PLACE AND ORGANIZING FOR EMERGING TECHNOLOGIES: CHALLENGES OF SCALING 3D PRINTING ACROSS A UK HOSPITAL

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ABSTRACT

We examine how places shape the way emerging technologies scale across hospital organizations. Through a five-year ethnographic field study on organizing 3D printing (3DP) across a major UK National Health Service (NHS) hospital, we unpack place dynamics which entail processes of place bending, place extending and place framing. Informed by a practice lens and a process research approach, we develop insights that theorize the constitutive role of place in terms of its resources, materiality and location meaning. Our findings contribute to *how* and *why* the scaling of 3DP failed in three different situated places.

INTRODUCTION

Scholars of technology, work and organizing have long demonstrated the importance of digital technologies for the process of organizing (Bailey, Leonardi, & Barley, 2012; Orlikowski & Scott, 2008; Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007). Previous studies have illustrated the importance of different forms of materiality in jointly influencing organizing (Barrett, Oborn, Orlikowski, & Yates, 2012), how the capabilities of technologies (just as much as the choices people make about them) can shape organizing (Leonardi, 2011) and how these technologies are consequential (Faraj, Pachidi, & Sayegh, 2018). Emerging technologies such as artificial intelligence, data analytics and robotics, to name a few, are fundamentally reshaping organizations and pose new and significant challenges to organizing (von Krogh, 2018).

Despite the noteworthy contributions of previous work, the literature is silent on the situated dynamics of how and where these emerging technologies scale (or fail to do so). This issue brings into question the role of spatial dynamics in shaping the organizing of emerging technologies – a key question for organization science. Guided by recent research that emphasizes the critical role of place in organizational work (de Vaujany & Vaast, 2013; Lawrence & Dover, 2015), we suggest that place is an important material dimension that is often overlooked, and that, being relational, it can influence the materiality of emerging technologies. In this paper, our focus is on emerging technologies that bridge the digital and physical domains which have been largely underexplored. In particular, we explore how the organizing of emerging technologies needs to account for situated places and how they influence scaling across the organization.

To do so, we performed a five-year fieldwork study which focused on the emerging technology of 3DP, at a clinical innovation department of a major NHS hospital. 3DP is a hybrid emerging technology that bridges the digital and physical domains, as it requires both digital modelling practices and physical 3D printers located in particular places to transform digital models into tangible artefacts. Organizing for 3DP requires attention to the duality of the physical and digital and can provide insights into organizing and emerging technologies. We, therefore, examine *how do places shape the organizing for the emerging technology of 3DP?* The paper builds on the wider social science scholarship that has highlighted how the physical and social spaces influence interaction in multiple and often unexpected ways (Lefebvre, 1991; Massey, 2005; Oborn, Barrett, Orlikowski, & Kim, 2019).

We extend theory on how places shape the organizing of emerging technologies (Locke, 2001). We followed an inductive research design, starting from an interest in organizing practices across occupational boundaries of a hospital, and remained open to emerging fieldwork insights. Informed by a practice lens (Feldman & Orlikowski, 2011; Nicolini, 2012) and a process research approach (Langley, 1999), we collected detailed longitudinal data over five years on how places actively shaped and reshaped organizing for 3DP, by deploying ethnographic methods. Our research contributes insights that theorize three different place dynamics – namely, place bending, place extending and place framing. In so doing, we show how places shape the organizing of emerging technologies. Moreover, we highlight the challenges associated with organizing for and scaling emerging technologies, which complement the literature that argues that generativity and convergence can enable digital innovations to grow and scale rapidly in unprecedented ways (Henfridsson & Bygstad, 2013; Huang, Henfridsson, Liu, & Newell, 2017; Yoo, Henfridsson, & Lyytinen, 2010).

LITERATURE REVIEW

The literature on digital innovation has highlighted the generativity and convergence of digital technologies (Yoo, Boland, Lyytinen, & Majchrzak, 2012; Zittrain, 2006) in enabling widespread transformation and scaling up. Although there is agreement about the importance of scaling digital innovations and a growing body of work on the generative mechanisms by which scaling is achieved, research is less clear about *where* and *how* scaling of emerging technologies takes place within an organization. This is a significant omission, as scaling happens in situated places and with specific resources, that can influence how digital technologies subsequently grow. Earlier work has highlighted the continued importance of place in a digital world which has implications for scaling across time and space (Barrett & Walsham, 1999). More recently, Bailey et al., (2012) caution against the lure of the virtual and argue that increased dependence on digital tools to simulate, visualize and test new complex products leads to unintended consequences of separating physical objects and people from the virtual representations of design objects. These studies highlight the continued importance of place in a digital world, which is mostly absent from the literature on organizing emerging technologies and their scaling up.

Theoretical Framework

To address our research question, we adopt a practice perspective (Feldman & Orlikowski, 2011; Schatzki, 2002, 2005). First, our framework suggests that phenomena are situated and have a specific 'location', situated in a field of organized interests and in relation to

other events, places and phenomena (Nicolini, 2011). Second, in the context of organizing for emerging technologies, we highlight the importance of resources which have long been recognized as important in innovations involving processes of digitization (Henfridsson, Nandhakumar, Scarbrough, & Panourgias, 2018; Lyytinen, Yoo, & Boland Jr., 2016). The process of digitization brings new heterogeneous resources together, blurs industry boundaries and enables new ecologies (Lyytinen et al. 2016). As a consequence, how resources are used actively shapes places and is consequential for the success or failure of scaling emerging technologies. Thirdly, our theoretical basis takes seriously the materiality of 3DP as an innovation that bridges the digital and physical domains; it requires both digital modelling practices and physical 3D printers located in particular places to transform digital models into tangible artefacts. More specifically, we highlight the consequential dynamics of materiality in organizations (Orlikowski, 2007, 2010), view materiality as how work is instantiated in practice (Beane & Orlikowski, 2015) and take seriously the relationality of place(s) for the scaling of emerging technologies. Finally, we draw on insights about the symbolic and socio-political nature of spaces to highlight the importance of location meaning. Through spatial practices, actors from different disciplinary practices can impose their definition, meanings, values and rules onto a situation (Rodner, Roulet, Kerrigan, & Vom Lehn, 2019). We suggest that such spatial manipulation can impact how material and symbolic resources are circumscribed and acquired to influence the scaling of 3DP.

METHODOLOGY

Research Context and Site Selection

Overall, to address our research question, we aim to extend and refine theory (Locke 2001) on how places are implicated in the scaling of emerging technologies, as well as theorize why places matter in organizing for such technologies. We performed a fieldwork study at a clinical innovation group of a UK, NHS hospital (henceforth CIG), spanning five years. We selected this research setting for purposes of explorative richness, as little theoretical precedent exists for inquiry in this domain (Pettigrew 1990). CIG is a multidisciplinary centre that supports and accelerates the development of emerging medical technologies to address unmet patient needs while improving patient safety. 3DP requires organizing across diverse occupational communities of practice within the hospital; hence CIG has comprised of heterogeneous experts at different points in time throughout our fieldwork.

Data Collection

We have collected data through multiple methods. The first author spent at least three days a week, on average, over five years, within the research and development (R&D) group, directly examining and following how hospital actors attempted to scale up the innovation of 3DP, at three distinct places. Our primary data sources include ethnographic observations (400 hours) and detailed field notes (400 pages, single-spaced) of how 3DP was developing over time. Moreover, we conducted in-depth, semi-structured interviews with participants from various hierarchical levels and disciplines (55), supplemented by archival data (20GB of project progress documents, emails, technical specifications and design files of 3D printed medical devices. Our initial interviews were exploratory; we collected rich data on the organizing practices of the 3DP

projects CIG were working on by using an open and flexible interview design. Our detailed field notes (Emerson, Fretz, & Shaw, 2011) during participant observation allowed us to document the practices of the different groups involved in scaling 3DP in real-time, as well as at several project meetings, where audio-recording was not allowed. As a participant, the first author was granted access to the hospital as an honorary researcher and was physically located at the R&D subgroup, regularly interacting with members of the team and developing several close informants. The honorary researcher role was a natural one to conduct participant observation because the first author was an accepted, yet temporary, member of the organization.

Data Analysis

Parallel to data collection, we proceeded with multiple readings of our field notes, exploratory writing and discussions with colleagues paying particular attention to surprises and puzzles (Abbott, 2004). During this process, and as a first step of analysis, we paid attention to the longitudinal nature of our data and adopted a process research approach (Langley 1999), to track the flow of events. This led us to employ a multitude of strategies for analyzing the data, such as narrative strategy (Langley, 1999; Pentland, 1999) and a grounded theory strategy (Strauss & Corbin, 1990). Our open coding focused on the everyday practices of the multidisciplinary groups at CIG (Feldman and Orlikowski 2011), such as practices of rapid prototyping, designing and anatomical modelling, while remaining alert to emerging ideas. Through this process and over time, we were sensitized to the emerging importance of place, resources and location meaning when attempting to scale up the emerging technology of 3DP. Once place emerged as a topic of interest, we went back to our data and mined our field notes, interviews and documents for relevant clues and meaningful events. In this second round of analysis, we focused our attention on documenting, exploring and unpacking how 3DP was organized and how places were actively shaped and justified. We knitted our findings together as scenarios. Namely, how the 3DP lab was centralized away from surgical departments to avoid territorial disputes (scenario 1), the attempted renovation of the biomedical engineering workshop into a 3DP hub, (scenario 2), and finally, how the neurosurgeons were claiming a distinct, third place away from the hospital (scenario 3).

PLACE DYNAMICS FOR ORGANIZING 3D PRINTING

Organizing 3DP as a Centralized Lab

Our first scenario demonstrates the dynamics of place bending. We use this term to refer to the way radiologists organized 3DP by centralizing the innovation in a 'neutral' place for a multidisciplinary team. In this configuration, 3D modelling and printing were performed in house. A 3DP technician was recruited to run the service and work with surgeons as end-users. Place bending is a place dynamic through which the ongoing activities embedded within particular places become reshaped through technology to redirect and increase the scope of practices associated with the technology. This dynamic can help organize the use of emerging technologies by enabling new ways of tying the existing activities in one place to the emerging technology and the new associated practices. In so doing, place bending augments the use of place as existing activities become tied to the emerging technology, thereby broadening their current reach and scope of service opportunities. A key aspect of place bending is the gradual

shift in emphasis on the possible practices enabled through the new technology in a particular place or location. Place bending is enabled by broadening the available resources, stimulating knowledge integration through material artefacts, and aligning the location meaning.

Organizing 3DP as a Service Innovation

The second scenario demonstrates the dynamic of what we call place extending. In this case, the organizing strategy adopted by the biomedical engineers was to redirect resources through renovating their mechanical workshop and attempting to merge it with the centralized 3D lab at their location of choice. In this configuration, 3D modelling would still be conducted in-house, as well as some of 3DP, though the majority of medical device 3DP would be outsourced to external service bureaus, as the complexity of their projects was higher than the 3D lab. Place extending is a place dynamic which organizes an emerging technology by replacing patterns of action in new locations and connecting these new sets of activities to actions in distant places. In so doing, there is an attempt to tie together these separate places by controlling the actions in one place and linking them to another through the connected activities. These connected activities become possible through the new sets of practices enabled by emerging technologies. By replacing patterns of action in a new location, control from a distance is attempted, and new task jurisdictions can emerge around technology use. Actors extend their control in one place to another geographical location by co-opting existing practices associated with the emerging technology in a specific place. They also extend the new practices associated with the emerging technology by redirecting resources into the new place, supplanting location meaning, and reconfiguring the materiality of place in the new location.

Organizing 3DP as a Spin-Off

Finally, the third scenario demonstrates the dynamics of place framing. We use this term to refer to the way neurosurgeons attempted to organize 3DP through framing a new category of care through offering the service in a distinctly different place. In this configuration, 3D modelling would be conducted at a new spin-off organization, external to the hospital, and 3DP would be outsourced entirely. Place framing dynamics aims to create a new category of place. In contrast to reshaping existing activities, or replacing activities in an extended location, place framing draws on the new possibilities seen as inherent in emerging technologies to recreate what activities are possible, and where. As such, place framing attempts to set new parameters of what activities are relevant, problematic or urgent. Scaling an emerging technology in this manner is thus also highly political as the current order is questioned so that a new category of activities can be made. Place framing is required so that the new activities associated with the emerging technology are a break (and reframing) from what is currently seen as possible. This is accomplished by re-categorizing what are available resources, redefining location meaning and developing new material arrangements and places for the activities associated with the emerging technology.

DISCUSSION AND CONCLUSIONS

In this paper, we have addressed the question of how places shape the organizing of emerging technologies. Through a five-year-long fieldwork study, which focused on the case of

3DP at a major NHS hospital, we elaborate theory on the continued importance of place and its significance with the complexity of possible service configurations. Our findings theorize the role of resources, location meaning, and materiality in organizing for emerging technologies. Specifically, we show these considerations shape and are shaped by, the digital-physical hybrid nature of the 3DP artefact, which in turn is significant in influencing the scaling attempts by the different disciplinary groups.

Place Matters in Digital Innovation

First, our study has implications for the nascent but growing stream of research that examines the role of place in innovation. We build on recent work that takes a broader view of how distinct geographical places are entwined with local practices and materialities in transforming the trajectory of emerging technologies over time (cf. Oborn et al., 2019). Studies in this domain emphasize how places can have profound consequences for the actors involved, their practices and the outcomes of innovation processes (de Vaujany & Vaast, 2013; Lawrence & Dover, 2015; Sergeeva, Huysman, & Faraj, 2018). We build on this emerging stream of research by furthering our understanding of how place dynamics are intimately connected with the organizing of emerging technologies. Specifically, from our findings, we theorize how place bending, place extending, and place framing are implicated in the organizing of digital technologies. As such, we contribute an understanding of how the constitutive role of resources, materiality and location meaning, which taken together, explain the challenges and opportunities of organizing emerging technologies, in particular digital-physical hybrids, across three different places. Our study departs from previous research by taking the relationality of place seriously and examining longitudinally the attempted scaling of the technology in three different places within the hospital.

Organizing Strategies for Scaling

Second, our study contributes to the emerging technologies literature by elaborating how places are consequential for scaling such technologies. Previous research has highlighted that generativity and convergence can enable digital innovations to grow and scale rapidly in unprecedented ways (Huang et al. 2017; Henfridsson and Bygstad 2013; Yoo et al. 2010). Our findings allow us to make sense of the processes underpinning the scaling of emerging technologies, as evidenced by the unexpected outcomes in the scaling of 3DP. Oborn et al., (2019) argue that scaling emerging technologies is an emerging, deeply contextualized process in space and time. Our study resonates with this view and further elaborates how places are consequential for scaling. For example, our theoretical concepts of place bending, extending and framing are intimately connected to scaling, but do not guarantee the scaling of 3DP. Relatedly, Bansal, Kim, & Wood (2018) note that scale is confounded with size in organization and management scholarship. Instead, they argue that "scaling up" requires a fine-grained understanding of local spaces rather than merely "sizing up" across different geographies. Our research builds on this perspective of scaling by empirically providing a fine-grained understanding of how place dynamics are related to challenges associated with scaling emerging technologies in different places.

REFERENCES AVAILABLE FROM THE AUTHORS