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Boundary objects, power and learning: The matter of developing sustainable practice in organizations.

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Abstract:

This article develops an understanding of the agential role of boundary objects in generating and politicizing learning in organizations, as it emerges from the entangled actions of humans and non-humans. We offer two empirical vignettes in which middle managers seek to develop more sustainable ways of working. Informed by Foucault's writing on power, our work highlights how power relations enable and foreclose the *affordances*, or possibilities for action, associated with boundary objects. Our data demonstrate how this impacts the learning that emerges as boundary objects are configured and unraveled over time. In so doing, we illustrate how boundary objects are not fixed entities, but are mutable, relational, and politicized in nature. Connecting boundary objects to affordances within a Foucauldian perspective on power offers a more nuanced understanding of how 'the material' plays an agential role in consolidating and disrupting understandings in the accomplishment of learning.

Introduction

> "Crucial to understanding the workings of power is an understanding of the nature of power in the fullness of its materiality. To restrict power's

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> productivity to the limited domain of the "social," for example, or to figure matter as merely an end product rather than an active factor in further materializations, is to cheat matter out of the fullness of its capacity" (Barad 2003: 810).

This article addresses the sociomaterial and politicised character of learning. We explore how so-called 'boundary objects' play agential roles in learning to develop sustainability in organizations (Benn and Martin 2010). Boundary objects are concrete or abstract artifacts that possess different social significances in different social worlds, yet maintain a 'common identity' across these boundaries (Star and Griesmer 1989: 8, Star 2010). This characteristic enables these objects to contribute to learning in communities where people have diverse viewpoints and ways of working, and they have received growing attention from scholars of organizational learning. However, as we shall explain, it remains unclear how something becomes (or stops being) a boundary object. We contribute to understanding about how boundary objects are shaped through political agendas (Lee 2007), showing how they are configured, reinforced and dismantled through power, which shapes the networks to which boundary objects belong. In so doing, we demonstrate that boundary objects are not passive entities with a static 'standardised infrastructure' (Trompette and Vinck 2009), interpreted by active humans who learn.

Our data analysis follows the learning of middle managers as they develop ways to reduce the carbon footprint of their organizations. We track two boundary objects that emerge and dissolve during this time, specifically a 'sustainability checklist'

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and the concept of 'carbon reduction'. We suggest that these phenomena play an agential role in learning through their *affordances* (Gibson 1979); the possibilities they offer for action – or here, for generating learning. Over time, the shifts in affordances associated with boundary objects can affect the kind of learning generated in a network of relationships between people and things, in the form of the disruption or consolidation of existing understandings. Drawing on a Foucauldian approach to power, we illustrate that these affordances emerge, not from any brute characteristics or from a limitless supply of socially constructed meanings, but through the power relations that order the networks giving entities their form.

Recognising how affordances configure and politicise boundary objects over time and in relation to other actors in a sociomaterial network enables us to track how learning emerges, shifts, and is reinforced or challenged over time and as the power relations in sociomaterial networks alter. Therefore, we answer calls from other scholars to better address the connections between learning and power (Contu 2014, Contu and Willmott 2003, Heizmann 2011), and to critically examine the role of the material in learning (Nicolini, Mengis and Swan 2012) and in managerial life, which often reduces the social to the intangible, and the material to the sensibility of human knowledge (Strati 2007).

Our article is structured as follows. The literature review positions boundary objects as agents in learning to develop sustainable practice. We show it is not yet clear in the literature a) how boundary objects emerge and dissolve in networks of practice, or b) how they become politicised, and we explain why these aspects are worth exploring.

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We argue that paying attention to the affordances of boundary objects and the discursive power relations that shape them can develop understanding on how boundary objects are implicated in learning over time. Following our methodology section, we offer empirical two vignettes, which illustrate how learning to develop sustainable practice connects to the shifting affordances of boundary objects. We conclude by drawing out the implications of this research for understanding the materiality and politics of management learning, drawing attention to the mutability, relationality and politicization of boundary objects.

Learning to develop sustainable practice: the role of boundary objects

Following Benn, Edwards and Angus-Leppan (2010: 185) and Benn and Martin (2008: 397), we understand 'learning to develop sustainable organizational practice' as the development, sharing and embedding of understandings and activities that enable organizations to 'meet the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, 1987: 43). The literature in this field has shown how contested social, environmental and economic understandings of sustainability generate trade-offs and tension in organizations (Banerjee 2011, Hahn, Figge, Pinkse et al 2010). It has also emphasised the role of learning in enabling sustainability to be embedded and maintained (Fenwick 2007), in particular through sustainability awareness raising (Haugh and Talwar 2010, Siebenhüner and Arnold 2007) and identifying a role for change agents (Hesselbarth and Schaltegger, 2014, Wiek, Withycombe and Redman 2011). Nonetheless, despite substantial recognition in the literature (Clegg et al 2005,

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Corradi et al 2010) that learning is not simply a cognitive or individual endeavor, Benn, Edwards and Angus-Leppan (2013) argue that empirical studies examining the situated practices by which members of organizations co-develop and enact new ways of being sustainable remain rare. One exception is Fenwick's research into North American organizations (2007: 643), which discovered a shift away from Corporate Social Responsibility towards learning through 'everyday improvisation' that precipitates new practices.

Boundary objects are considered important to learning because they enable 'connecting' and 'shared focus' – both recognized by Fenwick (2007) as crucial to the successful implementation of sustainable practice in organizations. They were first identified in Star and Griesmer's (1989) analysis of the collaborative work of amateurs, professional ecologists and administrative personnel at the University of Berkeley's Museum of Vertebrate Zoolology. The authors identified that boundary-crossing discussion and learning centred on certain artifacts, including the Museum itself, maps of California, and species of birds. Operating at the threshold between two social worlds, the authors suggested that boundary objects are characterized by interpretive flexibility (Star 2010, Star and Griesemer 1989), so that they are understood differently in each of these worlds. Star and Griesmer (1989: 410-411) originally list four types of boundary objects:

1. Repositories: Indexed collections of objects (e.g. a library, a database).
2. Ideal Type: Objects that are vague, malleable representations (e.g. a prototype, a diagram).

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3. Coincident Boundaries: Objects mapping out boundaries between different groups (e.g. a map of regional boundaries, an organizational chart)

   Standardized Forms: Objects with a standardized method or procedure or, which sets out information in standardized format (e.g. an application form, a Gantt chart).

Drawing on this work, scholars of learning for sustainability have considered how boundary objects facilitate learning by transferring, disrupting and transforming knowledge about sustainability that is accomplished within social relationships (Benn, Edwards and Angus-Leppan 2013, Benn and Martin 2010, Brand and Jax 2007, Carlile 2002, Gherardi and Niccolini 2002, Holden 2013, Knorr-Cetina 2001). Benn, Edwards and Angus-Leppan (2013) identified several boundary objects connecting stakeholders involved in teaching sustainability in Australian Higher Education. Teaching pro-formas such as assessment forms functioned as 'standardized form' boundary objects, whilst a shared online information system emerged as a 'repository' boundary object that enabled discussion around best teaching practice. Their research also showed how the discourse around teaching for sustainability was configured as an 'ideal type' boundary object that could be applied appropriately in different contexts.

However, boundary objects have not been defined consistently in the literature, the term having become something of a boundary object itself. For Trompette and Vinck (2009), the focus on interpretive flexibility has been at the expense of a second characteristic: a standardized infrastructure meeting the informational needs of different communities or stakeholders. This results in the possibility for 'any interface

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mechanism between knowledge or actors' to be called a boundary object (Trompette and Vinck 2009: l). In contrast, Lee (2007) point outs that only two of Star and Griesemer's original four categories of boundary objects (repositories and standardized forms) necessitate this shared infrastructure, suggesting that standardization is not appropriate in instances when collaborative practices are not yet routinized or fully coordinated. Star's (2010) later work confirms that boundary objects are not defined by inherent characteristics, but by their scale and scope. In other words, an object with interpretive flexibility may most usefully be studied as a boundary object a) when it generates measurable levels of learning or knowledge transfer, which Star defines as 'the organizational level' and b) when it is useful conceptually for researchers to characterize it as such (Star 2010: 612).

Benn, Edwards and Angus-Leppan (2013: 185) show that boundary objects are important in organizational learning for sustainability. The artifacts they examined included repositories of best practice, which could be integrated and embedded in different contexts, and pedagogical protocols, which offer a consistent way of teaching sustainability across boundaries. Additionally, the concept 'sustainability', with its economic, environmental and social permutations, has itself been described as a boundary object (Benn, Edwards, and Angus-Leppan, 2013, Benn and Martin 2010, Brand and Jax 2007). Whilst the interpretive flexibility of sustainability may enable boundary-crossing discussions, it can also reduce 'being sustainable' to a check-list of objectives used by humans to justify their own interests (Brand and Jax 2007). As Kimble, Grenier and Goglio-Primard (2010: 442) suggest, boundary objects do not

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inhabit politically neutral arenas and are part of the 'political interplay' of cross-boundary learning. Nonetheless, it cannot be argued that people may interpret sustainability, or any other boundary object, however they like. Huvila (2001) suggests that boundary objects are discursive articulations - that is, they are never neutral to power, but are always produced out of, and therefore mobilize, the webs of normative relationships and assumptions which privilege certain kinds of knowledge and foreclose others (Foucault 1980).

Therefore, boundary objects can materialize understandings about what counts as sustainability and what does not, being part of the web through which relations are organized, boundaries defined, and subjectivities configured (Foucault 1991, 1980, Law 2002). This perspective questions the idea that boundary objects are complete and passive entities, interpreted by active human learners. Ewenstein and Whyte (2009) and Lutters and Ackerman (2007) emphasize that many boundary-spanning objects are things-in-process. They are constantly unfolding, working to generate learning and even negotiating the boundaries of networks themselves (Lee 2007). Benn, Edwards and Angus-Leppan (2013) show how a list of 'sustainability issues' actively worked as a 'boundary-negotiating artifact' (Lee 2007) by bringing communities together to share ideas.

Such work integrates boundary objects into a perspective which views learning and knowing as ongoing, collaborative accomplishments that perform reality, and which views boundary objects as embedded in rather than separate to this process (Carlile 2002). Furthermore, it speaks to sociomaterial accounts of practice, which destabilize

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the Cartesian separations between material and social, and the human and non-human, and which instead give attention to how the material and social are entangled together within activities such as learning (Fenwick 2010, 2015). Scholars working from a sociomateriality perspective debate the extent to and manner in which the social and material are mutually constitutive and inter-penetrative (see Jones 2013 for further discussion), and to which they perceive a symmetrical or equivalent approach to agency between humans and non-humans (Jones 2013). However, broadly speaking, researchers of sociomateriality make two claims. Firstly, they argue that the material is inescapably entangled with the social. For scholars of activity theory, this occurs as humans and non-humans meet and respond to one another either during practice (e.g. Kaptelinin and Nardi 2006, Pickering 1993). For Actor-Network theorists, and those influenced by Barad's (2003) agential realism, this entanglement occurs at an ontological level, such that the features of material and social entities are not separate or pre-existing, but are brought into being together, performed relationally through practice (Barad 2003, Latour 2005, Law, 2002, Leonardi 2013, Orlikowski 2007, Scott and Orlikowski 2013). Secondly and relatedly, sociomaterial perspectives emphasise that the material is an inescapable force in the co-production of effects and changes such as learning (Hardy and Thomas 2015). They consequently attempt to de-centre the human from this process, broadening understandings of practice out to include wider networks of people and things (Barad 2003, Fenwick 2010, Latour 2005, Orlikowski 2007, Taylor and Van Every 2000).

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Recognising that boundary objects are relationally configured, enacted entities enables us to see how, as they are performed within or across different networks, they are generated in multiple ways that indicate interpretive flexibility. However, this does not necessarily indicate that boundary objects offer limitless interpretations, and there is much about their emergence and dissolution within sociomaterial networks that remains unclear. In what follows, we argue that the interpretive flexibility attributed to boundary objects such as 'sustainability' can be better understood by applying the concept of affordances (Gibson 1979) to Foucault's account of capillary power (Foucault 1979).

The Affordances of Boundary Objects and the Politicization of Learning

Gibson (1979) defines an affordance as a bundle of characteristics associated with an object, which imbue it with a range of possibilities for action. For example, common workplace objects such as printers (usually affording 'print-ability'), or car parking spaces (usually affording 'park-ability') might also afford new opportunities for learning about how to be sustainable in relation to energy and fuel consumption. Affordances have enabled scholars to examine the agential role of artifacts in mobile learning (Turner 2005, Wright and Parchoma 2011) and the 'world-making' activities of cultural practice (Sutherland 2013). Whilst some scholars define affordances as the essential, measurable properties of an object (Gibson 1979), others consider them subjective, perceived characteristics (Norman 1988) informed by the user's experiences (Greeno 1994) or familiarity with the object (Turner 2005), and still more have

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suggested that understanding all the eventual affordances (perceived or real) of an object is impossible (Oliver 2005, Wright and Parchoma 2011).

We propose that affordances are perhaps neither characterised by brute, static characteristics, nor the product of limitless interpretations. Instead we examine the possibility, informed by Foucault (1980, 1991), that the affordances of boundary objects are produced and foreclosed through discursive power relations.

Foucault conceives of power as generative of subjectivities and ways of knowing, rather than as a tool for mobilizing resources in the pursuit of different interests (Heizmann 2011, Lawrence et al 2005) or as a variable contained by social contexts. Following Foucault (1980, 1991) Butler (1999), and Barad (2003), power provides the conditions of possibility for any kind of learning and subjectivity. These emerge together as effects shaped through power (Nicholson and Carroll 2013), which extends, like capillaries, 'into the very grain of the individual' (Foucault 1980: 39). As Foucault explains, 'power produces; it produces reality; it produces domains of objects and rituals of truth. The individual and the knowledge that may be gained of him belong to this production' (Foucault 1991: 194).

Knowledge, the knowing subject and the learning processes by which knowledges are legitimized or dismantled, are always given their conditions of possibility through relations of power so that they are politicized at an ontological level (Mol 1999, Oksala 2010). Hence, 'the exercise of power perpetually produces knowledge and conversely, knowledge constantly induces effects of power' (Foucault 1980: 52). This is evidenced in the Action Learning (AL) literature, which explores how the specific conversations

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taking place in AL sets are not simply tainted with, but made possible by the political agendas and emotional states of participants (Gilmore and Anderson 2012, Vince 2004,) and researchers (Huzzard, Ahlberg and Ekman 2009). Simultaneously, these same power relations foreclose or render impossible alternative conversations. From a Foucauldian, post-structuralist perspective, power relations generate the conditions that enable any kind of learning.

Boundary objects have particular significance for understanding the politicized nature of learning because as Carlile (2002) indicates, boundaries are sites for conflicts and negotiations of interests, as well as for translations of meaning that can never be power-neutral (Hvila 2001, Kimble, Grenier and Goglio-Primard 2010). Therefore, we suggest it is worth paying attention to how power might produce and delimit boundary objects' affordances, so that certain possibilities for knowing, learning, and doing might become associated with boundary objects, and other possibilities might become 'un-thinkable' (Barad 2003, Butler 1999). As a consequence, the number of affordances associated with any entity would potentially become limited to those that are made possible by power, generated through relational webs of normative assumptions or 'discourses' (Foucault 1980).

Using empirical data, we show that boundary objects generate a range of mediated learning effects, because in different networks they offer different affordances (or possibilities for action). From this, we consider boundary objects as 'multiple' entities (Mol 1999), configured and politicised differently through their affordances rooted in

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different networks of practice. As Whittle and Spicer (2008: 614) point out, 'What is a rock for an accident-prone stumbler becomes a sedimentary layer for a geologist'.

Appreciating the affordances of boundary objects might help us better understand the way these entities are implicated in learning. Here, we track what happens to their affordances when networks of relationships shift over time and as actors and groups learn to develop low carbon sustainable practices. We aim to build theory about the relationship between power and boundary objects as entities that emerge and fall away, enabling different kinds of learning in the form of consolidated or disrupted understandings. This addresses a number of literature gaps identified by other scholars. These gaps include the politicization of networked knowledges (Contu 2014, Heizmann 2011), how boundary objects might make learning 'come to matter' (Cooren, Fairhurst and Hüet 2012) by disrupting as well as standardising understandings (Gherardi and Niccolini 2002, MacPherson and Jones 2008). Our study required a method that enabled us to access the learning implicated in developing more environmentally sustainable operations. The data collection and analysis process is the focus of the next section.

Methodology

This article presents two 'vignettes' (Miles and Huberman, 1994) from different case organizations (one private-sector and one public sector) participating in [Research Project], a project designed to support and research the development of low carbon practice of public and private sector organizations within [region] and their supply chains. We selected these vignettes because they offer concise, contrasting, and

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representative illustrations of boundary objects in learning. They enable us to generate understanding about how boundary objects are re-configured and dissolved within and between networks over time. Our aim is to provide vivid, unique cases that persuade the reader of their plausibility and use in building theory (Golden-Biddle and Locke 1991), so that we can contribute to knowledge about how boundary objects help to configure learning. We suggest that while our data is not replicable, our theorizing might extend knowledge of boundary objects beyond our present context of developing sustainable business practice (Eisenhardt 1989).

Case studies help theorists develop conceptual insights through exploring the actions of individuals in context (Siggelkow, 2007; Yin, 2013). Indeed, it has been argued that insights into how individuals make sense of and enact their social world can only be gained through interpretive, qualitative methods (Weick 1989). We required a case study method that enabled us to track learning over time, as it occurs,. Our methodology is therefore case-study based and longitudinal in nature (Morgan & Smircich, 1980; Guba & Lincoln, 1994) and informed by a thematic approach to data analysis (DeSantis and Ugarriza 2000). We negotiated access with 17 private and public sector case organizations, of which 6 participated in Action Learning Sets (henceforth ALSs) designed to help participants learn about and lead lower carbon business practice in their organizations. These organizations were chosen according to the time they could give to the ALSs, and to ensure as broad and varied a range of participants as possible. A total of 42 procurement professionals, senior executives and directors participated in this process.

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AL is 'philosophically rooted in theories of learning from experience' (Marsick and O'Neil 1999: 170), and has been developed through three major schools of thought, focusing on scientific questioning (Revans 1982), experiential learning (Kolb 1984) and critical reflection (Pye, 1994, Weinstein 1995). Each of these perspectives is indebted to Lewin (1947), who first linked the individual learning experience to social context. AL takes place in groups called 'sets', in which individuals engage with and collaborate to find solutions to real-time problems, during regular meetings that take place for a number of months. This process encompasses a collaborative, experiential approach to learning (Kolb, 1984), enabling 'reflection on real-time work experience dealing with unfamiliar problems' (Raelin, 2006: 152) such that the group's reflections on past practice act as a basis for future action.

The [name of research project] ALSs involved between 5-8 individuals, all from the same case organization, and were facilitated by the authors (one of whom is accredited in AL techniques by the Institute of Leadership and Management). Each member of an ALS described a 'problem' they faced in developing low-carbon management practice. The other members of the ALS responded through spontaneous questioning (Revans, 1982), applying their own knowledge and understanding to help the presenter identify possible 'solutions'. At the next meeting, each participant reflected on his/her progress and, using spontaneous questioning, the group identified the next course of action. A typical ALS met monthly or sometimes every other month, for between 5 hours and a full working day, for a total of six meetings. Each ALS was digitally recorded and transcribed or, very rarely, minuted extensively by a scribe, and

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records were shared with and corrected by participants, who had given informed consent on data collection.

During our analysis of over 180 hours of data collected from 6 series of ALSs, we retained the transcripts of the ALSs in chronological order so that the journey of both human and non-human entities could be tracked. We noticed how discussion about reducing carbon emissions and 'being sustainable' often focused on artifacts such as refrigerators, kettles, office heating systems, lighting and contracts, and began to highlight this in our notes. When such patterns were echoed across the different ALSs, these were cross-referenced so that these interactions could be compared and contrasted. In sum, we recognize that we were 'making sense of making sense' (Jackson (2006: 264): immersed in fieldnotes and observations, as well as transcriptions of actors' narratives and ALS meetings over time, we were sifting and sorting data as 'textual ethnographers' (Jackson, 2006) to identify patterns and themes within and across ALSs. Our approach is therefore commensurate with a theory building perspective (Eisenhardt, 1989; Siggelkow, 2007; Weick, 1989) in which we develop an understanding of the affordances of boundary objects in relation to learning about becoming sustainable.

We close this section by noting that all ALS interactions are threaded with political agendas, including those of the researcher (Vince 2004, Huzzard, Ahlberg and Ekman 2010). Indeed, learning can never be a neutral endeavor because it is made possible through the power relations that order subjectivities, social relationships and knowledges (Nicholson and Carroll 2013). These are termed the 'conditions of our freedom' by Crane (2008). In our analysis, we draw attention to how we as researchers

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were part of the matrix that configured the affordances of boundary objects. In positioning ourselves as part of the 'spatial psychodynamics of learning' (Vince 2011), we hope to offer a fuller account of the conditions producing and politicising learning in these vignettes, than might otherwise be achieved.

Analysis and Discussion

The two examples presented here illustrate the mutable nature of boundary objects, and trace the affordances of boundary objects to show how learning materializes or 'comes to matter' (Cooren, Fairhurst and Hüet 2012) in part through these artifacts. The first vignette explains how an artifact's 'boundary object' status falls away, as its multiple affordances coalesce. The coalescing affordances produce learning by consolidating understandings associated with the boundary object. The second vignette illustrates a reversal of this process: the transformation of an entity with reasonably stable affordances into a boundary object with conflicting affordances. In this case, the emergent learning takes the form of disrupting existing understandings associated with the boundary object (Nicolini 2011, Contu 2014). Both examples emphasise the temporal, mutable, multiple nature of the 'boundary object' status, as power enables the generation of new affordances or the coalescence of previously conflicting ones. After presenting our data, we draw out the implications for researchers and learners as we explore how affordances of boundary objects are mediated over time and as sociomaterial relationships, are enabled and undone through power.

Dissolving a boundary object: DairyCo and the affordances of 'carbon reduction.'

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Our first vignette focuses on a privately-run Dairy company (DairyCo). The boundary object around which discussion focused was the concept of 'carbon reduction'. This artifact was enacted differently over time, contingent upon the political agendas underpinning the relationships that bring it into being. This enabled learning in the form of consolidated understandings about the value and relevance of practices supporting carbon reduction.

Meeting 1 took place on campus, following an event run by [research project name] for organizational members of a supply chain professional body. DairyCo Participant 1, a senior director, acknowledged that reducing carbon emissions (for example, by reducing fuel usage) might induce cost savings, but explained that DairyCo had no time to be involved:

> DairyCo Participant 1: "we are so busy with day to day operational challenges, that we just don't even have time to think about things that don't need to be done today, right now. I can't afford to think about carbon reduction". [DairyCo Meeting 1]

During this initial meeting carbon reduction emerged as a boundary object spanning two configurations of relationships: DairyCo and [Research Project]. Carbon reduction is configured differently within these two social worlds, in relation to the value of becoming more sustainable. It most closely resembles the 'Ideal Type' form of boundary object identified by Star and Griesemer (1989) - a vague concept, with multiple possibilities for action. From DairyCo Participant 1's perspective, carbon reduction affords possibilities for action which conflict with the successful running of

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the business. The need to deliver milk to purchasers on time is crucial, and using time and manpower to focus on carbon reduction is not in DairyCo's interest. In contrast, for us (the researchers), carbon reduction offers an interesting potential research opportunity.

These understandings are not related to carbon reduction's essence, but are produced through the affordances that emerge relationally through the different relationships enacting each social world (Star and Griesemer 1989), each of which is formed through specific political tensions and agendas (Kimble, Grenier and Goglio-Primard 2010). These affordances have a performative effect, calling carbon reduction into being differently in each context. However, as time passed, DairyCo experienced alterations to its sociomaterial relationships, which in turn led to a shift in the affordances offered by carbon reduction. This precipitated learning within DairyCo, in the form of a new awareness about the benefits of reducing carbon emissions.

One week later, DairyCo Participant 1 contacted us again, explaining that DairyCo had won a lucrative contract supplying milk for a major supermarket chain. Although not the cheapest bidder, DairyCo won the contract because they were the most local supplier, which supported the supermarket's carbon reduction policy. We arranged further meetings with DairyCo, which, importantly, took place on their milk processing premises. Here, DairyCo Participant 1 has learned to view participation in [name of research project] as sensible:

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> DairyCo Participant 1: "If carbon is on the purchaser's agenda, it affects whether we get the business or not. Being carbon-friendly could help us expand in local markets". [DairyCo Meeting 3]

This story illustrates how the affordances of carbon reduction are (re)generated through a change in organizational priorities (and, as we show later, a change in the material learning environment), which shape the political landscape of learning (Vince 2011). DairyCo's sociomaterial network now includes new sociomaterial entities: a supermarket contract and the procurement policy of a supply chain purchaser. These new, overlapping configurations generate new affordances associated with carbon reduction, and reconfigure DairyCo as a carbon-friendly organization – both from the perspective of the supermarket, and of DairyCo employees. As a result, Participant 1 'learns' that minimizing DairyCo's carbon footprint as a sensible option.

Importantly, this mediation of affordances is rendered through the politics of the supplier-purchaser relationship. As Hingley's research (2005a) points out, the neutral language of much 'relationship marketing' and supply chain management literature belies the power imbalance in supplier-supermarket relationships, in which supermarkets and large retailers are able to exert control over smaller organizations in their supply chain. This is especially pertinent to agri-food businesses within supermarket supply chains (Hingley 2005b). Supermarkets' demands have a disciplinary effect on suppliers like DairyCo, configuring their practices in ways that conform to and benefit the supermarket as a dominant force (Hingley 2005b, Cox 2004). This disciplinary mechanism is noted to have been particularly impactful in

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carbon reduction, which is recognised as an 'emerging agenda' for large organizations managing their supply chain (Correia et al 2014). Consumer demand for 'ethical' products (Freidberg 2004) and EU policies including the 2020 legislation on carbon reduction require large organizations to embed environmentally-friendly practices into their routines of production and consumption, so that minimising harm to the environment becomes part of the dominant discourse within the supply chain (Berger et al 2001). In this case, the supermarket's contract to supply places new demands on DairyCo to conduct operations in a carbon-friendly manner and reconstructs DairyCo's understanding of carbon reduction as a legitimate, 'think-able' activity for DairyCo:

> DairyCo Participant 3: "Carbon [reduction] is not something that I've given thought to before [DairyCo won the Supermarket contract]. I thought it was just a meaningless buzzword, a fad. Now I can see that we will have to engage with it." [DairyCo Meeting 3]

Participant 3's learning materializes through a similar shift in carbon reduction's affordances, which initially configure carbon reduction as 'meaningless buzzword', but which later manifest its possibilities for maintaining DairyCo's operations during a challenging economy. This learning is produced through the networked practices of the supermarket, the contract, and DairyCo and the research project, which dissemble old assumptions and enable new ways of understanding the apparent relevance (or 'meaningless'-ness) of reducing carbon emissions.

Further nuances are gained by paying attention to the wider 'spatial psychodynamics' of learning (Vince 2011) in which carbon reduction is embedded. As

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Vince points out, the spatial configuration of the learning environment is not simply a container for learning, but is part of the networked relationships bringing boundary objects into being, and generating learning outcomes. Importantly, the new supermarket contract coincided with a change in meeting location for DairyCo participants. The first meeting took place following a presentation by academics in a university lecture theatre, which was attended by people wearing suits from diverse corporate backgrounds. Perhaps unsurprisingly, DairyCo participants found it hard to learn the value of carbon reduction, when surrounded by sociomaterial arrangements that afford few possibilities for action in relation to farming, milk production or processing.

Indeed, Hawkins has explained that sociomaterial effects such as learning are undone or disrupted (2015) by inconsistencies in the affordances presented by the sociomaterial environment. In contrast, the second meeting took place on DairyCo's rural farm-based premises at the request of DairyCo's Director. Participants and academic researchers met in a portacabin, next to a large barn filled with noisy milk processing machinery, and DairyCo's employees were dressed in their overalls, fluorescent jackets and boots, having come straight from their shifts. This new, more familiar space alters the affordances associated with carbon reduction. Rather than emerging as a site for disrupted understandings or incompatibilities in the form of environmental/economic trade-offs (Hahn, Figge, Pinkse et al 2010), it is assembled consistently as a valuable business opportunity, relevant to everyday operational experiences. As a result, new practices supporting carbon reduction become discussable

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not just through a change in supplier relationships, which configure DairyCo as carbon-friendly, but also through a change in the material environment through (not in) which learning is produced. This change is evidenced below.

By the end of DairyCo's continued work with [research project], DairyCo had developed and trialled the UK's first cardboard milk bottle in local supermarkets. Once again, a shift in the sociomaterial network occurs, in which cardboard, a milk bottle, and other entities shape the affordances of carbon reduction. DairyCo's director expressed the hope in a local newspaper that 'Ultimately, all UK milk will be produced in these new bottles, which would bring huge environmental benefits'. Therefore, the affordances offered by carbon reduction now include 'huge environmental benefits', opportunities for business development, and as the Director's newspaper comment indicates, a new way to promote the company in the local media.

All these affordances are now aligned in a way that generates learning in the form of consolidated understandings of carbon reduction as beneficial for DairyCo's operations, and of DairyCo itself as an environmentally friendly organization. This consolidation is so marked that a question mark now exists over whether carbon reduction remains a boundary object. Although carbon reduction continues to knot together DairyCo, the supermarket and [Research Project] (Lindberg and Czarniawska 2006), it no longer fits the vague 'ideal type' form (Star and Griesmer 1989), because it is now rooted in and contextualised by specific DairyCo practices. While it continues to connect social worlds, the interpretive flexibility originally identified by Star and Griesemer (1989) as a key attribute of boundary objects is also much less evident

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because its affordances are in alignment – DairyCo has 'learned' that carbon reduction is a positive and valuable activity, which brings its understanding of this artifact into line with [Research Project] and the supermarket.

Relationships with the new supply chain contract, the spatial environment, the cardboard milk bottle and the research project itself configure carbon reduction in ways that enable certain affordances to emerge and prevent others. In so doing, they politicize boundary objects at an ontological level: they are the conditions that make carbon reduction possible (Barad 2003, Mol 1999). Researchers such as Huzzard, Ahlberg and Ekman (2010) have identified the political nature of AL, where the agendas of those present, including the researcher/facilitator, are catalysts, with the result that some learning outcomes are enabled and others are foreclosed and rendered 'un-learnable'. This vignette demonstrates how these politics are played out in the relationship between learning and boundary objects, which is enacted over time. [Research Project] is part of the network of relationships through which the affordances of carbon reduction are reconfigured and rendered consistent, and through which its boundary object status is reinforced and later altered or possibly even dissolved. Highlighting the potential for impact of the researcher on boundary objects' affordances and on the learning that is generated through the shifts in these affordances, addresses one way in which the AL researcher is entangled in the production of learning. This also helps situate boundary objects more clearly in relation to the unfolding of learning within temporal, political and spatial/material relationships (Fahy, Easterby-Smith and Lervik 2014).

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Vignette 1 illustrates how an artifact's status as boundary object is destabilized when it is enacted in ways that render its affordances consistent. Carbon reduction is reconfigured through specific contextualized practices that are recognized as valuable for DairyCo. In contrast, the following vignette explores this process in reverse: how an entity with an originally consistent set of affordances later emerges as a boundary object. Once more, the possibilities for action presented by this artifact are shifting and multiple, enabled and foreclosed by the power relations through which sociomaterial entities, and the learning that they produce together, achieve their form (Bloomfield, Latham and Vurdubakis 2010).

Generating a boundary object: PublicOrg and the affordances of the 'sustainability checklist'

PublicOrg is a large regional public sector organization with over 100 offices and buildings, and employing approx. 7,000 people. At their first meeting, PublicOrg's ALS participants described an organizational culture in which high levels of energy consumption are normalised:

> PublicOrg Participant 1: "There's this culture of silo thinking – each room has its own fridge! In (name of office,) they have about 30 fridges and they only need one". [PublicOrg Meeting 1]

Items such as kettles, heating systems and refrigerators, which are expensive to run financially and in terms of their carbon footprint, were important focal points for discussion in PublicOrg ALSs, and in ALSs undertaken at other case study

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organizations. They are part of the means through which 'unsustainability' in PublicOrg is materialized or 'comes to matter' (Cooren, Fairhurst and Hüet 2012, Barad 2003) and through which participants learn about more sustainable ways of working (Fenwick 2010, 2007). As participant 3 points out early on in the ALSs:

> PublicOrg Participant 3: "We have an article in our [name of organization] magazine nearly every month on sustainability. This month, it's been around computers, making people log off properly...I think next month it is likely to be recycling, we are sending all our old [equipment] to Ghana rather than send it all for shredding…the following month will be battery recycling…" [PublicOrg Meeting 2]

Here, Participant 3 explains how several entities (computers, old safety equipment, batteries, and so on) are implicated in awareness-raising initiatives that develop learning for sustainable practice at PublicOrg. Importantly, none of these afford possibilities for learning about sustainability by themselves. As Fenwick (2015, 2010) points out, learning is not located exclusively in the human (by the manipulation of these artifacts) or the material (through the determination of human action). Instead, the magazine, people, article, battery and computers engage in a series of interactions which from a Foucauldian perspective, have a disciplinary effect because they are inscribed with norms about the sustainable conduct of people and things together: 'logging off' computers. Similar to those at DairyCo, PublicOrg's practices are also vehicles for power in that they produce sustainable subjects, who have learned to regulate their action in line with these norms -'people who log off properly'. Nonetheless, the

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affordances associated with many artifacts once again shift over time. The saga of the 'sustainability checklist' demonstrates how, at PublicOrg, this generated learning in the form of diversified, rather than consolidated understandings in relation to a boundary object.

During an early ALS, one participant handed around a checklist of sustainable office practices. Designed to help employees learn to manage their energy use, the list includes 'turning off printers' and 'turning off lights when you leave a room'. Below, the participants explain why the checklist was initially welcomed by PublicOrg employees.

> PublicOrg Participant 5 [examines the checklist]: "It's a lot easier for people to buy into because [the actions listed are] not too big, it's specific, and it's achievable."
>
> PublicOrg Participant 2: "Yes, there are only six things on the checklist, and this is an organization where people are used to taking instructions."
>
> [PublicOrg Meeting 2]

The checklist brings together artifacts within six objectified practices ("six things"), which afford the possibility to enact 'green-ness' through performed relationships between humans and material things. Its aim is to generate uniform understandings about the value of and practices associated with lowering carbon emissions. Therefore, it can be understood as a disciplinary technology, a 'micro-technique of power' (Clegg 1989:191) that orders learning and subjectivity through

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producing the range of options by which employees should regulate their conduct, all of which have capillary effects in supporting the sustainability agenda (Foucault 1991).

Participant 2 confirms that the checklist's affordances are relationally configured and would differ, if they were part of a different network of entities, shaped by different relations of power, which does not produce subjects who are 'used to taking instructions' (Bloomfield, Lathan and Vurdubakis 2010, Wright and Parchoma 2011). The checklist is therefore implicated in the performance and regulation of employee identities (Symon and Pritchard 2014), by attempting to produce 'sustainable subjects' and homogenise conduct in line with norms about sustainability.

By seeking to prescribe and standardise practice, the checklist resembles a 'standardized form', identified by Star and Grisemer (1989) as a type of boundary object. Nonetheless, at this point, the checklist cannot be classified as a boundary object because its affordances are consistent; it is not understood differently in different social worlds (Star and Griesemer 1989:393). But as time progressed, the checklist's status altered: it emerged as a boundary object as its affordances became increasingly inconsistent and misaligned. This inconsistency impacted on the learning generated within the ALS and in PublicOrg more widely. At the following meeting, PublicOrg Participant 2 reported that the checklist's distribution to employees had coincided with an announcement for 750 planned redundancies at PublicOrg. This new information transformed the affordances presented by the cards:

> PublicOrg Participant 2: [distributes the small card with 6 reminders about recycling and energy use] Unfortunately we've had some adverse comments

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about the cards on the staff message boards – asking 'why are we wasting money on this?'

PublicOrg Participant 1: "The comment I heard was 'Printing out all these cards – not very green, is it?'"

PublicOrg Participant 2: "I thought it was a great idea. But I think everyone is busy with other priorities and no one is happy."

Public Org Participant 5: "Do you think [name of organization] has stepped back on this because of the changes from [date of planned redundancies]?"

PublicOrg Participant 2: "There are huge challenges – we're not stepping back, but there are other things going on."[PublicOrg Meeting 3]

It has been recognised that emotions are not managed separately from the learning process (Gilmore and Anderson 2012) and that the emotions connected into learning are likely to alter significantly during longer-term interventions (Anderson and Gilmore 2010). Here, it becomes clear that emotions are connected into the 'spatial psychodynamics of learning' (Vince 2011), in ways that reshape the affordances offered by material objects. During this sensitive period of job losses, the checklist's affordances are altered and it is reconfigured as an unsustainable waste of time, money, and paper. It no longer enables an homogenised understanding about reducing the value of carbon emissions (Brand and Jax 2007) but is re-constituted at the boundary between two discourses about 'being safe from redundancy', and 'being green'. Over time, the checklist becomes a boundary object with a potentially dissonant range of affordances that alter and disrupt understandings (Benn, Edwards and Angus-Leppan 2013,

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Macpherson and Jones 2008) in the entwined processes of learning and subjectification (Clegg, Kornberger and Rhodes 2005).

Within this ALS, the sustainability checklist evolves over time to co-produce, unravel, and contextualise participants' learning about how to develop and disseminate sustainable practices. Their discussion above recognises the checklist as a localised and temporal materialization of the trade-offs (between cost and carbon, between raising awareness and increasing use of paper) that occur when implementing sustainability initiatives (Hahn, Figge, Pinkse et al 2010). It enables learning not through ordering or homogenising understandings, but by problematising and disrupting them (Clegg, Kornberger and Rhodes 2005). The rejection of the checklist by PublicOrg employees teaches participants that for some employees, the possibility of becoming a 'sustainable subject' is foreclosed:

> Participant 5: It's not a foregone conclusion that everybody's green these days. (PublicOrg Meeting 3).

Artifacts like the sustainability checklist become boundary objects when their affordances diversify, offering multiple possibilities for generating understanding (here in relation to 'carbon reduction' and 'organizational priorities'). This diversification, caused by changes in the wider network, generates the disruptive potential and multiplicity of boundary objects. As well as reconfiguring the artifact as boundary object, we propose that the diversification of affordances also produces learning in the form of disruption of existing understandings, as opposed to the consolidation of understandings demonstrated in vignette 1. They are politicised ontologically (Mol

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1999) because the conditions of their being are not 'given' or the result of 'essence', but generated through the ordering processes governing and legitimising the wider relations of which they are part.

Concluding Discussion: How affordances generate and politicise learning to develop sustainable organizational practice.

In this article, we build on the notion that boundary objects (and other material entities) are not simply the tools of 'people who learn' (Fenwick 2010, Nicolini 2011). They play agential roles in co-generating, bridging and disrupting understandings, which in this context are about making organizations more sustainable. Our specific contribution offers a fine-grained empirical example (over time), which tracks the emergence and dissolution of boundary objects through their affordances or possibilities for action. We illustrate how this shapes the learning that develops within networks of people and things.

Drawing on a Foucauldian conceptualization of power as enabling the conditions of possibility for any kind of knowing, we show how sociomaterial relationships alter over time, producing affordances associated with boundary objects that are both politicized and shifting. It is these shifting affordances, rather than the objects themselves, which disrupt understanding and open up, or close out, possibilities for new learning. In vignette 1, changing sociomaterial relationships within DairyCo ensure the alignment of affordances associated with carbon reduction. This enables learning in the form of consolidated understandings about how and why to reduce carbon emissions. In other cases, as with Vignette 2 and the 'sustainability checklist', the emergence of

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new sociomaterial relationships causes affordances to diversify, reconfiguring entities as boundary objects. Where the range of affordances is too great, or these affordances are too incompatible, learning emerges in the form of diversified or disrupted understandings associated with a boundary object (as opposed to consolidated understandings). This has implications for the literature on learning to develop sustainable practice, because it helps to explain why in some cases sustainable practice is understood as a both/and scenario ('making money AND saving energy') and in others, it remains stuck as an either/or trade-off ('saving jobs' versus 'saving energy').

However, while 'learning to develop sustainable practice' has been the context of our work, this article builds theory more generally about how the affordances of boundary objects are implicated in learning, within and across all kinds of sociomaterial networks. Our data suggests that to retain its status as a boundary object, an entity must offer affordances that are *inconsistent enough, but not too inconsistent*. Vignette 1 illustrates that the boundary object status of 'carbon reduction' falls away when its affordances coalesce (not inconsistent enough), so that it becomes taken for granted as a part of the DairyCo management philosophy. In contrast, Vignette 2 illustrates what happens when a network shifts so profoundly, that previous possibilities for understanding sustainability generated by a boundary object (the 'sustainability checklist') are rendered completely incompatible (too inconsistent) with altered, discursively generated understandings about organizational priorities. Their subsequent discussions about sustainability invoke a familiar debate around social/economic/environmental trade-offs. This indicates evidence of the ALS

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participants' learning, in the form of a more nuanced awareness of the challenges of raising awareness of sustainability initiatives in an era of cuts and job losses. In this way, a diversification of affordances enables learning by disrupting previous, overly simplistic understandings, rather than by consolidating forms of knowing.

Our research contribution shows how the limits and forms of boundary objects are shaped by their affordances, which confer on them three important characteristics: mutability, relationality, and politicization. In relation to the first characteristic, mutability, we demonstrate that boundary objects are not permanently such: the emergence or dissolution of their 'boundary-ness' is related to the ways in which networks reconfigure themselves, which present new or mediated affordances for learning, and which foreclose others.

Secondly, our vignettes indicate the relationality of boundary objects, in that their form emerges through the relational practices of human and non-human entities, rather than as a result of an artifact's brute characteristics. Therefore, we argue that boundary objects are not standardised through a 'given' infrastructure as Trompette and Vinck (2009) suggest. Any apparent standardization is not an inherent part of the entity and can be consolidated, mediated or demolished through interaction.

Finally, we draw attention to way that boundary objects are politicized through their affordances. The mediated possibilities for action generated by a boundary object are enabled and foreclosed through the shifting power relations that give networks of practices, subjects, and learning their form. Connecting the affordances of boundary objects to an understanding of power, informed by Foucault, enables a more fine-

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grained picture of how power is threaded through the networks in which learning is accomplished. Certain possibilities for understanding are enabled, and others are rendered 'unthinkable'. In the case of both our vignettes, the affordances of boundary objects were produced through the power/knowledge discourses configuring the sociomaterial environment (Hawkins 2015), including the agendas embedded in AL methods and changes to organizational priorities in the face of new business opportunities (DairyCo) and redundancy plans (PublicOrg). These relationships enable the subjectivities of learners and the potential for learning, together, in relation to the affordances associated with boundary objects.

The arguments presented here integrate the notions of 'the material' and materiality more fully into our understanding of how politicized, partial knowledges are brought into being, renegotiated and torn apart in practice. In so doing, our research also answers calls: to explore how boundary objects can foreclose as well as enable communication across diverse realities (Niccolini, Mengis and Swan 2011, Star 2010, Macpherson and Jones 2008), and to deepen the awareness of the power struggles within and between constellations of interconnected practices (Contu 2014). Drawing attention to the affordances of boundary objects, and their agential roles in the emergence and resolution of dissonances in learning, we help develop a stronger understanding of how power intersects with management learning.

From our research, we conclude that paying attention to the affordances of boundary objects offers valuable insights both to practitioners and researchers regarding organizational learning. These caution against reducing 'the social' in learning to 'the

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human'. We propose that attention should be paid to material things as they come to matter to participants in learning. Further research into the affordances of the entities that work to give learning its form would help develop a stronger understanding and build further knowledge about how learning 'matters' in practice, and dynamics of power in this learning process. Consequently we argue that research that draws attention to the materiality of learning will help to ensure its relevance to participants and managers, whose understanding of the world is brought into being in relation to non-human entities, to which they are always linked in practice.

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