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Special Theme: Project Management in E-Science: Challenges and Opportunities

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Abstract. In this introduction to the special theme: Project Management in e-Science: Challenges and Opportunities, we argue that the role of project management and different forms of leadership and facilitation can influence significantly the nature of cooperation and its outcomes and deserves further research attention. The quality of social interactions such as communication, cooperation, and coordination, have emerged as key factors in developing and deploying e-science infrastructures and applications supporting large-scale and distributed collaborative scientific research. If software is seen to embody the relational web within which it evolves, and if the processes of software design, development and deployment are seen as ongoing transformations of this dynamic web of relationships between technology, people and environment, the role of managers becomes crucial: it is their responsibility to balance and facilitate the dynamics of these relationships.

Key words: e-science, cyberinfrastructure, collaboratories, e-infrastructures, usability, interdisciplinary collaboration, agile management, agile development, team-building, project management, leadership, facilitation of e-science teams, software development

The goal of developing e-Science (large-scale distributed computational, data and communication, infrastructures and middleware) is to support the emergence of new kinds of scientific practice: multi-institutional and multi-organisational, multi-disciplinary, and higher-speed sharing of scientific data and analysis allowing the exploration of new scientific questions and the evolution of 'big science' (Hey and Trefethen 2003; Atkins 2003; Finholt 2003; Foster and Kesselman 2004; NSF 2005). e-Science projects are characterised by complex processes of 'relationality, integration of heterogeneity, sustainability, standardisation, scaling up or extension, human work and technological delegation, and the always already social [Cyberinfrastructures]…' (Ribes and Lee 2010, p. 241). Achieving the ambitious goal of e-science is, thus, a challenging undertaking depending on numerous factors, one among which (and, we argue here, a very important one) is the management of e-science teams. The task of e-Science managers is to facilitate the work of their team in the course of conception,

development, implementation, and use of large-scale technological systems and infrastructures that cut across multiple communities of highly specialised professionals and encompass active collaborations between domain experts over prolonged periods of time in dynamic environments. Understanding the specific e-science challenges at work here and how management and team-building may resolve them (or not) could be informed by and could inform further the CSCW research agenda focused on the situated development of technologies for cooperative practices. Such research agendas would encompass also ethnographic studies of e-science managers' and teams' strategies (from the very conception of an e-science project and its team onwards) for developing *usable* technologies and embedding e-science. This includes exploring, firstly, how team leaders, facilitators, and team-members, individually and collectively, manage the development of requirements for infrastructures and middleware; and, secondly, how internal and external team interactions and their facilitation in the process of system development shape the communication of requirements and, hence, the functionality of infrastructures (e.g. see Lloyd and Simpson 2005; Warr et al. 2007a' b; Spencer et al. 2010).

These research themes direct special attention to the human infrastructure (or 'the arrangements of organisations and actors that must be brought into alignment in order for work to be accomplished', Lee et al. 2009:484), of e-infrastructure (cf. Lee et al. 2010). Indeed, e-Science is a socio-technical field and social processes are as important in shaping technology as is the engagement with its material aspects (Hine 2006; Jirotka et al. 2006; Jankowski 2007; Olson et al. 2008; Edwards et al. 2009; Ure et al. 2008; Ribes and Lee 2010). The increasing complexity of e-science projects has given rise to a new set of challenges underpinning the quality of human interactions on these projects, including alignment of goals and interests, motivated participation, trust and sustainable cooperation (see e.g. Olson and Olson 2000; Lawrence 2006; Lee et al. 2009; Jirotka et al. 2006; Ribes and Finholt 2008; Zimmerman and Finholt 2007; Warr et al. 2007a, b; Lee et al. 2010; Spencer et al. 2010; Darch et al. 2010a' b; Lee et al. 2010). These challenges shape e-infrastructures and may limit the successful implementation and embedding of e-science. Thus, the quality of social interactions such as communication, cooperation, and coordination, have emerged as key factors in developing and deploying e-science applications. However, the role of project management and different forms of leadership and facilitation that can influence significantly the nature of cooperation and its outcomes has remained understudied.

Due to the particular attributes of e-science projects, including uncertainty, dynamism, diverse interests in the academic research context, and interdisciplinary distributed teams, e-science management defines the outcomes as it is interweaving the social and technical aspects of e-infrastructures. In e-science, management faces specific challenges (e.g. see Lloyd and Simpson 2005; Warr et al.2007a; Spencer et al. 2008; Spencer et al. 2010). These challenges need to be examined taking into account the important role of project management as a lived relational experience and not only as a technical process. Additionally, if software is seen to embody the

relational web within which it evolves, and if the processes of software design, development and deployment are seen as ongoing transformations of this dynamic web of lived relationships between technology, people and environment, the role of managers becomes crucial: it is their responsibility to balance and facilitate the dynamics of these relationships. Thus, if the effectiveness of managers is reduced (e.g. if they have good ideas enhancing collaboration but no power to implement them, or no sufficient knowledge about how to implement them), the quality of software is reduced too.

Lloyd and Simpson (2005) argue that because of their particular culture, the distributed and multiple partnerships and institutions and the peculiarities of academic context (versus industry), multidisciplinary collaborative e-research projects require special management skills and tools, different to those in 'traditional' management. Project managers must pay special attention to team building and to effective facilitation of communication and collaboration (see also Darch et al. 2010a, b; Warr et al. 2007a, b; Spencer et al. 2010). Research attention so far has addressed mostly the relationships with users, while the internal team relationships have been neglected even if they are also important for the development and embedding of e-science. For example, as Spencer et al. (2010) argue, a better understanding of the experience and organisation of service providers and technology developers themselves is crucial to improve the accessibility and usability of e-Science services as well as software development. Further, it is important to gain insight into the needs at the individual, local, national and transnational contexts since each is characterised by different requirements and modes of use that directly affect the quality of e-infrastructure development and deployment. All of these factors have to be considered when reasoning about how to improve the development, accessibility and usability of e-science projects. Indeed, daily practices and orchestrated processes of team-building, facilitation, leadership and management impact significantly on design, development and user engagement together with the formal use of concepts, tools, and techniques.

Two of the papers in this special section offer empirical, theoretical and methodological insights into some of the main communication and collaboration challenges and opportunities facing e-science projects. Both papers raise key issues in understanding the role of managing e-Science research for embedding e-science applications. Each case-study provides an in-depth analysis of the lived experience of facilitating and working in a team and using tools to support communication and collaboration. The authors' analyses of situated practices further the CSCW research agenda by providing invaluable insights into the social and organizational challenges to design and deployment of technologies supporting large-scale and distributed collaborative scientific research.

Often, in response to calls for funding, e-science collaborations have been formed in haste or as part of shared political and economic survival interests. Such collaborations may not involve the motivation for a deep level of collaborative engagement that is necessary for the creation of a shared vision

(the first step towards successful e-science collaborations). This may then prevent the delivery of meaningful outputs and may, thus, inhibit usability and adoption of technology. Additional consequences of superficial or uninformed team-building may be the loss of trust in the nature of such collaborations or growing scepticism and misunderstanding of e-science projects and their potential. Although some quality interactions may emerge as a result of luck and serendipity, if ad hoc and sporadic engagements prevail, they will limit the possibility for transformative research. Targeted deep engagement is a prerequisite for mutual understanding as opposed to superficial social and intellectual exchanges and is an essential ingredient in the development of e-science. Deep and productive engagement can result from competent management, facilitation and leadership. Although there have been some reports on ways of building e-science teams, these have mainly focused on what should be done rather than how, and we still lack sound theoretical and methodological frameworks for understanding what goes on in the process of e-science team building and how to facilitate it. Both papers in this special section comprise a step forward in this direction.

The first paper, *Bridging the Interdisciplinary Divide: Co-Creating Research Ideas in e-Science Teams* by Deana Pennington, demonstrates precisely the importance of management of e-science collaborations by conceptualising it as an active process of orchestrating interdisciplinary learning. Pennington explores team-building as a relational practice and a group learning process (Boreham and Morgan 2004). Such analytical framework extends the existing analysis of social factors in the development of e-science (Olson and Olson 2000). The case-study exemplifies the value of theoretically and methodologically sound design and facilitation that can enable 'the co-creation of research problems at the intersection of science and technology'. The findings support existing arguments that creativity and transformative ideas depend on the quality of team interactions but it also shows further how one could manage such interactivity as a learning process. Of course, generalising one particular experience is not possible, but still, this case-study is a useful lesson in how much effort needs to go into e-science team facilitation and what tools may work well in the specific context of e-science. The article is also a valuable source of references to theoretical and methodological literature from other fields that CSCW researchers and practitioners could leverage. The author also provides self-reflective insights into the role of the facilitators as 'boundary spanners' (Williams 2002), 'providing a model of participatory interaction focused on: communicating, learning, questioning to achieve understanding and exploring potential linkages' between collaborators from different disciplines. This article suggests that, in the interest of meaningful research and technology development, usability and adoption, more attention needs to be paid to how people on e-science teams interact and how this interaction is facilitated. It also shows empirically that among other ingredients, transformative research may necessitate transformative learning.

The second paper, *Agile Project Management: a Case Study of a Virtual Research Environment Development Project* by Rob Procter et al., also argues that we need to understand the crucial role of cooperative practices in design and management for usability and that simply focusing on the technical changes of requirements and design recommendations is not sufficient to guarantee usability and adoption. This is a contribution to the recent CSCW and software engineering studies of software development (Dittich et al. 2009) problematising traditional methods which focus on quantitative control, and instead—unpacking the variety and complexity of lived experiences of software development as a cooperative practice and its consequences. Cooperative team-work shapes design and development, and thus the technomethodologies of software and applications. The authors explore the subtle complexity and dynamics in social interaction and facilitation involved in balancing the tensions between improvising and ordering a development of Virtual Research Environment (VRE).

VREs, or collaboratories, have increasingly become a subject of research since the late 1980s. Among others, the Science of Collaboratories (SOC) project at the School of Information, University of Michigan, has contributed significantly to understanding what makes a collaboratory successful and has studied the different forms they take (Bos et al. 2007; Olson et al. 2008, Finholt 2003; Olson et al. 2006; Zimmerman and Finholt 2007; Zimmerman 2007). This also includes some, albeit limited, discussion of the new forms of management that are necessary on such projects (e.g. see the chapters in Olson et al. 2008). Olson et al. (2008) and others (e.g., Ribes and Lee 2010) also stress that in spite of potential benefits, the increasing scale and complexity of VREs present numerous challenges, some of the main ones being social and organisational. Complete or partial failure and underperformance may be caused by organisational problems such as misalignment of goals, lack of common ground and trust, poor usability and insufficient user base among others (e.g. in Grudin 1988; Hesse et al. 1993; Orlikowski 1992; Olson and Olson 2000; Weisband 2002; Mark 2002; Hinds and Weisband 2003; Gibson and Manuel 2003; Jeffrey 2003; Chin and Coveney 2004; Cummings and Kiesler 2007, 2005; Hartswood et al. 2005; Beckels 2005; Procter et al. 2006; Jirotka et al. 2006; Ure et al. 2008; Voss et al. 2009, see also the chapters in Olson et al. 2008; Lee et al. 2010). These challenges are even more enhanced in the context of agile development of a Web 2.0 VREs, where constant change, rapid development and strong user engagement create further complexity.

Procter et al., (this issue), show how the agile management of such a Web 2.0 VRE plays an important role in user engagement, coordination and delivery when requirements are uncertain, and the team must constantly negotiate tensions between what users require and what developers see as possible, or between flexibility and meeting targets set by the funding body. The authors show that agility can be practiced in a distributed environment so long as the team inhabit and participate actively in a shared communicative space (in this case, Skype

messaging) and the manager succeeds in balancing the management of people and the management of process, as well as in facilitating knowledge sharing and ongoing change and in maintaining team morale by empowering and supporting the team members. This article contributes further to understanding the lived reality of agile work and its impact on usability while so far agile development and management have been described mainly as a set of methods rather than a situated practice (e.g. Anderson 2003; Chin 2008; Puri 2009; Goodpasture 2010).

Further research could explore the role of management, leadership and facilitation in more detail with regards to the following issues:

- developing and managing a common vision on e-science projects;
- organisational barriers to collaboration and team development; legal, financial and social constraints among others;
- managing sustainability, uncertainty, change, risk, and conflict;
- managing different contexts, distributed teams and workers;
- issues of power, hierarchy, implementation and responsibility;
- managing barriers of language and culture in the teams, interdisciplinarity and other forms of cultural difference;
- managing different types of working groups, mixed teams;
- agile management;
- building trust in a multidisciplinary/interdisciplinary team;
- managing multiple projects;
- tools and forms of communication to manage disparate teams and different stakeholders;
- tools and forms of collaboration between different stakeholders;
- user engagement; requirements and design;
- managing relationships with users and user expectations;
- the role of funding bodies, commerce, industry, research councils, universities and departments and other important actors for the success or failure of e-science projects.

Researching such topics poses both challenges and opportunities for CSCW research—by enriching the existing methods and theories employed in studying e-science through ethnographic studies; by subjecting these methods and theory to critical examination; and by offering interdisciplinary insights—towards a deeper understanding of the human as well as the technical alignments in e-science.

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