tool enables the team to do a new division of labour in Phase 4

The team colour coded them and decided for each Bucket to include a different set of functions depending on whether this would be something: a) radiologists would use on a day-to-day basis; b) something the Solution Team could just demonstrate; c) a piece of innovative research leading to publications; d) a statement on the Blueprint deliverable; e) or a project constraint. This enabled them to construct a new "pictorial" language that even remote clinical team members could understand how to contribute their work.

The 5 Buckets tool emerges as a new boundary object (Carlile, 2002, 2004; Star 2010) enabling collaborative working by creating the affordances for a new division of labour. This was a new template serving as the basis for negotiating a way forward with project work in Phase 4. This new tool enabled the project team to overcome inertia and cope with the ambiguity to define the project scope.

In order to resolve that problem further, the project team adopts a new type of work interaction, *visualisation exercises*, for the designers to check how different parts of the developing system connect together and to evaluate the team's progress in group meetings; actors begin again to work with relational agency and they develop a new type of meeting, visualization exercises that serves as a new tool enabling boundary crossing. Soon, the group's activity includes initial testing of the prototype's performance with the radiologists.

This, then, involves designing a new type of meeting, *demonstrations*, meetings convened for the purpose of evaluating progress with the clinical researchers and radiologists – we, now, see how through deploying relational agency the team expands to actively include and involve the project's end-users in testing the new system with the designers. Relational agency was deployed through two types of demonstrations used in Phase 4: a) big demonstration meetings at Com Lab with all partners involved and b) smaller demonstrations of the system's functions at hospitals involving the system's administrator, M2 designers and clinicians. Then, there is a big meeting with clinicians and radiologists, where the radiologists give feedback to the designers.

Louise - radiologist 1: I guess we want to be able to talk with each other…[meaning with other clinicians] and not just type through the system, right? (turns to radiologist 2 around the table)

Annette - radiologist 2: Yes. You see, historically *[emphasis in the original] we are not used to typing but talking. (turns to the designers)*

Sienna – project manager: Is there anything you can do about this, Grid team? (turns to the designers)

Alex – M1: Well, you want to be able to talk to people in the same clinic or do it across clinics?

Louise - radiologist 1: Both, I guess.

Jonathan – M1 team leader: How about Access Grid? (turns to Alex)

Alex - M1 lead architect: Yes certainly…(turns to Jonathan). We can include an Access Grid facility in the system. [this is a videoconferencing facility to support collaborative working from remote sites]

Sienna – project manager: Anything else? (to the radiologists)

Working with relational agency in the Solution Team

Relational agency (Edwards, 2011) involves a capacity for working with others to strengthen purposeful responses to complex problems. As a joint and more powerful form of engaged agency, relational agency is presented as an alternative to the idea of professionals as heroic individuals (Edwards, 2005, 2011). Relational agency occupies a conceptual space between a focus on learning as enhancing individual understanding and a focus on learning as systemic change and includes both. It fits squarely within socio cultural theories of the mind by seeing mind as outward looking, pattern-seeking and engaged with the world (Greeno, 1997).

7. Conclusion

Following Edwards (2011), we conceptualise relational agency in teams as a point in the development of the team's work where actors overcome their willingness and their conviction to operate as solo experts and they respond resourcefully and creatively to each other to move the work forward. Our findings, however, suggest that working with relational agency is not a permanent state in team practice. The deployment of relational agency is an **episodic process**; the team moves iteratively forward and backwards between moments of working responsively and achieving creative interaction through relational agency, and moments where interaction becomes for various reasons uncreative and actors revert back to the organizational boundary. Management practice to foster relational agency then involves engaging actors to recognize and reflect on the link between motivation and object formation, enabling them to develop tools for boundary crossing, and encouraging them to learn to work with contradictions, rather than attempt to manage those away, by constructing inclusive boundary objects.

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