

Method Matters in the Social Study of Technology: Investigating the Biographies of Artifacts and Practices

Sampsa Hyysalo

Aalto University, Finland/sampsa.hyysalo@aalto.fi

Neil Pollock

University of Edinburgh, UK

Robin Williams

University of Edinburgh, UK

Abstract

Science and Technology Studies understandings of technological change are at odds with its own dominant research designs and methodological guidelines. A key insight from social shaping of technology research, for instance, has been that new technologies are formed in multiple, particular (albeit interlinked) settings, by many different groups of actors over long periods of time. Nonetheless, common research designs have not kept pace with these conceptual advances, continuing instead to resort to either intensive localised ethnographic engagements or broad stroke historical studies, unable to address both the intricacy and extent of the process in tandem. There has consequently been increasing interest in extending current methodological and analytical approaches through longitudinal and multi-site research templates. We discuss this fundamentally methodological critique and its implications through one of these approaches: the 'biographies of artifacts and practices' (BOAP) framework, which by now offers a twenty years body of studies to reflect upon methodological choices in different sociomaterial settings. This paper outlines the basic principles of BOAP and its significant variations, and discusses its contribution to STS understandings of innovation, especially user roles in innovation. We finish by arguing that if STS is to continue to provide insight around innovation this will require a reconceptualisation of research design, to move from simple 'snap shot' studies to the linking together of a string of studies.

Keywords: method, methodology, research design, sociotechnical change, social studies of technology, design, use

Introduction

Does STS have method? There are perhaps few studies or episodes that throw into sharp contrast why STS scholars need to give more attention to

its methods than Steve Woolgar's (1991) "configuring the user" paper. Back in the 1990s, Woolgar made the argument that technology design(ers)

constrain the actions of technology users: user behaviour is configured by the designer and disciplined by the technology. Woolgar (1991: 59) wrote that through “defining the identity of future users and setting constraints upon their likely future actions”, the technology (and the designer) constructs ‘the user’. This concept was widely taken up. Along with a number of similar ethnographic ‘laboratory studies’, it became something of a model for how STS research on technology could or should be conducted. This template showed, most immediately the richness of knowledge from ethnographic studies of designer and user engagements with technology. A large number of similar studies followed, involving often intensive ethnographies of particular settings (e.g. Akrich, 1995; Oudshoorn et al., 2004). Mackay et al. (2000), in contrast, showed differently to Woolgar that configuration is not a one-way process: whilst designers do construct users, they are in turn configured by both users and the internal exigencies within their own organisation.

There are a number of potential things to say about this contrasting finding, most notably that, Mackay et al. (2000), in studying not just (one small part of) the design phase of the technology but also the technology’s implementation and use, threw light on the limitations of the Woolgarian framework. They showed how Woolgar’s research design, restricted to the study of actions and comments made by designers about the imagined ‘user’, produced a highly limited (and we may add, overly-politicised) account of design-user relations. This points to ‘closure effects’ that research design choices can have and their significant implications for the kinds of observation and interpretations the analyst might make.

The issue of how current analytical templates and research practices produce somewhat unbalanced and reductive accounts is a little-discussed feature within STS (Hine, 2007). It has been argued that, because of this, the discipline suffers from a problematic intellectual legacy that limits its potential application to wider domains (Golinski, 1998). In rallying against the universalistic claims of science and technology, STS has turned to and sought to generate a research programme out of methodological situationism (Knorr-Cetina, 1981; see also Burawoy, 1998). Importantly, as part of

this, it has historically prioritised ethnographic engagements with science and technology in the making – often through intensive laboratory studies of science (Sismondo, 2004).

Unfortunately, a considerable part of the contemporary sociotechnical landscape is inconveniently structured for these forms of social scientific inquiry. Some of the key insights of early studies of the Social Shaping of Technology (SST) in the 1980s and 1990s (MacKenzie and Wajcman, 1999) posed a methodological conundrum for STS scholars embarking upon fieldwork. They showed how new technologies were hardly ever shaped in a single setting and that processes of sociotechnical change rarely occurred over the space of a few months (the typical length of a laboratory ethnography). Rather they emerge out of and across wide-ranging spatial contexts and are more often played out over many years (and, in some cases, decades).

To provide an adequate picture of technology shaping, as Hine (2007) has remarked, one would need to study not just the intricate practices of one particular setting but the wide range of locales in which a technology evolves and even perhaps the interlinkages across these settings. In the 2000s, a new wave, characterized as ‘Mark II’ SST research, argued for methodologies and frameworks that engaged with “a wider conception of relevant actors and of the terrain of transformation” (Russell and Williams, 2002: 71). This call was prompted by scholars seeking to reflect the role of users and various intermediaries groups in shaping technology (Sørensen, 1996). This meant the array of settings necessary to understand the dynamics of technological change was multiplied even more dramatically. Others have gone further still, arguing the need to study both actors and structures (e.g. Bijker, 1995), stability and change (Bijker, 1995; Geels et al., 2016), etc. In part this recognition has emerged in response to theoretical debates around the neglect of structural conditions in both ANT and SCOT, resulting in overly situational and potentially internalist analyses (Klein and Kleinman, 2002; Russell, 1986; Woodhouse, 1991).

Here an inconvenience arises, however, because in calling for (more) sophisticated understanding of technological change, STS scholars

promote modes or (perhaps more precisely) 'visions' of research that go beyond or are at odds with their currently accepted analytical templates and research practices. Indeed, many of those advocating more encompassing approaches (e.g. Bijker, 1995; Geels et al., 2016) have themselves not lived up to the standards they espouse. For instance, those calling for the inclusion of broad historical overviews of technology development, alongside more intricate detail of technology-in-the-making (Bijker, 1995; Geels et al., 2016), have tended to assume that the phenomena that come into view with close up, real time, inquiry do not differ from the view offered by broad historical sociology. Overall, these considerations points to the need to begin to discuss the import of *research design and methodological matters* in S&TS in addition to theoretical debates, and in doing so recognizing that the research design issues are not hard-wired to particular theoretical traditions. At the same time, most discussions about methodological choices have remained deeply undertheorized and led to generic prescriptions in methods handbooks, and in so doing lost sensitivity to sociomaterial contexts investigated.

The dangers of inadequate or limited research designs are not trivial. As Law (2007) has convincingly shown, methods are performative. The same goes for research designs and study templates: the investigator's choice to limit or conversely extend the scope and scale of the research design will yield a significantly different picture of the agency, structure, impact and materialities related to the technology under investigation as illustrated by our discussion of the diverging understandings of design emerging from Woolgar's (1991) and Mackay et al. (2000) different research framings. Scholars have begun to address these issues, questioning current analytical templates and seeking to remedy them through setting out alternative perspectives sensitive to the extended (both in space and time) nature of contemporary technological development, for instances through 'infrastructure' (Bowker and Star, 1999), 'knowledge infrastructure' (Edwards, 2010) or 'information infrastructure' (Monteiro et al., 2013). Critiques of existing research designs and proposals for alternative have also emerged around the 'biographies of artifacts and practices'

(BOAP) framework, which has evolved from its first articulation in the 1990s to a point where today there exist close to twenty long-term studies of information systems, health care technologies, social media, energy technologies to name a few. The approach has developed into a coherent alternative in thinking about methodological and research design choices. In this paper we take stock of its development and import for research designs in S&TS, underscoring for instance that the portrayal of users in innovation changes further once extended research templates are used to investigate it.

We first outline the basic rationale and principles of BOAP, and discuss some of the common variations in how it has been pursued. In particular, we show how BOAP throws light on a blind spot in the otherwise emphatically reflexive STS field (Lynch, 2000): This is the failure to give consideration to such issues of how research results may be as much affected by the study framing as by theoretical point of departure. This is startling given STS attempts to explain the practical everyday accomplishment of science and technology in the making. It points to a weakness in the discipline. After this, we review how BOAP studies, in various ways, call into question some taken for granted assumptions concerning innovation. We focus in particular on conceptions of the role of the user and user-led innovation. We finish by noting one consequence of the BOAP approach: that, if we wish to develop an effective understanding of contemporary technological innovation, we will need new kinds of research design - a move from 'snap shot' studies to the linking together of 'a string of investigations'.

Biographies of artefacts and practices: origins, rationale and key facets

Origins and rationale of biographies of artifacts and practices research

The BOAP approach had two key sites of emergence in the mid- to late- 1990s, one in Edinburgh and the other in Helsinki, which merged into a shared research program by the mid-2000s. Both strands drew from SST research and its original emphasis on "technology in the making". Though

Table 1: Studies on Enterprize Systems

Studies to capture the biography of Enterprize Systems in multiple interlinked settings
Industry applications software leading to Commercial Off-The-Shelf solutions (Brady et al., 1992)
Computer-Aided Production Management (CAPM) leading to Enterprize Resource Planning (ERP) systems (Williams, 1997a)
Extension of ERP to higher education and its implementation (Pollock, 2000; Cornford and Pollock, 2003; Pollock & Williams, 2007)
Producer – User collaboration in developing new ERP modules (Pollock et al., 2003)
Evolution of Product Data Management technology in China (Wang, 2007)
Generification strategies by producers to extend ERP to new contexts (Pollock et al., 2007; Pollock and Williams, 2008)
Development and customer support by vendors (Grimm, 2008, 2012; Pollock and Williams, 2008; Pollock et al. 2009)
Package Software User groups and their influence on vendors (Mozaffar et al., 2015; Mozaffar, 2016; Pollock and Hyysalo, 2014)
Industry Analysts role in the Packaged Software Marketplace (Pollock and Williams, 2008, 2016)

initially often focused on laboratories and production facilities as the key places to study technological change (Bijker et al., 1987; Law and Bijker, 1992; MacKenzie and Wajcman, 1999), by the 2000s STS research had evolved to recognise the roles which consumers and users played within artefact development (Silverstone et al., 1992; Sørensen, 1996; Oudshoorn and Pinch, 2003). This threw light on the cycles of ‘domestication’ and ‘appropriation’ as adopters adapted systems to meet local circumstances, and the wide range of actors, particularly intermediate and final users crucial in getting new systems to work (Fleck, 1988, 1994; Miettinen and Hasu, 2002; Pozzebon and Van Heck, 2006; Sørensen and Williams, 2002; Williams and Edge, 1996). Since these cycles could be played out across multiple locales and extended timeframes, scholars sought improved research templates that could capture the range of intertwining settings involved in the evolution of complex technologies, effectively moving the studies beyond ‘innovation journey’ that had typically be assumed to end with successful commercialization (van de Ven et al., 1999; van de Ven and Poole, 2005).

The idea of that artifacts would have ‘biographies’ that feature different states of existence in connection to the social relations wherein they become to feature was proposed by Kopytoff (1986). Extended beyond only commodifica-

tion process as Kopytoff used it, the ‘biography of Artifacts’ seemed a fitting metaphor to characterize the extended and evolving nature of innovation that takes place at multiple sites and times in which, for instance, software applications in manufacturing and the service sector became shaped (Brady et al., 1992; Pollock et al., 2003; Pollock and Williams, 2008).

Parallel in timing to these Edinburgh studies, Finnish researchers used Activity Theory to investigate how Health technology innovations were shaped in networks of ‘activity systems’ and, in turn, how the involved organisations and practices evolved in the process (Miettinen, 1993; Hasu, 2000; Miettinen and Hasu, 2002). Examining change not only in technologies but also in practices, organizations and institutions was adopted in the cohering approach ‘and practices’ added to it (Hyysalo, 2010; Pollock and Hyysalo, 2014).

To date BOAP research has engaged with several types of technologies. The longest research lineages has been on Enterprize Systems (See Table 1) and health technology innovations (see Table 2) that were used to develop the BOAP methodology. Once the approach had become more elaborated in late 2000s it was more programmatically utilized, adapted and extended in a range of other settings and studies (Table 3).

Table 2: Biographical Studies of Health Technologies

Studies on Health Technology development, use and evolution
Development and use of Magneto-Electroencephalo-Graphy (MEG)-brain imaging technology (e.g. Hasu, 2000, 2001, 2005; Hasu and Engeström, 2000; Miettinen and Hasu, 2002)
Collaboration in Positron-Emission Tomography (PET)-tracer development (Hyysalo, 2000), Collaborative design and use of Diabetes management databases (Hyysalo and Lehenkari, 2002, 2003), Design and use of Safety alarm technology for the elderly and disabled (e.g. Hyysalo, 2003, 2004, 2006a, 2006b).
Development of Telechemistry diagnostic analysers (Höyssä and Hyysalo, 2009), Living lab development of safety floor system for elderly care (Hakkarainen, 2017; Hakkarainen and Hyysalo, 2013, 2016; Hyysalo and Hakkarainen, 2014)
Evolution of electronic prescribing systems (Mozaffar et al., 2014; 2015; 2016)

Table 3: Biographical Studies on other settings since 2005

Introduction of new formation systems in Greek Banking (Kaniadakis, 2006)
Social Media: Virtual world for teenagers (e.g. Johnson, 2013; Johnson et al., 2010)
Evolution of new wireless telecoms standard Wibro (Suh, 2014)
User innovation and peer support in Small scale renewable energy technologies in Finland (e.g. Freeman, 2015; Heiskanen et al., 2014; Hyysalo et al., 2013a, 2013b, 2016a, 2017, 2018; Juntunen, 2014)
Arctic all terrain vehicles (Hyysalo and Usenyuk, 2015; Usenyuk et al., 2016)
Social media: Platform for teachers and learners (Hannukainen et al., 2017)
Digital disruption in recording industry (Sun, 2016)
Development of strategic planning software for Automotive manufacturing (Wiegel, 2016)
Maritime interdiction in the war on drugs in Columbia: practices, technologies and technological innovation (a.k.a. narco-subs) (Guerrero, 2016),

BOAP key principles and concepts

The above BOAP studies highlight eight recurring characteristics, which can be considered core markers of the approach. Rather than seeing these as a ‘definition’ of BOAP, they should be seen as minimal inclusion criteria. They represent different methodological responses to the marked contingencies in sociotechnical change, which make it difficult for researchers to reliably predict in advance (for instance on the basis of theory) what might be revealed and occluded by selecting a singular or limited set of vantage points . We insist that BOAP is a methodological (and in that capacity in part meta-theoretical) approach to the study of sociotechnical change that is compatible with several substantive traditions in the STS field as we point out in discussing each marker:

1. BOAP studies must have sufficient spatial and temporal *reach* to empirically engage the dynamics of the studied phenomenon (e.g. studies could look at an individual innovation together with the evolution of an industrial field). The studies must encompass the multiple loci and times wherein sociotechnical change is shaped and move beyond singular ‘snap-shot’ accounts (e.g. those accounts that portray phenomena from a singular vantage point of e.g. designers Woolgar, 1991 or consumers e.g. Silverstone et al., 1992). This is in line with the call by Marcus (1995) for *multi-sited ethnography*, going beyond particular organisational settings being particularly relevant to highly dispersed processes of scientific and technological life (Hine, 2007; Monteiro et al., 2013) and by those advocating more structural considerations as part of S&TS analyses (e.g. Klein and Kleinman, 2002; Russel, 1986);

2. The shaping of technology and practices must be viewed as taking place within *ecologies of interconnected actors*, and not only study the actors only with respect to how affect the studied technology (e.g. see Bijker's [1995] "relevant social groups") as this leaves aside the rationales by which they operate. It also misses the often complex and subtle mechanisms by which actors within an ecology interrelate (Russell, 1986; Hyysalo, 2010; Pollock and Williams, 2016). This BOAP premise is similarly found in other ideas and disciplines (e.g. 'linked ecologies' (Abbott, 2005); 'social worlds-arenas' framework (Clarke and Star, 2003); 'networks of activity systems' (Engeström, 2000));
3. It may be particularly fruitful to identify and research *interstices*, the moments and sites in which the various focal actors in the ecology interlink and affect each other and the evolving technology. An overall understanding of the ecology of actors is typically used to pinpoint key locales where these interstices may be researched in detail, perhaps by ethnographic means. A typical case is Hyysalo's (2004) delineation of 'visible handshakes': settings and processes by which developers and users of health technology were effectively co-constructed. Similarly Mozaffar's (Mozaffar et al., 2015, Mozaffar, 2016) study of the innovative role of packaged software user groups, led her to quickly realise that the key developments were no longer in the subgroups she had chosen to study, leading her to shift field sites until she had traced how the innovation activities had evolved (Mozaffar, 2016). The focus on interstices is shared by many in S&TS, classic cases being Hennion (1989) and Callon et al. (2002) yet the use of broader scale analysis to identify the sites to focus on is more rare, yet found in studies of infrastructures Monteiro et al., (2013); Ribes and Polk, (2015) and in studies examining the evolution of scientific fields (e.g. Cambrosio and Keating, 1995; Edwards, 2010; Fujimura, 1996);
4. Pursue research at multiple temporal and spatial *scales*. BOAP is at odds with accounts that assume sociotechnical change could be adequately understood through a 'birds-eye' descriptions only. There is a need to bridge between the analyst's bird's eye view and the actors' real-time 'frogs' eye' perceptions, which typically feature high levels of uncertainty and contingencies (e.g. the 'fog of innovation' (Höyssä and Hyysalo, 2009)) that can entirely disappear from historical data and broad overviews. 'Data grain size framing effects' e.g. where studies limit themselves to just one preferred level of data and analysis (a.k.a 'granularity bias' (Hyysalo, 2010)) are surfaced in BOAP investigations time and again. Questioning the dominant research framings in literature can be the starting point for inquiry into a richer set of contexts (e.g. Stewart and Hyysalo, 2008) or the major outcome of the investigation (e.g. Hyysalo, 2010; Pollock and Williams, 2008, 2016). This facet is shared in STS oriented technology and organisation studies in studies of practices (e.g. Nicolini, 2012), Activity theory (Cole, 1996; Engeström, 2000) and in Symbolic Interactionist Social worlds – Arenas framework (Strauss, 1978; Clarke and Star, 2003; Clarke, 2005);
5. Different temporalities and spans of change are seen as *multiple enacted contexts* (Hyysalo, 2004, 2010), not as the ontologically distinct layers that emerge for example from the 'multi-level perspective' (Braudel, 1995; Geels, 2002; Geels and Schot, 2007) or the traditional approaches that locate action within context conceived as 'surrounding layers' (Strauss and Corbin, 1990). In BOAP, events are seen as simultaneously constituting and being constituted by broader patterns: the context for any situation is understood as being comprised of differently paced constituents, as previously discussed in microhistory (e.g. Levi, 1988) and socio-cultural psychology (Cole, 1996; Engeström, 1987) and in distributed cognition (e.g. through the 'Hutchins cube' where the same moment is analysed in terms of the development of practitioners, practices and the situated enactment of action (Hutchins, 1995)). BOAP thus seeks to inquire into the links between relevant constituents to see their influences and interrelations (or lack of). Studying different contextual constituents

means employing an array of often differing, conceptual tools, analysis types and methods to diverse materials (Hyysalo, 2010: 43). BOAP's preference for ethnographic study thus does not mean an in-built 'micro sociological' focus, but an examination of how the structuring elements are present in real-life situations, and in turn, how the situations reshape the structuring elements and what can be learned about the patterns and structures as they are enacted. The position resonates with Situational analysis by Clarke (2005) yet refrains from flattening the empirically salient topologies in contextual factors (Star, 1995) and thus differs markedly from actor-network theory (Latour, 1987, 2005) or Ethnomethodology (e.g. Suchman, 1987);

6. Investigate the shaping and shape of technology in the process. Akin to many STS approaches, BOAP studies insist on paying attention to *materiality*: the content and form of technology as it shapes, and is shaped by, the interrelations between actors (Latour, 2005; Kallinikos, 2004). This goes for the material nature of the focal technology studied (and differences that results from these being e.g. complex large software systems, discreet physical objects, or only partially tangible methods or services), as well as the production systems, tools and infrastructures which designers and users enact in their practices (cf. Cambrosio and Keating, 1995; Galison, 1997). This is to say, BOAP insists on carefully investigating the different materialities and their effects in different sites and times of technology's life and carefully reflecting on what this entails for the overall research design - something more often claimed than carefully done in social studies of technology!;
7. Create *balanced and empirically adequate* accounts of the different actors in the ecology phenomena, rather than assume, for instance, that key design decisions would be made by designers (for, as we discuss below they often come from users);
8. Attend to the *detailed dynamics of sociotechnical change* both empirically and theoretically. This has been the focal interest in all BOAP research to date. It has involved pursuing a

detailed understanding of change in different settings and moments. This is at odds with resorting to high-level depictions of sociotechnical change. We discuss below the risk that widely adopted SST conceptions of sociotechnical change as 'social construction' or as 'mutual shaping' or 'systems transition' as a template to characterise the relevant processes and nett outcomes may be used as an excuse for high level generalisation that occludes the detailed processes constituting it (see below section on main findings of BOAP program) (Bijker, 1995; Schot and Geels, 2007; Geels et al., 2016).

To further clarify this rationale let us contrast the BOAP approach to the methodological criteria for investigating the socio-technical change in classical STS studies. For instance, Bijker (1995) notes that a theory of sociotechnical change needs to provide symmetrical explanation of success and failure; to engage with change/continuity; and the interplay between actor/structure in the seamless web of technology production. While we agree with these points, our dissatisfaction with large bodies of STS studies is that they struggle to live up to their own criteria due to their unduly simplistic and limited research designs. In this respect, the above BOAP core elements offer a set of *guideposts* for what it would mean if scholars sought to take these ambitious goals seriously, in light of our current understandings of sociotechnical change.

BOAP research designs and what these imply for S&TS researchers

Ideally, as the above guideposts suggest, BOAP investigation would connect in-depth studies of the various interlinked actors involved in, and affected by, the sociotechnical change in question. This means deploying a number of mutually complementary studies on different aspects of the biography of technology, and over different time frames of analysis. Practically, the development of BOAP investigations may be more or less programmatic depending upon the availability of resources (e.g. staff time, the research funding environment) and access constraints. The beginnings of a BOAP investigation may not differ much

from any other STS research, but as the research progresses, previous research is extended to a string of further studies – building upon existing knowledge and the various ideas/issues that unfold from this work, reflecting upon puzzles and gaps in understanding and emerging theorising. Herein lies an important research design issue that is not unique to BOAP but concerns STS research broadly: what does one do after initial research set-up and findings? STS authors critiquing situated single site analyses share this concern (Karasti and Blomberg, 2018; Hine, 2007) and BOAP studies have been fiercely critical of STS researchers' apparent infatuation with single 'snap-shot' studies that are often rich on detail and insight, but by necessity limited to a single locus and moment and often revolving around the perspective of a single actor group– offering a narrow viewpoint in the process of how technologies are shaped (Hyysalo, 2010; Pollock and Williams, 2008). Reflecting on our own evolving research practices we observe that BOAP research design progressions feature different kinds of *continuation strategies*:

- 1) There is an opportunity to extend enquiry longitudinally – which may serve to increase our robustness of understanding of innovation processes and their outcomes and in particular to revisit knowledge claims made in previous studies (which as Pollock and Williams (2008) note, in their ERP study, were almost the reverse of the eventual outcomes) and in this way explore the effects of temporal closure on findings. Extension has taken place either through follow-on studies in affinity to ethnographic studies of infrastructuring (e.g. Karasti and Blomberg, 2018) or through an historical analysis of the studied phenomena and its context (e.g. Hyysalo, 2004; Hyysalo and Usenyuk, 2015; Pollock and Williams, 2008; Usenyuk et al., 2016) in affinity to activity theoretical studies (Engeström, 2000; Miettinen, 1998).
- 2) There is an opportunity to broaden the empirical scope of study across different settings. Here there may be a balance between what we may describe as intensification and excursion:
 - a) *intensification* – characterises studies which have pursued a more comprehensive and detailed exploration of the developer-user nexus (e.g. Hyysalo, 2010; Hyysalo and Usenyuk, 2015; Johnson, 2013), where research has progressed through several parallel scales of inquiry: from tracing the biography of a technology development or the evolution of practices in use to undertaking episodic studies (of varying durations of minutes to months) of design, appropriation/implementation and use. As these parallel studies progressed, focal points for detailed ethnographic enquiry would begin to be selected: chosen so that they are likely to be informative with regard to broader scales of change in design–use relationships as indicated by previous studies and/or likely to reveal patterns in sociotechnical change that were of special interest for the study.
 - b) *excursion* – refers to cases in which the follow-on studies engage with new sets of relationships, locales, and types of actors identified in previous studies. In the course of such a journey, the research questions are likely to change significantly. Thus the research journey undertaken by Pollock and Williams took them from addressing ERP implementation challenges (Williams, 1997b), to understanding the developer–user nexus in packaged software development (Pollock and Williams, 2008), to understanding the knowledge infrastructures and new kinds of actors which underpin the operation of the IT market (Pollock and Williams, 2016). Similarly, Hyysalo et al. (2013a, 2016a) have moved from user innovation in renewables to peer support, to user created information infrastructures, to user roles in affecting energy transition (Heiskanen et al., 2014; Hyysalo et al., 2013b, 2018).

BOAP investigation data, methods and interpretation

STS research is often given credit for its versatile data gathering and analysis methods. The variety in available data tends to grow with multi-sited and longitudinal studies such as those in BOAP, which have typically combined ethnographic and historiographic methods including the collection of documents, in-depth interviews and records of field observations. Access and data availability regularly feature as key research design considerations in BOAP studies. Given the increasing salience of electronic communication (especially in studies of social media and software packages), digital traces of user behaviour and design change logs have proven very useful (Johnson, 2013). Pollock (Pollock and Hyysalo, 2014) gained unrestricted access to a key informant's email communications across a long timeframe, which allowed for tracking the interplay between actors in detail as it evolved. The studies of user innovation in renewable home heating analysed half a million posts on Internet discussion fora in varying detail (Hyysalo et al., 2013a, 2013b, 2016a).

Multiple data sources and types allow both data and method triangulation (Denzin, 1989). Extending S&TS enquiry beyond single settings emphasises how different data types and sites of data collection also typically have their own framing effects. Ethnographic observation, recorded in field notes and audio and video recordings provided a first-hand experience of the realities of design and use of technology. However, these are 'noisy' and chaotic settings; understanding and experience accumulates only slowly and partially – some elements may be taken for granted; other processes may not yet be readily recognised by involved actors or research scholars but may only emerge over time or by contrasting different settings. Interviews provide a more focused method of eliciting knowledge but may be shaped by the interests and self-justification of actors involved. Thus interviews with technology developers may be coloured by their (often enthusiastic) visions and goals and may therefore conflate potential with achievement. Users, whose perspectives are constrained by particular locales, conversely may be well versed in current practices but may lack the breadth of experience or skills needed to develop a clear picture of unfolding developments or anticipate

futures. The immediacy of ethnographic insights arising from field observation and interview could bring to the surface particular conflicts, concerns and events that appeared particularly interesting for research, and in this way assist in analysing other sources of data, such as documents, but could conversely tempt scholars to exaggerate the unique importance of the particular processes, events and settings observed.

Similarly to other multisite studies, BOAP research designs are built to allow for the further juxtaposition of different actors' narratives and perspectives, and in doing so increasing the trustworthiness and robustness of analysts' interpretations through two mechanisms. First, through studying different actors across several inter-linked sites and comparing juxtaposed accounts, otherwise taken for granted features and local *framing effects* can be unpicked and balanced accounts of interaction created. Moreover, second, the extended scope of study tends to level out particular actor concerns or displays put on for the ethnographer when one enters the site over a sustained period.

A characteristic feature of data analysis in BOAP studies has been a recursive movement between different data-sets and different sampling strategies to examine data at different grain-sizes. Analysts typically seek to construct some overarching narrative(s) of the biographies in question (whether this is over months, years or decades). At the same time, they typically work on more detailed analyses of the most interesting processes within and perspectives on the data. Often the two proceed in parallel: when the analyst develops insights into specific events, s/he typically explores possibilities to trace connections and smaller or larger contributions to the overarching narrative(s). The broader scale descriptions, in turn, help to position particular events in relevant contexts. Figure 1 offers a stylised representation of the research design developed for Hyysalo's (2010) study of safety-alarm systems for the elderly. The arrows represent research activities; circles represent shorter episodes that the informants or the researchers regarded as particularly significant. Different bodies and granularities of data and time frames of analysis were systematically compared.

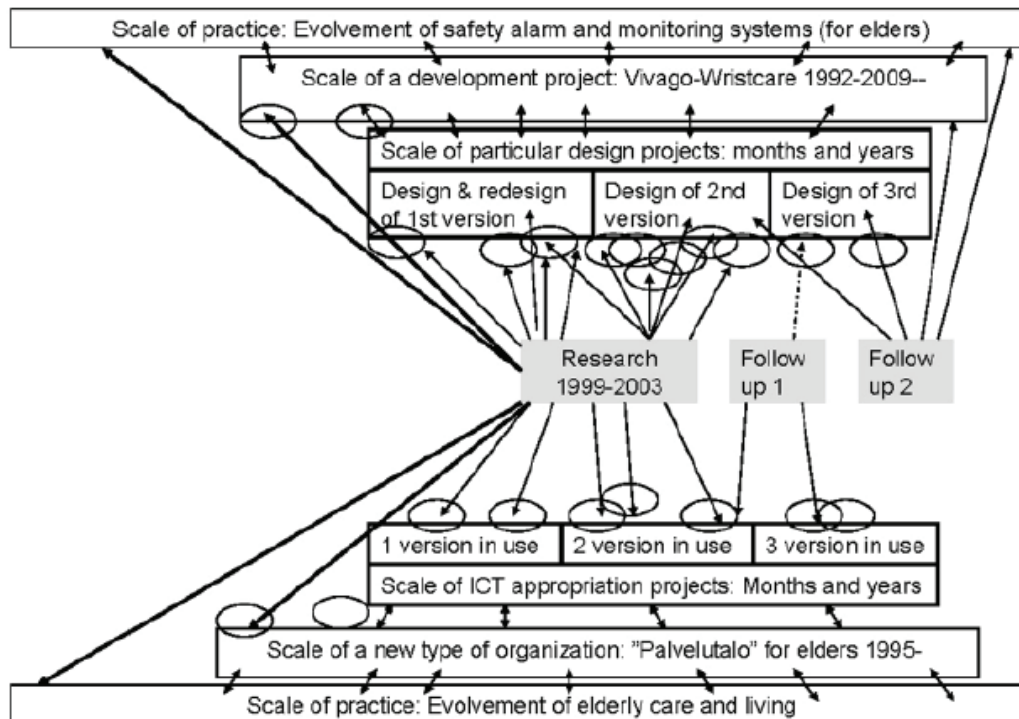


Figure 1: BOAP Research design on studying health technology in a start up.

We now illustrate why this research approach and analysis procedures are worthy of attention on the grounds of its contribution to theory building by examining four instances where BOAP studies have called into question widely established understandings of innovation, and in so doing, opened up a series of new questions and resonances between STS and related approaches in innovation studies and design research.

BOAP as a vehicle for empirical and theoretical knowledge creation: Some key findings

Beyond User involvement as localisation and empowerment

In STS and related fields oriented to responsible design (e.g. participatory design, human centred design, computer supported collaborative work), user involvement has traditionally be seen as a vehicle for empowerment, and a means for achieving effective technologies (Hyysalo et al., 2016a; Schuler and Namioka, 1993; Simonsen and Robertson, 2013; Stewart and Williams, 2005;

Voss et al., 2009a). As well as ensuring user participation and engagement in implementing new technologies, this has included calls to involve users, including end-users who will operate the technology, in systems design and development. This view of the importance of involving users – with their knowledge of existing technologies and operating procedures - finds a close parallel with studies of the role of users in Innovation Studies. Here scholars have differentiated user domain knowledge and manufacturing domain knowledge and highlighted the presence of difficult to transfer ‘sticky’ knowledge between these domains (Baldwin and Von Hippel, 2011; Tyre and Von Hippel, 1997; Von Hippel, 1988, 2005).

Findings that have emerged from longitudinally following technology development in multiple sites within BOAP studies call into question some of these ‘one-sided’ accounts of users and innovation. For example, its equation with empowerment, or the assumption that user involvement early in the systems design is the most decisive way to bring user domain knowledge into design (contrasted by instead the ways in which users

contribute to the reworking and evolution of technology in use - see below). BOAP also foregrounds how user involvement is not necessarily only about localisation (another key presumption). Users are also involved in efforts to 'generify' packaged products, in detaching their features from those matching too closely particular localities and become suited in a variety of different customer sites (Hyysalo and Lehenkari, 2002, 2003; Pollock et al., 2007; Pollock and Williams, 2008). Generification can potentially disgruntle existing users as their specific needs may end up deprioritised in the redesigns that render the package appealing to wider clientele (Hanseth and Bygstad, 2015; Johannessen and Ellingsen, 2009). To mitigate this risk, producers have been found to pursue various user involvement strategies. First, users (as individuals, as particular organisations or as broader user communities) are part and parcel of what may be strategic development directions for the vendor. They are also monitored for user developed solutions that can be incorporated and further iterated into producer offerings (Johnson et al., 2014a; Mozaffar, 2016; Pollock and Hyysalo, 2014). Second, users are part of "cacophony management": forging consensus among the conflicting preferences found within the clientele (e.g. about what ought to become general features (Hyysalo and Lehenkari, 2003; Mozaffar, 2016)). Third, users are involved in witnessing and consenting to development directions elevated as strategic, and thus imperative, for the vendor (Hyysalo and Hakkarainen, 2014; Johnson et al., 2014a; Mozaffar, 2016; Pollock and Williams, 2008). Indeed vendors of standard solutions have been forced to develop strategies to orchestrate their relationships with their user communities (Johnson, 2013; Johnson et al., 2014a).

Importantly, longitudinal biography studies show that categorising innovation as being either by the user or by the manufacturer is in many cases misleading. Most innovation processes have a shifting locus of innovation regardless of whether they started from users or producers. Biographies of innovation tend to be long and winding journeys rather than a clear one time-space event. In many cases, an adequate register would be to talk about user *contributions* to innovation rather than contrasting user (i.e. "user innovation") and

manufacturer innovation (Johnson et al., 2014b; Hyysalo, 2009; 2010; Hyysalo et al., 2016b; Pollock and Williams, 2008; Usenyuk et al., 2016). This is particularly pertinent given the ongoing mainstreaming of user involvement as a resource within innovation strategy rather than a means for empowerment (Hyysalo et al., 2016a). Instead of an "empowered user", the industry operates with "managed prosumers" e.g. efforts to produce productive users (Hyysalo et al., 2016a; Johnson et al., 2014a). These are users who are engaged in marketing, community building, forecasting and co-financing in addition to their contributions to design and usages (Mozaffar, 2016; Pollock and Hyysalo, 2014). Many users are not naïve either. They participate in technology development for various reasons, which are not limited to creating better technology. Rationales for involvement include gaining personal skills, getting their (technology or service) needs met, securing access and proximity to the vendor. The 'business of being a user' can reach further into strategies in affecting competitors and the interplay of different user sub-communities and longer development paths of products and services (Pollock and Hyysalo, 2014).

The observations of extended user involvement, range of roles and considerable amounts of design-in-use have resonated with and to some extent informed parallel development in design research, where approaches for extended co-design and infrastructuring have emerged. Some of the work had direct interactions with BOAP such as the *co-realization* approach, where the collaborative systems design is extended to the workplace after launch to engage in development once a system is "used in anger" and its various possibilities, limitations and organizational implications become clearer (Hartswood et al., 2002; Voss et al., 2009b). Similar ideas have then been picked up in extended co-design with and for communities of practice (Botero, 2013; Botero and Hyysalo, 2013). These approaches have recently blended in with *design for infrastructuring* (Buscher et al., 2009; Karasti and Baker, 2004; Karasti et al., 2010; Pipek & Wulf, 2009) seeking to create computer systems (or systems-of-systems) that can support the development of effective work practices and enhancements over a long

period – again paralleling the BOAP study shift into knowledge infrastructures.

In sum, once the research design is extended to cover multiple loci and times in the technology's biography, the processes of and rationales for engaging users in innovation appear in new and considerably different light. Situated local use and generic design of a product are, in a more encompassing view, snapshots of the complex interplay of user and developer contributions in the protracted processes of innovation. We shall next move to examine the purport of this in conceptualisations of technology-user relations in STS.

Configuring the user vs. series of configurational movements

Many early technology studies writers adopted from the sociology of science the idea of 'closure' of meaning and stabilisation of form (Bijker and Pinch, 1984; Latour, 1987). The success of technology was treated as an outcome of efforts to enrol the relevant stakeholder groups in accepting what the appropriate form and meanings given to technology would be. If all the work—including standardisation; black-boxing of functionality; integrating the technology into wider systems; and creating markets, practices, and distribution—achieved its mark, the network supporting the technology would be hard to reverse, also making the success of the technology appear inevitable in retrospect (Bijker, 1995; Callon, 1991; Latour, 1987).

Various concepts were coined to address closure as well as the opening up of technology. "Configuring the user" attempted to describe how designers built 'the user' into technology in ways that favoured enactment of only certain kinds of uses and users (Grint and Woolgar, 1997; Woolgar, 1991). 'Domestication' conversely addressed how the form and meaning of new technology were altered when it was placed in contexts of use with their own pre-existing social and moral order (Silverstone et al., 1992; Sørensen, 1996). Inscription, prescription, and users' subscription or de-inscription conceptualised the interplay between the efforts of designers and of users in crafting and making their own reading of technology design and use in ways analogous to

author/readers of the script of a play (Akrich, 1992; Akrich and Latour, 1992; Latour / Johnson, 1988).

The extended research designs across BOAP studies show that instances where overly zealous developers succeeding in mechanistically configuring the user (a la Woolgar) are rather exceptional. When observed at more length, such configuration goals are often complemented by arrangements geared towards enticing users into using technology, assessing their responses to new technology, and articulating their preferences and getting them represented in design (Johnson et al., 2014a; Mozaffar, 2016; Pollock and Hyysalo, 2014). BOAP studies do not suggest, however, a wholesale dismissal of Woolgar's concern with how design may seek to prefigure users and use. It is a good starting point but requires a conceptual shift towards viewing technology developer-user relations not as discrete episodes but as a *series of configurational movements*. There is the gradual and continuous shaping of technology that takes place in multiple arenas and modes in the life of technology, con-figuring things together into assemblies and capabilities for action and actors becoming included in its story, in the biography of technology.

Our conceptualization of technology development and user-developer relations is more detailed and extensive than innovation studies concepts such as "interactive model of innovation" by Freeman (1979) involving supplier-user coupling and "learning by interacting" (Lundvall and Vinding, 2005) or in the widely adopted STS terminology of "mutual adaptation" of technology and organization (Leonard-Barton, 1988; McLaughlin et al., 1999). Indeed these generic conceptualisations may be argued to act as what could be called 'cloaking metaphors' in that they flag the need to get inside the process, but are used as a promissory substitute for this analysis (for similar arguments regarding cloaking in such models and ensuing erroneous results see Miettinen, 2002; Scott-Kemmis and Bell, 2010; Tyre and Von Hippel, 1996). The more technical usage of 'configuration' retains the sense of the many elements being figured together, while resisting connotations of a unified and universal entity that might be implied by terminologies of a system, object, or artefact (Fleck, 1988, 1993). This

is particularly relevant in characterising complex technologies such as ICT in equally complex organisational settings. Many aspects of configurations reach temporary closure and become more difficult to reverse. *Pre-configuration* among designers tends to reflect some closure of meaning and stabilisation of form among them. Pre-configurations among users include, but are not limited to, procedures, routines, norms, conventions of artifact usage, and patterns in implementing new technologies. Other typical pre-configurations are those of regulators and institutions connected to a particular kind of technology or domain of users. Any closure or stabilisation reached only among partial constituencies (whether of designers, users, or third parties) tends to remain limited in time and in space. Technological configurations are routinely subject to *de-configuring*, altering and questioning the technology, extant ways of practising and regulation. They are also regularly subject to *reconfiguring*: connecting, adding in, repurposing, omitting, and creating new solutions that change the shape of the socio-technical configuration. Importantly, these moments blend in with above noted active forms of *co-configuring technologies and practices* along the more or less contested sets of developer-user relations, and passive co-configuring such as acceptance of shortcomings, silencing of some of the problems, agreeing to defer changes et cetera. (Helgesson and Kjellberg, 2006; Hyysalo, 2010).

The analytical focus upon series of configurational movements is not merely of value in exploring designer-user relations but can be more broadly applied to a number of actor strategies in the course of distributed innovation processes. Actors have limited capacity to engage across temporally and spatially wide-reaching (indeed, potentially unbounded) interaction processes and, instead, make a series of partial interventions within their span of control and relevance. For example, industry analysts like Gartner have a strategic position in making the market, but this is a fragile achievement rooted in their ability to retain cognitive authority - something they must do again and again across multiple fields (Pollock and Williams, 2016). There are no guarantees as to the power of their position and, in contrast to the immutability implied in ANT terminology

of *Obligatory Passage Points*, they have to retain their position vis a vis other sources of knowledge within the continually transforming industry field (ibid).

The ability to follow technology over long-term whilst zooming-in on key moments thus flags the generative nature of partial closures and stabilizations. These appear equally requisite for 'success' and 'failure'. As Pollock and Williams (2008) note, "if a supplier like SAP has succeeded in conquering the world, it did so one sector at a time, carefully, in a process characterised by setbacks and 'reversals'"

The high(er than expected) prevalence of innofusion

Tracing the series of configurational movements across studies has also come to highlight the importance and higher prevalence of phenomena that had been seen as exceptions. The notion of *innofusion* e.g. the blending of innovation and diffusion in the evolution of new technology (Fleck, 1988, 1993) is one of these. Innofusion was first observed in industrial robotics in the 1980s (Fleck, 1988, 1993), where a purportedly general purpose technology (robotics) had to be tailored and further developed for specific purposes at the sites of use. This further development work was shared between the vendors and customers and allowed the robotics technology to establish useful applications. Despite its clear contribution to improving the technology, innofusion was often not planned or wanted by developers or users. Neither party expected they would need to invest further development efforts in a seemingly ready technology.

Innofusion fell off the conceptual radar in both Innovation Studies and STS or was portrayed as simply characterizing a specific development context and time. This appears to have been, however, an artefact of methodological preferences: Innovation studies scholars preferred to conduct studies of innovations at a lower level of resolution than is needed for innofusion to become apparent, while the prevalence of single site studies occluded the phenomenon from STS and qualitative information systems researchers. In BOAP studies, however, innofusion appears common and to take multiple different forms. *Unwanted 'accidental' innofusion* akin to Fleck's

original study has been documented in many settings including multimedia (Williams et al., 2005), health care applications (Hyysalo, 2010; Hyysalo and Hakkarainen, 2014), renewable home heating technologies (Hyysalo et al., 2013a, 2013b; Heiskanen et al., 2014).

But other forms of innovation processes have also been identified. Complex enterprise software packages featured similar dynamics. However in this setting, rather than disorganised innovation, vendors had devised whole repertoires for handling it (Pollock and Williams, 2008). This pattern of *managed innovation* has been since found in packaged software more widely: among different ERP/CRM vendors (Mozaffar, 2016; Mozaffar et al., 2015; Wang, 2007), logistics software (Wiegel, 2016), and health record systems (Hyysalo and Lehenkari, 2002, 2003). Similar mechanisms arise in collaborative development arrangements such as living labs (Hakkarainen and Hyysalo, 2013, 2016; Hyysalo and Hakkarainen, 2014) and long-term co-creative design where the development effort is purposefully arranged to happen at real user sites (Botero and Hyysalo, 2013, Hartwood et al., 2002).

In 'perpetual beta' digital service development strategies there is further intensification, a *planned innovation*, where innovation is taken as the core organising principle for service development. No longer being orchestrated for each new customer segment at the time, short release cycles are used throughout to adjust the service to emerging usage directions, peer content creations and changes in customer base (Johnson, 2013; Johnson et al., 2014b).

Finally, studies on user's innovative activities show that *dispersed innovation* may also remain an effective, albeit not necessarily very efficient, innovation dynamic in cases where no developer company/community takes charge of coordinating, re-integration and generification of site specific adaptations by users. Usenyuk's study of user designed ultra-light arctic vehicles shows how highly site specific construction 'proximal design', a thorough blending of innovation and diffusion, can result in gradual elaboration of construction principles and emergence of a wide-spread complex class of technology (Hyysalo and Usenyuk, 2015; Usenyuk et al., 2016). Even in such

dispersed cases, various interaction arenas and repositories of knowledge were needed for innovation to proceed across sites.

To sum up this section, research design and methodology choices affect greatly the conceptual models and empirical understanding of studied phenomena. Through the example of user involvement in innovation we illustrated how localist studies have maintained limited and outdated views of the roles that users play in innovation; how the extended research designs of the biography approach suggest new conceptual synthesis that is able to intertwine key insights from detailed studies to long-term processual views of innovation; and how methodological choices are not relevant only in the elaboration of new concepts but in assessing the relevance (or otherwise) of existing ones as the case of innovation suggests.

Conclusions

Together with other scholars, we have argued that science and technology are inconveniently structured for many of the analytical templates deployed by STS scholars (Hine, 2007). Studies limited to single or a few sites and times in the shaping of technology have become popular in STS, shaped on the one hand by pragmatic constraints of project funding and duration and on the other by the localist turn and the effectiveness of ethnographic methods in eliciting practitioners' understandings.

The reluctance of STS scholars to discuss issues of research design and practice has allowed the adoption of simplified research designs involving narrowly framed field studies (or conversely, broad-stroke historical descriptions). However, STS needs to move given its historical scepticism towards 'method' (Latour and Woolgar, 1979) if it is to continue to apply its insights to wider domains (Golinski, 1998).

There is the need for studies that not only drill down into the detail of settings, but, at the same time, pay attention to the long time spans of technological development. We remain sceptical regarding the practical forms of guidance that current templates provide for researchers about how to address technologies across multiple

levels and time frames. Without the analytical cues as to the important sites and settings for investigation, encompassing the broader context as well as immediate sites of interaction, we find ourselves encouraged towards one or other type of (narrow) research design.

Whilst empirically focusing on single settings or moments has provided resources for some of the important narratives favoured by STS scholars, they have (more unhelpfully) created *framing effects*. This fragmentation and framing of enquiry has consequences. It (more or less drastically) limits our understanding of the workings of technoscience, and runs the risk of generating reduced forms of analysis. We have identified a number of failings of interpretation that arise, for example, both in our own work and that of STS scholars more generally, when studies embrace one or other mode of study and neglect immediate or historical processes. These may be adequate for understanding simple social interactions (as exemplified by Woolgar's (1991) 'configuring the user' study) but have serious drawbacks in grappling with the multiple interconnections of modern societies arising in particular from globally integrated technological systems.

The BOAP approach was borne as a response to this problem. It argues for greater thought to be given to more adequate methodologies and research designs capable of dealing with the complex phenomena under investigation. BOAP provides the means to explore, rather than take for granted, the different actors and factors in the course of the social shaping of technology. Let us be clear. We are not suggesting the capture of the *full* range of actors and factors involved in the biography of a technology. This would not be feasible let alone desirable. But we are clearly saying that not capturing the full range of actors does not entail that whatever goes. In practice, research can only unevenly and incompletely approach the ideal of covering all the key sites and their interrelations. Every research design involves choices about where to address research effort. New sites and relations become visible in the course of fieldwork. What we have illustrated is how STS as a field may require more awareness to what approaches it uses to encourage decisions (and compromises) about which black boxes to

open for detailed examination and those which are to be left unexplored. This calls for flexibility in research design coupled with the willingness to keep on pursuing the line of investigation beyond the single setting and project funding.

No method or framework is without limitations. The analytical template of biographies of artifacts and practices set out in these pages is not easy or without challenges. When first introduced to these ideas, scholars often respond that the ideal of addressing multiple sites and temporalities is admirable but impossible to achieve. It can also be potentially demoralising, indeed inhibiting for those moving into a new research field within time and resource constraints. Our own experience runs to the contrary. More encompassing research designs are doable if one takes it as a long term goal and not a rigid one-off requirement for a specific research project. As part of this we argue for a move from snap shots to the linking together of a *string of studies*. This would be to knit together different kinds of evidence—that includes historical studies, ethnographic research, qualitative studies of local, and broader development. While BOAP investigations may start with specific discrete studies, with a limited scope, they will be conducted with an awareness of how a more robust understanding might be achieved by addressing a wider number and range of settings and extended temporal framing. Attempts to expand the empirical scope must confront pragmatic constraints of gaining access to different sites, the availability of respondents and documentary materials, the timing and pacing of developments being studied, the limitations of typical research projects and difficulties securing funding for follow-up studies, etc. Overcoming these constraints may call for a group effort, bringing together multiple researchers to work on different sites and times to more overarching depiction of the phenomena under study.

Finally, a small reflection on the domains in which one needs such complex methodological templates. BOAP emerged in research on information infrastructures and health technologies, characterized by the complexity of technology development, implementation and use. It has subsequently been successfully and fruitfully applied to a range of settings, technological forms

and moments of innovation from Arctic sledges and South American Narco Submarines to automotive manufacturing systems and teenage virtual worlds. The BOAP approach suggests a need to adjust the specific research strategy within the approach according to the sociomaterial form of the technologies and practices being studied and also the foci selected. Developing further the repertoire of specific strategies for different settings is methodological work-in-progress. This all is to say, as convenient snap-shot studies may be, we suggest it is time to move beyond single

focus studies in STS and open up for reflexive discussion wider repertoires of research design. This paper seeks to open up this debate.

Acknowledgements

Sampsa Hyysalo acknowledges support from Academy of Finland grant no: 289520 "Getting collaborative design done". Neil Pollock acknowledges support from the UK Economic and Social Research Council (ESRC) grant no: ES/M007626/1 'Ranking the Rankers'.

References

- Abbott A (2005) Linked ecologies: States and universities as environments for professions. *Sociological Theory* 23(3): 245-274.
- Akrich M (1992) The description of technological objects. In: Bijker WE and Law J (eds) *Shaping Technology / Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press, pp. 205-224.
- Akrich M and B Latour (1992) A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies. In: Bijker W and Law J (eds) *Shaping Technology / Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press, pp. 259-264.
- Akrich M (1995) User representations: Practices, methods and sociology. In: Rip A, Misa TJ and Schot J (eds) *Managing Technology in Society*. London: Cassel Publishers, pp. 167-184.
- Baldwin C and Von Hippel E (2011) Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science* 22(6): 1399-1417.
- Bijker WE (1995) *Of Bicycles, Bakelite, and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge, MA: MIT Press.
- Bijker WE, Hughes TP and Pinch TJ (eds) (1987) *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.
- Bijker WE and Pinch TJ (1984) The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science* 14(3): 399-441.
- Botero A (2013) *Expanding Design Spaces*. Helsinki: Aalto University Press.
- Botero A and Hyysalo S (2013) Ageing together: Steps towards evolutionary co-design in everyday practices. *CoDesign: International Journal of CoCreation in Design and the Arts* 9(1): 37-54.
- Bowker GC and Star SL (1999) *Sorting Things out: Classification and Its Consequences*. Cambridge, MA: MIT Press.
- Brady T, Tierney M and Williams R (1992) The commodification of industry-application software. *Industrial and Corporate Change* 1(3): 489-514.
- Braudel F (1995) *Mediterranean and the Mediterranean World at the Age of Philip 2*. Translated by S. Reynolds. 2nd revised edition. Berkeley: University of California Press.
- Burawoy M (1998) The extended case method. *Sociological theory* 16(1): 4-33.
- Büscher M, Christensen M, Hansen KM, Mogensen P and Shapiro D (2009) Bottom-up, top-down? Connecting software architecture design with use. In: Büscher M, Slack R, Rouncefield M, et al. (eds) *Configuring User-Designer Relations*. London: Springer, pp. 157-192.
- Callon M (1991) Techno-economic networks and irreversibility. In: Law J (ed) *A Sociology of Monsters: Essays on Power, Technology, and Domination*. London: Routledge, pp. 132-161.
- Callon M, Méadel C and Rabeharisoa V (2002) The economy of qualities. *Economy and Society* 31(2): 194-217.
- Cambrosio A and Keating P (1995) *Exquisite Specificity*. Cambridge, MA: MIT Press.
- Clarke AE (2005) *Situational Analysis—Grounded Theory after the Postmodern Turn*. Thousand Oaks, CA: Sage.
- Clarke AE and Star SL (2003) Symbolic interactionist science, technology, information and biomedicine studies. In: Reynolds LT and Herman NJ (eds) *Handbook of Symbolic Interaction*. Walnut Creek, CA: Alta Mira Press, pp. 539-574.
- Cole M (1996) *Cultural Psychology: A Once and Future Discipline*. Cambridge: Harvard University Press.
- Cornford J and Pollock N (2003) *Putting the University Online: Information, Technology and Organizational Change*. London: Routledge.

- Denzin NK (1989) *The Research Act: A Theoretical Introduction to Sociological Methods*. 3rd edition. Englewood Cliffs, NJ: Prentice Hall.
- Edwards PN (2010) *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge, MA: MIT Press.
- Engeström Y (1987) *Learning by Expanding: An Activity-Theoretical Approach to Developmental Research*. Helsinki: Orienta-Konsultit Oy.
- Engeström Y (2000) Activity theory as a framework for analyzing and redesigning work. *Ergonomics* 43(7): 960-974.
- Fleck J (1988) Innofusion or diffusation? The nature of technological development in robotics. *Edinburg PICT Working Paper* 4.
- Fleck J (1993) Configurations: Crystallizing contingency. *International Journal of Human Factors in Manufacturing* 3(1): 15-36.
- Fleck J (1994) Learning by trying: the implementation of configurational technology. *Research Policy* 23(6): 637-652.
- Freeman C (1979) The determinants of innovation: Market demand, technology, and the response to social problems. *Futures* 11(3): 206-215.
- Freeman S (2015) Immersed in pellet technology: Motivation paths of innovative DIYers. *Outlines. Critical Practice Studies* 16(1): 54-80.
- Fujimura J (1996) *Crafting Science: A Sociohistory of the Quest for the Genetics of Cancer*. Cambridge, MA: Harvard University Press.
- Galison P (1997) *Image and Logic: A Material Culture of Microphysics*. Chicago: University of Chicago Press.
- Geels F W (2002) Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case study. *Research Policy* 31(8): 1257-1274.
- Geels FW, Kern F, Fuchs G, Hinderer N, Kungl G, Mylan J, Neukirch M and Wassermann S (2016) The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the German and UK low-carbon electricity transitions (1990-2014). *Research Policy* 45(4): 896-913.
- Geels FW and Schot J (2007) Typology of sociotechnical transition pathways. *Research Policy* 36(3): 399-417.
- Golinski J (1998) *Making Natural Knowledge: Constructivism and the History of Science*. Cambridge: Cambridge University Press.
- Grimm C (2008) *Ethnographic study of a global software package producer*, unpublished doctoral dissertation, University of Edinburgh Business School, Scotland.
- Grimm C (2012) *Inside a Secret Software Laboratory: An Ethnographic Study of a Global Software Package Producer*, New York: Springer Gabler.
- Grint K and Woolgar S (1997) *The Machine at Work: Technology, Work, and Organization*. Cambridge, UK: Polity Press.
- Guerrero J (2016) *Maritime interdiction in the war on drugs in Columbia: practices, technologies and technological innovation (a.k.a. narco-subs)*, unpublished doctoral dissertation, School of Social and Political Science, University of Edinburgh: Scotland.
- Hakkarainen L (2017) *Caring for Technology: Evolving living lab collaboration*. Helsinki: Aalto University.
- Hakkarainen L and Hyysalo S (2013) How do we keep the living laboratory alive? Learning and conflicts in living lab collaboration. *Technology Innovation Management Review* 3(12): 16-23.
- Hakkarainen L and Hyysalo S (2016) The evolution of intermediary activities: Broadening the concept of facilitation in living labs. *Technology Innovation Management Review* 6(1): 45-58.

- Hannukainen P, Mäkinen S and Hyysalo S (2017) Organisational adoption of the lead user method: A follow-up study on intentions versus actions. *International Journal of Business Excellence* 12(4): 508-536.
- Hanseth O and Bygstad B (2015) Flexible generification: ICT standardization strategies and service innovation in health care. *European Journal of Information Systems* 24(6): 645-663.
- Hartwood M, Procter R, Slack R, Vob A, Buscher M, Rouncefield M and Rouchy P (2002) Co-realisation: Towards a principled synthesis of ethnomethodology and participatory design. *Scandinavian Journal of Information Systems* 14(2): 9-30.
- Hasu M (2000) Constructing clinical use: An activity-theoretical perspective on implementing new technology. *Technology Analysis & Strategic Management* 12(3): 369-382.
- Hasu M (2001) *Critical transition from developers to users*. Academic Dissertation, University of Helsinki, Department of Education, Finland.
- Hasu M (2005) In search of sensitive ethnography of change: Tracing the invisible hand-offs from technology developers to users. *Mind, Culture, and Activity* 12(2): 90-112.
- Hasu M and Engeström Y (2000) Measurement in action: An activity-theoretical perspective on producer-user interaction. *International Journal of Human-Computer Studies* 53(1): 61-89.
- Heiskanen E, Hyysalo S, Jalas M, Juntunen J and Lovio R (2014) User involvement and radical innovation: The case of heat pumps in Finland. In: Juninger S and Christensen P (eds) *Highways and Byways of Radical Innovation: The Perspective of Design*. Kolding: Kolding Design School, pp. 171-198.
- Helgesson CF and Kjellberg H (2006) Macro-Actors and the sounds of the silenced. In: Czarniawska B and Hernes T (eds) *Actor Network Theory and Organizing*. Malmö: Elanders Berlings, pp. 145-164.
- Hennion A (1989) An intermediary between production and consumption: The producer of popular music. *Science, Technology, & Human Values* 14(4): 400-424.
- Hine C (2007) Multi-sited ethnography as a middle range methodology for contemporary STS. *Science, Technology, & Human Values* 32(6): 652-671.
- Höyssä M and Hyysalo S (2009) The fog of innovation: Innovativeness and deviance in developing new clinical testing equipment. *Research Policy* 38(6): 984-993.
- Hutchins E (1995) *Cognition in the Wild*. Cambridge, MA: The MIT Press.
- Hyysalo S (2000) *Yhteistyö ja ajallisuus pet-merkkiaineiden tuotekehityksessä* Turku: Turun yliopiston historian laitos, 54. (Collaboration and temporality in development of pet-tracers).
- Hyysalo S (2003) Some problems in the traditional approaches to predicting the use of a technology-driven invention. *Innovation*, 16(2): 118-137.
- Hyysalo S (2004) *Uses of Innovation. Wristcare in the Practices of Engineers and Elderly*. Helsinki: Helsinki University Press.
- Hyysalo S (2006a) Practice bound imaginaries in automating the safety of the elderly. *Social Studies of Science* 36(4): 599-626.
- Hyysalo S (2006b) The role of learning-by-using in the design of healthcare technologies: A case study. *The Information Society* 22(2): 89-100.
- Hyysalo S (2009) User innovation and everyday practices: Micro-innovation in sports industry development. *R&D Management* 39(3): 247-258.
- Hyysalo S (2010) *Health Technology Development and Use: From Practice Bound Imagination to Evolving Impacts*. London: Routledge.
- Hyysalo S, Juntunen J and Freeman S (2013a) Internet Forums and the Rise of the Inventive Energy User. *Science & Technology Studies* 26(1): 25-51.

- Hyysalo S, Juntunen J and Freeman S (2013b) User innovation in sustainable home energy technologies. *Energy Policy* 55: 490–500.
- Hyysalo S and Lehenkari J (2002) Contextualizing power in collaborative design. In: Binder T, Gregory J and Wagner I (eds) *Proceedings of Participatory Design Conference 2002*. Malmö, Sweden: Computer Professionals for Social Responsibility, pp. 93-104.
- Hyysalo S and Lehenkari J (2003) An activity-theoretical method for studying user-participation in IS-design. *Methods of Information in Medicine* 42(4): 398-404.
- Hyysalo S and Hakkarainen L (2014) What difference does a living lab make? Comparison of two health technology innovation projects. *CoDesign* 10(3-4): 191-208.
- Hyysalo S and Usenyuk S (2015) User dominated technology era – Dynamics of dispersed peer innovation. *Research policy* 44(3): 560-576.
- Hyysalo S, Jenssen TE and Oudshoorn N (2016a) *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. New York: Routledge.
- Hyysalo S, Repo P, Timonen P, Hakkarainen L and Heiskanen E (2016b) Diversity and change of user driven innovation modes in companies. *International Journal of Innovation Management*. 20(2): 1650023.
- Hyysalo S, Johnson M and Juntunen J (2017) Diffusion of consumer innovations in small scale renewable energy technologies. *Journal of Cleaner Production* 162(supplement): S70-S82.
- Hyysalo S, Juntunen J and Martiskainen M (2018) Energy internet forums as acceleration phase transition intermediaries. *Research Policy* 47(5): 872-885.
- Johannessen L K and Ellingsen G (2009) Integration and generification—agile software development in the healthcare market. *Computer Supported Cooperative Work (CSCW)* 18(5-6): 607-634.
- Johnson M (2013) *How Social Media Changes User-Centred Design-Cumulative and Strategic User Involvement with Respect to Developer–User Social Distance*. Doctoral Dissertation, Aalto University, Finland.
- Johnson M, Hyysalo S and Tamminen S (2010) Virtuality of virtual worlds, or, what can we learn from play-acting horse-girls and marginalized developers. *Symbolic Interaction* 33(4): 603-633.
- Johnson M, Mozaffar H, Campagnolo GM, Hyysalo S, Pollock N and Williams R (2014a) The managed prosumer: Evolving knowledge strategies in the design of information infrastructures. *Information, Communication and Society* 17(7): 795-813.
- Johnson MS, Hyysalo S, Mäkinen P, Helminen P, Savolainen K and Hakkarainen L (2014b) From recipes to meals... and dietary regimes: Method mixes as key emerging topic in human-centred design. In: *Proceedings of the 8th Nordic Conference on Human-Computer Interaction*, Helsinki, 26-30 October 2014, pp. 343-352. New York: ACM.
- Juntunen J (2014) Domestication pathways of small-scale renewable energy technologies. *Sustainability: Science, Practice, & Policy* 10(1): 1206–1230.
- Kallinikos J (2004) Farewell to constructivism: Technology and context-embedded action. In: Avgerou C, Ciborra C and Land F (eds) *The Social Study of Information and Communication Technology: Innovation, Actors, and Contexts*, Oxford: Oxford University Press, pp. 140-161.
- Kaniadakis A (2006) *The Agora of Techno – Organisational Change*. Unpublished PhD Thesis, Research Centre for Social Sciences, University of Edinburgh, Scotland.
- Karasti H and Baker KS (2004) Infrastructuring for the long-term: Ecological information management. In: *System Sciences, 2004. Proceedings of the 37th Annual Hawaii International Conference on*, Big Island, HI, 5-6 January 2004. IEEE.
- Karasti H, Baker KS and Millerand F (2010) Infrastructure time: Long-term matters in collaborative development. *Computer Supported Cooperative Work* 19(3-4): 377-415.

- Karasti H and Blomberg J (2018) Studying infrastructuring ethnographically. *Computer Supported Cooperative Work* 27(2): 233-265.
- Klein HK and Kleinman DL (2002) The social construction of technology: Structural considerations. *Science, Technology & Human Values* 27(1): 28-52.
- Knorr-Cetina KD (1981) The microsociological challenge of macro-sociology: Toward a reconstruction of social theory and methodology. *Advances in social theory and methodology*: 1-47.
- Kopytoff I (1986) The cultural biography of things: commoditization as process. In: Appadurai A (ed) *The Social Life of Things: Commodities in Cultural Perspective*, Cambridge: Cambridge University Press, pp. 64-91.
- Latour B (1987) *Science in Action: How to Follow Scientists and Engineers through Society*, Cambridge, MA: Harvard University Press.
- Latour B (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
- Latour B and Johnson J (1988) Mixing humans and nonhumans together: The sociology of a door-closer. *Social Problems* 35(3): 298-310.
- Latour B and Woolgar S (1979) *Laboratory Life*. Beverly Hills, California: Sage.
- Law J (2007) Making a mess with method. In: Outhwaite W and Turner SP (eds) *The Sage Handbook of Social Science Methodology*. London: Sage, pp. 595-606.
- Law J and Bijker WE (eds) (1992) *Shaping Technology / Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press.
- Leonard-Barton D (1988) Implementation as mutual adaptation of technology and organization. *Research Policy* 17(5): 251-267.
- Levi G (1988) *Inheriting Power. The story of an Exorcist*. Chicago: University of Chicago Press.
- Lundvall BÅ and AL Vinding (2005) Product innovation and economic theory--user-producer interaction in the learning economy. In: Christensen JL (ed) *Product Innovation, Interactive Learning and Economic Performance*. Amsterdam: Elsevier Science, pp. 101-128.
- Lynch M (2000) Against reflexivity as an academic virtue and source of privileged knowledge. *Theory, Culture & Society* 17(3): 26-54.
- Mackay H, Carne C, Beynon-Davies P and Tudhope D (2000) Reconfiguring the user: Using rapid application development. *Social Studies of Science* 30(5): 737-757.
- MacKenzie D and Wajcman J (eds) (1999) *The Social Shaping of Technology*. 2nd ed. Buckingham: Open University Press.
- Marcus GE (1995) Ethnography in/of the world system: The emergence of multi-sited ethnography. *Annual Review of Anthropology* 24: 95-117.
- McLaughlin J, Rosen P, Skinner D and Webster A (1999) *Valuing Technology: Organisations, Culture, and Change*. London: Routledge.
- Miettinen R (1993) Methodological issues of studying innovation related networks. *Working papers of VTT Group for Technology Studies* 4.
- Miettinen R (1998) Object construction and networks in research work: The case of research on cellulose-degrading enzymes. *Social Studies of Science* 28 (3): 423-463.
- Miettinen R (2002) *National Innovation System: Scientific Concept or Political Rhetoric*. Helsinki: Edita.
- Miettinen R and Hasu M (2002) Articulating user-needs in collaborative design. Towards activity-theoretical approach. *Computer Supported Collaborative Work* 11(1-2): 129-151.

- Monteiro E, Pollock N, Hanseth O and Williams R (2013) From artifacts to infrastructures. *Computer Supported Co-operative Work* 22(4-6): 575-607.
- Mozaffar H (2016) *The Role of User Groups in Generic Enterprise Applications: How far does User Driven Innovations Travel*. PhD. Thesis, University of Edinburgh, Scotland.
- Mozaffar H, Williams R, Cresswell K, Morrison Z, Slee A and Sheikh A (2014) Product diversity and spectrum of choice in hospital ePrescribing systems in England. *PLoS ONE* 9(4): e92516.
- Mozaffar H, Williams R, Morrison Z, Cresswell K, Bates DW and Sheikh A (2015) The evolution of the market for commercial computerized physician order entry and computerized decision support systems for prescribing. *Journal of the American Medical Informatics Association* 23(2): 349-355.
- Mozaffar H, Williams R, Cresswell K, Pollock N, Morrison Z and Sheikh A (2016) The challenges of implementing packaged hospital electronic prescribing and medicine administration systems in UK hospitals: Premature purchase of immature solutions? In: Aanestad M, Grisot M, Hanseth O, et al. (eds) *Information Infrastructures within European Health Care - Working with the Installed Base*. Cham: Springer, pp. 129-149.
- Nicolini D (2012) *Practice Theory, Work and Organization: An Introduction*. Oxford: Oxford University Press.
- Oudshoorn N, Rommes E and Stienstra M (2004) Configuring the user as everybody: Gender and design in information and communication technologies. *Science, Technology & Human Values* 29(1): 30-63.
- Oudshoorn N and Pinch T (eds) (2003) *How Users Matter. The Co-Construction of Users and Technologies*, Cambridge, MA: MIT Press.
- Pipek V and Wulf V (2009) Infrastructuring: Toward an integrated perspective on the design and use of information technology. *Journal of the Association for Information Systems* (10)5: 447-473.
- Pollock N (2000) The virtual university as timely and accurate information. *Information, Communication & Society* 3(3): 349-365.
- Pollock N, Williams R and Procter R (2003) Fitting standard software packages to non-standard organizations: the 'biography' of an enterprise-wide system. *Technology Analysis & Strategic Management* 15(3): 317-332.
- Pollock N and Williams R (2007) Technology choice and its performance: Towards a sociology of software package procurement. *Information and Organization* 17(3): 131-16.
- Pollock N and Williams R (2008) *Software and Organization*. Routledge: New York.
- Pollock N, Williams R and D'Adderio L (2007) Global software and its provenance: Generification work in the production of organization software packages. *Social Studies of Science* (37)2: 254-280.
- Pollock N, Williams R, D'Adderio L and Grimm C (2009) Post local forms of repair: The (extended) situation of virtualised technical support. *Information & Organization* 19(4): 253-276.
- Pollock N and Williams R (2016) *How Industry Analysts Shape the Digital Future*. Oxford, Oxford University Press.
- Pollock N and Hyysalo S (2014) The business of being a user: The role of the reference actor in shaping packaged enterprise system acquisition and development. *MIS Quarterly* 38(2): 473-496.
- Pozzebon M and Van Heck E (2006) Local adaptations of generic application systems: the case of Veiling Holambra in Brazil. *Journal of Information Technology* 21(2): 73-85.
- Ribes D and Polk JB (2015) Organizing for ontological change: The kernel of a research infrastructure. *Social Studies of Science* 45(2): 214-241.
- Russell S (1986) The social construction of artefacts: A response to Pinch and Bijker. *Social Studies of Science* 16(2): 331-346.

- Russell S and Williams R (2002) Concepts, spaces and tools for action? Exploring the policy potential of the social shaping perspective. In: Sørensen K and Williams R (eds) *Shaping Technology, Guiding Policy: Concepts, Spaces and Tools*. Cheltenham, UK: Edward Elgar, pp. 133-154.
- Schuler D and A Namioka (eds) (1993) *Participatory Design: Principles and Practices*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Scott-Kemmis and Bell M (2010) The mythology of learning-by-doing in World War II airframe and ship production. *International Journal of Technological Learning, Innovation and Development* 3(1): 1-35.
- Silverstone R, Hirsch E and Morley D (1992) Information and communication technologies and the moral economy of the household. In: Silverstone R and Hirsch E (eds) *Consuming Technologies: Media and Information in Domestic Spaces*. London: Routledge, pp. 13-28.
- Simonsen J and Robertson T (2013) *Routledge International Handbook of Participatory Design*. New York: Routledge.
- Sismondo S (2004) *An Introduction to Science and Technology Studies*. Malden, MA: Blackwell.
- Sørensen KH (1996) Learning technology, constructing culture. Sociotechnical change as social learning. *STS Working paper, University of Trondheim, Centre for Technology and Society* 18.
- Sørensen KH and Williams R (eds) (2002) *Shaping Technology, Guiding Policy: Concepts, Spaces and Tools*. Cheltenham. UK: Edward Elgar.
- Star SL (ed) (1995) *Ecologies of Knowledge: Work and Politics in Science and Technology*. Albany: State University of New York Press.
- Stewart JK and Williams R (2005) The wrong trousers? Beyond the design fallacy: Social learning and the user. In: Howcroft D and Trauth EM (eds) *Handbook of Critical Information Systems Research: Theory And Application*. Cheltenham: Edward Elgar, pp. 195-223.
- Stewart J and Hyysalo S (2008) Intermediaries, Users and Social Learning in Technological Innovation. *International Journal of Innovation Management* 12(3): 295–325.
- Strauss A (1978) A social world perspective. In: Denzin N (ed) *Studies in Social Interaction 1*. Greenwich: JAI Press, pp. 119-128.
- Strauss A and Corbin J (1990) *Basics of Qualitative Research*. London: Sage.
- Suchman L (1987) *Plans and Situated Actions*. Cambridge, UK: Cambridge University Press.
- Suh JH (2014) *The co-evolution of an emerging mobile technology and mobile services: A study of the distributed governance of technological innovation through the case of WiBro in South Korea*. Unpublished Doctoral Dissertation, University of Edinburgh, Scotland.
- Sun H (2016) *Digital disruption in the recording industry*. Unpublished Doctoral Dissertation, University of Edinburgh, Scotland.
- Tyre M and Von Hippel E (1997) The situated nature of adaptive learning in organizations. *Organization Science* 8(1): 71–83.
- Usenyuk S, Hyysalo S and Whalen J (2016) Proximal design: Users as designers of mobility in the Russian North. *Technology and Culture* 57(4): 866-908.
- Van de Ven AH, Polley DE, Garud R, et al. (1999) *The Innovation Journey*. Oxford: Oxford University Press.
- Van de Ven AH and Poole MS (2005) Alternative approaches for studying organizational change. *Organization Studies* 26(9): 1377–1404.
- Von Hippel E (1988) *The Sources of Innovation*. New York: Oxford University Press.
- Von Hippel E (2005) *Democratizing Innovation*. Cambridge, MA: MIT Press

- Voss A, Hartswood M, Procter R, et al. (eds) (2009a) *Configuring User-Designer Relations--Interdisciplinary Perspectives*. London: Springer.
- Voss A, Procter R, Slack RS, Rouncefield M, Slack RS and Büscher M (2009b) Design as and for collaboration: Making sense of and supporting practical action. In: Voss A, Hartswood M, Procter R, et al. (eds) *Configuring User-Designer Relations*. London: Springer-Verlag, pp. 31-52.
- Wang M (2007) *Cultivating the Generic Solution: The Shaping of Organizational Software Packages*. Unpublished Doctoral Dissertation, Research Centre for Social Sciences: University of Edinburgh, Scotland.
- Wiegel V (2016) *Biographies of an innovation: an ecological analysis of a strategic technology project in the auto-industry*. Unpublished Doctoral Dissertation, University of Edinburgh, Scotland.
- Williams R and Edge D (1996) The social shaping of technology. *Research Policy* 25(6): 865-899.
- Williams R, Stewart J and Slack R (2005) *Social Learning in Technological Innovation: Experimenting with Information and Communication Technologies*. Aldershot: Edward Elgar.
- Williams R (1997a) The social shaping of a failed technology: Mismatch and tension in the supply and use of computer-aided production management. In: Clausen C and Williams R (eds) *The Social Shaping of Computer-Aided Production Management and Computer Integrated Manufacture*. Luxembourg: European Commission, pp. 109-130.
- Williams R (1997b) Universal solutions or local contingencies? Tensions and contradictions in the mutual shaping of technology and work organisation. In: McLoughlin I and Mason D (eds) *Innovation Organizational Change and Technology*. London: International Thompson Business Press, pp.170-185.
- Woodhouse EJ (1991) The turn toward society? Social reconstruction of science. *Science, Technology and Human Values* 16(3): 390-404.
- Woolgar S (1991) Configuring the user: the case of usability trials. In: Law J (ed) *A Sociology of Monsters: Essays on Power, Technology, and Domination*. London: Routledge, pp. 57-99.