Political Dynamics in Knowledge Work:

Using visual artifacts to deal with pragmatic boundaries

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Abstract

Previous research on knowledge work has started to explore how organizational actors deal with pragmatic boundaries that arise from their different interests, priorities, and viewpoints. Material objects like visual artifacts can be used to shape and manipulate pragmatic boundaries, but our understanding of these dynamics is only partial. In this paper, we maintain that focusing on the uses of visual artifacts offers an opportunity to deepen our understanding of the political aspects of knowledge work. To this end, we conducted a practice-based study of an architectural project in which the building design became contested. Our empirical analysis reveals four practices in which visual artifacts are used to deal with pragmatic boundaries: surfacing, bridging, preventing, and minimizing. Through these practices, organizational actors can make boundaries more or less visible, with important implications on their power relations and the project at hand. The main contribution of our study is to advance understanding of the political dynamics in knowledge work by revealing how visual artifacts can be used to manipulate pragmatic boundaries. By so doing, our analysis also helps to move the conversation on visual artifacts beyond their role as epistemic objects that sustain (or hinder) knowledge work.

Keywords: knowledge, visual artifacts, pragmatic boundaries, politics, practice.

Introduction

Knowledge work is fraught with challenges that relate to the different interests, priorities, and viewpoints of organizational actors. This leads to the emergence of pragmatic boundaries that hinder knowledge integration and development (Bechky 2003b, Carlile 2004, Kellogg et al. 2006). Previous research has shown that actors can engage in dialogue to address their differences and deal with such boundaries (Mengis et al. 2018, Faraj and Xiao 2006, Tsoukas 2009). For instance, they can traverse boundaries by negotiating their differences or transcend boundaries by downplaying their differences (Majchrzak et al. 2012). We have also learnt that various types of material objects play an important role in supporting dialogue across boundaries. While this body of research has focused on technological artifacts and other types of boundary objects (Carlile 2002, Orlikowski 2000, Nicolini, et al. 2012), the role of visual artifacts has remained undertheorized. This is despite the fact that visual artifacts can be effectively used to manipulate boundaries; in particular, to reveal or conceal important differences in the actors' interests, priorities, and viewpoints.

We argue that a focus on the uses of visual artifacts is a missed yet promising opportunity to deepen our understanding of the political aspects of knowledge work. Visual artifacts (e.g. diagrams, drawings, models, sketches, and slides) are central to the making of organizational knowledge (Boxenbaum et al. 2018, Ewenstein and Whyte 2009, Meyer et al. 2013). Because of their representational capacities, they can be used to shape the meanings produced by others or even exclude them from the production of meaning (Barley et al. 2012, Bechky 2003a, Kaplan, 2011). Hence, attending to the uses of visual artifacts can shed further light on the practices by which organizational actors manage their differences in and around contested issues. It can specifically help to focus attention on the political dynamics related to revealing or concealing in knowledge work. Thus, we address the following questions: *How are visual artifacts used to deal with pragmatic boundaries? What are the effects of their uses on knowledge work?*

To this end, we adopt a practice perspective informed by a humanist tradition (Feldman and Orlikowski 2011: 1242). This suggests that human and material agencies are interdependent in their producing of effects, while recognizing intentionality as a distinct feature of human action. The focus

is placed on 'knowledgeable human action' and how its recurrent engagement with the artifacts at hand constitutes practices of artifact use (Orlikowski 2000: 421). Thus, we attend to visual artifacts 'in-use' (or 'in-practice') – i.e. what organizational actors do with visual artifacts in their situated actions when dealing with boundaries. We conceive of boundaries not as stable entities, but as social accomplishments (Langley et al. 2019) shaped through practices of using visual artifacts. Such practices are material as well as discursive (Nicolini 2011).

Drawing on this practice perspective, we conducted an in-depth ethnographic study of a design project. We focused on how architects, engineers, and their clients engaged with visual artifacts in shaping the building they were designing (i.e. an energy center). Over a six-month period, we followed design work in the architectural firm and observed fortnightly meetings of the design team. Our attention was captured by a critical incident; the client voiced their dissatisfaction with the building design and suspended the planning application. This episode provided the starting point for exploring how visual artifacts were used across different instances where pragmatic boundaries posed challenges for the project. Our methodological approach reflected a concern to foreground the uses of visual artifacts in practice, without reducing such artifacts to texts or talk (cf. Boxenbaum et al. 2018).

Our analysis reveals four practices of dealing with pragmatic boundaries in knowledge work: surfacing, bridging, preventing, and minimizing. Through such practices, actors can surface and then confront differences that are still latent (surfacing), find middle ground between different and polarized positions (bridging), anticipate and mute out differences that are not yet expressed (preventing), and reduce or smooth over the appearance of controversial issues (minimizing). Our analysis further reveals the key elements of the practices: the freezing and unfreezing of visual artifacts, their loci of production and consumption, and the ways in which they are controlled by the actors. These have implications for knowledge work, making boundaries more or less visible and altering the power relations between actors.

The main contribution of our study is to advance understanding of the political aspects of knowledge work by revealing the various ways in which visual artifacts can be used to manipulate the visibility of pragmatic boundaries. Specifically, we explain how visual artifacts can be mobilized not just to surface and bridge boundaries, but also to minimize their visibility or even prevent their

emergence. By so doing, we extend previous research on knowledge work that has tended to treat boundaries as relatively stable, manifest demarcations between organizational groups (Carlile 2004, Orlikowski 2002, see also Langley et al. 2019). Relatedly, our analysis of visual artifacts in-use adds to previous research that has examined 'traverse' and 'transcend' as dialogic approaches to deal with boundaries (Kellogg et al. 2006, Majchrzak et al. 2012, Mengis et al. 2018). We show that traverse and transcend are not alternatives, but mutually compatible approaches that can be entwined in the same project. Hence, we offer a more dynamic and nuanced view of knowledge work – illuminating its political aspects and overcoming the traverse-transcend dichotomy.

Finally, our analysis also extends research on visual artifacts in organization and organizing more generally (Meyer et al. 2013, Höllerer et al. 2019). In particular, we develop a political perspective on visual artifacts in-use that resonates with the seminal work by Barley et al. (2012), Bechky (2003a), and Kaplan (2011) but also extends it. While these scholars have pointed to the politics surrounding individual artifacts (e.g. engineering drawings), we develop a theoretical framework that accounts for multiple artifacts and the specific ways in which they can be used to manipulate the visibility of boundaries. By so doing, we also complement research on the epistemic role of visual artifacts (e.g. Ewenstein and Whyte 2009), which has foregrounded the collaborative relations that develop around their uses without however focusing on political dynamics.

Theoretical Background

Knowledge work at pragmatic boundaries

The practice perspective has challenged traditional views of organizational knowledge and knowing. It suggests that knowledge is not an asset to be managed in organizations but a practice that emerges in the everyday activities of organizing (Brown and Duguid 1991, Cook and Brown 1999, Miettinen et al. 2009, Orlikowski 2000, 2002, Nicolini 2011, 2012). From this perspective, knowledge is something that organizational actors do; it is enacted in their ongoing and situated actions as they engage the world (Orlikowski 2000: 249). This foregrounds the role of material artifacts (e.g. visual artifacts) in knowledge work to the point that organizational knowledge is understood as "a way of acting and using artifacts" (Miettinen et al. 2009: 1312).

While practice scholars hold different positions on the relation between human actors and material artifacts, we draw on a research stream underpinned by a humanist tradition (Feldman and Orlikowski 2011: 1242; Schatzki 2002). In this tradition, "it is humans who carry out practices and set in motion processes of intelligibility. While human actions involve and can be affected by artifacts … only human action can attribute purposefulness and affectivity" (Cecez-Kecmanovic et al. 2014: 815). This humanist vein of practice theory suggests that knowledge work is an ongoing social accomplishment. It draws attention to the social construction of boundaries (Langley et al. 2019) and the uses of material artifacts in 'knowledgeable human action' (Orlikowski 2000: 421).

The literature on knowledge work offers a variety of views on boundaries. The pragmatic view, in particular, foregrounds the political aspects of knowledge work, focusing on what is at stake for actors as they coordinate to share and integrate knowledge (Carlile 2002; 2004, see also Bechky 2003a, Kellogg et al. 2006). In this paper, we use the terms *pragmatic boundaries* and *boundaries* interchangeably to indicate our concern with the political aspects of working across boundaries. Knowledge work at a pragmatic boundary is characterized by three relational properties – i.e. *difference*, *dependence*, and *novelty* (Carlile 2004, Majchrzak et al. 2012), which are present in varying degrees and contingent on the setting at hand. Difference refers to the types of knowledge at hand (e.g. design and manufacturing) and the challenges posed by their integration. Knowledge differences are consequential in the case of dependence – i.e. when actors depend on each other for achievement of a common goal (Carlile 2004: 556).

Yet the most challenging aspect of working across boundaries is novelty. This occurs when actors are confronted with a task they have not done before (Majchrzak et al. 2012: 956) or new customer needs that affect their different domains of specialism (Carlile, 2004: 557). Here, novelty might result in conflicting interests between the actors that hinder their ability to assess and integrate knowledge. When interests conflict, "the knowledge developed in one domain generates negative consequences in another," thus requiring "a process where actors negotiate and change the knowledge and interests from their own domains" (Carlile 2004: 559). Hence, a pragmatic boundary arises when new requirements trigger conflicting interests between actors who depend on each other to develop knowledge. Pragmatic boundaries are found, for example, between designers and manufacturers

involved in new product development (Carlile 2002), anesthesiologists and surgeons stabilizing a patient (Faraj and Xiao 2006), or occupational groups involved in project work (Kellogg et al. 2006).

How to deal with these boundaries? A stream of research on the dialogic aspects of knowledge work has focused on the traverse and transcend approaches (Faraj and Xiao 2006, Majchrzak et al. 2012). In traversing boundaries, actors engage in 'deep-knowledge dialogue' (Majchrzak et al. 2012: 953); they question each other's assumptions, ask for or offer detailed explanations, and map their mutual dependences (e.g. Carlile 2002, 2004, Cook and Brown 1999, Mengis et al. 2018). This dialogue leads to creative processes of conceptual change (e.g. combination, expansion, and reframing) whereby actors can transform their current knowledge and create common understanding (Tsoukas 2009). Here, common understanding does not necessarily imply agreement or consensus but still enables actors to advance their knowledge work by reconciling the various meanings and priorities assigned to organizational issues (Okhuysen and Bechky 2009).

Further research has examined the dialogic practices used in situated settings where boundaries are traversed. Orlikowski (2002) explored how actors interact to traverse boundaries in complex projects, thereby enacting a collective competence in distributed organizing. Mengis et al. (2018) in turn explored situations of epistemic uncertainty where the problem at hand and dependences among actors are rather undefined. They found that drawing distinctions dialogically (e.g. between what is known and unknown) enabled actors from across different domains to create common understanding of unexpected results and to resolve the political tensions engendered by them. This entailed challenging previously held distinctions and reconfiguring mutual obligations and expectations.

Dialogic practices for traversing boundaries are contentious due to the conflicting requirements posed by knowledge work and the involvement of actors with different cultures and interests (Bechky 2003b, Carlile 2004, Nicolini 2011). The common understanding that ensues is best conceived as the result of power struggles among actors, rather than as a spontaneous agreement to fulfil organizational objectives (Contu and Willmott 2003). Its creation involves the exclusion or silencing of many actors: their viewpoints become visible only when power relations shift, enabling them to challenge the existing common understanding (Nicolini 2011: 613). This draws attention to

the politics underlying the creation of common understanding, including the material and discursive practices of reaching closure and resolving differences.

Scholars have also suggested that actors can integrate and develop knowledge by transcending boundaries rather than traversing them. They do so by downplaying (instead of confronting) their differences (Majchrzak et al. 2012: 952); which in turn reduces interpersonal conflict, encourages individual contribution, and enables flexibility in developing solutions. Kellogg et al. (2006) used the 'trading zone' metaphor to describe a coordination structure where actors can work across boundaries without forging agreement around procedures, protocols, and objects. Here, actors encounter to 'exchange' knowledge; they agree on the general procedures of the exchange even if they have different understandings of the knowledge traded and the purposes of the exchange itself. They further engage in practices of *displaying*, *representing,* and *assembling*: knowledge is displayed in a shared repository, is represented through use of communication genres (e.g. PowerPoint slides), and is assembled through modification and recombination (Kellogg et al. 2006).

The transcend approach reduces the extent and depth of the common understanding needed to carry out knowledge work. The use of dialogue is as important as in the traverse approach, though its aim is to *assemble* rather than *transform* knowledge (cf. Carlile 2004). Thus, dialogic practices to transcend boundaries unfold in fast exchanges and achieve breadth rather than depth. This is helpful in post-bureaucratic, inter-organizational, and project-based settings (Boland et al. 2007, Dodgson et al. 2007, Kellogg et al. 2006) where knowledge work is constantly changing, worth criteria are contested, and occupational jurisdictions are blurred. Transcending boundaries requires actors to reshape their work practices and relations; for example, by changing the temporal structure of project work from sequential to simultaneous (Boland et al. 2007). It also makes them lessen the stakes in the knowledge traded and reduce or even abandon opportunities to learn about the knowledge of others (Kellogg et al. 2006).

'Life in the trading zone' (Kellogg et al. 2006: 22), however, is not without challenges. The dynamic nature of knowledge exchanges turns the workspace into a 'trading floor' (Dodgson et al. 2007: 857) where individual work is constantly interrupted, thus causing rework and loss of focus. In the organization studied by Kellogg et al. (2006), for example, continuous revisions of the displayed

knowledge caused misunderstandings among the actors involved. Furthermore, attempts at transcending boundaries may result in a limited understanding of the consequences that the displayed knowledge has for the actions of others. They may also lead to an organizational group producing a 'dominant narrative' that suppresses different interpretations of the assembled knowledge, different standards for work practices, and different preferences for work priorities (Wolbers and Boersma 2013: 196).

Despite divergence in their orientations, both the traverse and transcend approaches underscore the role of dialogue and hint at the involvement of visual artifacts. We extend this previous research by exploring how visual artifacts are used in dealing with pragmatic boundaries – and the implications thereof. This is important *per se* but can also add to our understanding of the politics of knowledge work by elucidating how visual artifacts can be used to reveal or conceal pragmatic boundaries. In what follows, we take a closer look at visual artifacts as a specific type of material artifact used in knowledge work, with particular attention to their roles at pragmatic boundaries.

Visual artifacts at pragmatic boundaries

Visual artifacts are central elements of knowledge work. They are "produced and reproduced through different media," taking on multiple forms that range "from digital to physical, and from two- to multi-dimensional" (Comi and Whyte, 2018: 1058). Visual artifacts can be ascribed to the broader category of material agencies (Leonardi 2011) and yet retain their distinctiveness as 'artifacts of knowing' (Ewenstein and Whyte 2007: 81). As such, they support not just the representation of existing knowledge but also the generation of novel insights (ibid.). Through interaction with and around visual artifacts, organizational actors can share knowledge across boundaries (Carlile 2002), give form to what is not yet known (Ewenstein and Whyte 2009), enlist commitment around a given perspective (Henderson 1995, 1999), exclude others from the production of knowledge (Kaplan 2011), and shape the meanings developed on the other side of a boundary (Barley et al. 2012).

For the purposes of this paper, we focus on the visual artifacts that are most salient in our empirical setting – e.g. CAD drawings, Gantt charts, meeting agendas, digital photographs, and PowerPoint slides. These can be understood as aggregates of pictures, texts, and notations that exist in

various combinations and are inscribed onto a given space – i.e. on paper or online (Elkins 1999, Ewenstein and Whyte 2009). For example, a geographical map is a collage of pictures and texts with added notations such as symbols for places, latitude, and longitude (Elkins 1999: 85). Pictures engage the viewers in acts of looking; texts and notations prompt acts of reading and deciphering, respectively. While these elements (pictures, texts, and notations) engage the senses in different ways, it is impossible to discern their individual contribution in the use of a visual artifact.

Furthermore, it is rare to encounter pure forms of pictures, texts, and notations (Elkins 1999: 91). By conceiving of visual artifacts as aggregates of these elements, we eschew the dichotomy between pictorial and textual and avoid reducing visual artifacts to their textual component. Hence, our aim is not to distinguish between pictures, texts, and notations, but to underscore that visual artifacts integrate such elements (see also Höllerer et al. 2019). In Table 1, we provide examples of visual artifacts commonly used in design settings, which we organize according to their various combinations of pictures, texts, and notations.

Insert Table 1 about here

Following the practice-based humanist perspective, we approach visual artifacts as 'visual artifacts in-use' – placing the focus on what human actors actually do as they use visual artifacts to deal with their pragmatic differences. Drawing on Orlikowski (2000), our approach involves an analytical distinction between visual artifacts (as given combinations of pictures, texts, and notations) and their *uses* in practice (i.e. visual artifacts in-use). Visual artifacts can be socially recognized as general forms that transcend the experience of particular individuals and settings (e.g. as drawings, models, or sketches) but become meaningful only as they are enacted in recurrent and situated uses (i.e. as visual artifacts in-use). Hence, the same artifact can trigger different effects, depending on the specific circumstances of its use.

Research on visual artifacts in-use at pragmatic boundaries is limited. However, we can benefit from research that has explored how material artifacts more broadly enable actors to deal with boundaries. In his typology of boundary objects, Carlile (2002: 451) suggested that *objects or models*

(e.g. sketches) and *maps of boundaries* (e.g. Gantt charts) support not just the translation of knowledge, but also its transformation at a boundary. It is by annotating, modifying, or manipulating their content, that actors can "apply what they know and transform the current knowledge used at the boundary" (Carlile 2002: 452). This interaction with objects or models and maps – which we consider visual artifacts – enables representing differences and dependences at a boundary and building a common understanding that would not be possible through words alone.

Visual artifacts are interpretively flexible, like all types of material artifacts (Pinch and Bjiker 1984). For example, visual timelines enable multiple interpretations of milestones, deadlines, and deliverables (Yakura 2002). While the image of a timeline confers a sense of objectiveness to the flowing of time, "each participant in a project is free to interpret the timeline from his or her own perspective and to fill in the gaps in different ways" (ibid.: 959). This interpretive flexibility is central to a visual timeline functioning as a boundary object between organizational groups. Properties such as interpretive flexibility, however, are not inherent in the artifact itself but become manifest in the specific context of use (Zeiss and Groenewegen 2009). As noted by Levina and Vaast (2005: 340): "Outside of its use, it is impossible to determine whether an artifact has, or will ever, acquire a common identity or whether it will satisfy varied local needs."

A few scholars have argued that material artifacts (including visual artifacts) enable not just the traversing of boundaries but also their transcending (Majchrzak et al. 2012). Here, representations (Majchrzak et al. 2012), genres (Kellogg et al. 2006), and models (Boland et al. 2007, Dodgson et al. 2007) are used not to negotiate differences and dependences at a boundary, but to create an emerging map of collective knowledge that can be applied to the problem at hand. This is achieved, for example, by inscribing individual knowledge into 'scaffolds,' namely 'visual or verbal representations' that provide a neutral space for integrating knowledge (Majchrzak et al. 2012: 959). By dialoguing around the scaffold, actors avoid the interpersonal conflict that ensues from attempts to negotiate differences, and instead use the neutral scaffold to seek out creative tensions from the problem at hand. The scaffolds used to transcend boundaries are "fluid, incomplete, and continuously evolving to meet the needs of the knowledge work" (Majchrzak et al. 2012: 953).

Related research by Ewenstein and Whyte (2009) underscores the continuous unfolding of visual artifacts in knowledge work. This suggests that visual artifacts serve not just as boundary objects that cross boundaries, but also as epistemic objects that generate knowledge (cf. Knorr Cetina, 1997, 1999). As such, visual artifacts are provisional instantiations of an object of inquiry that is elusive and difficult to capture. For example, sketches enable architects to imagine and materialize a building that does not yet exist (Comi and Whyte, 2018). They embody a sense of lack or incompleteness that sustains knowledge development by raising questions and inviting exploration (Ewenstein and Whyte, 2009). This triggers cascades of representations that are constantly in flux rather than fully formed. The object of inquiry they represent is never fully actualized, though some of its aspects can be stabilized or frozen while others are opened up for exploration.

This results in a continuous flow and gentle reshaping of the artifacts at hand (Law and Singleton 2005: 338). To capture the unfolding of visual artifacts in-use, Whyte et al. (2007, 2008) use the metaphor of a continuum between fluid and frozen uses. These are not absolute categories, but a matter of degree: visual artifacts are never fully fixed but can be provisionally frozen to reach closure around the state of things they represent. The patterns of freezing and unfreezing configure the practice at hand; their entwinement enables actors to move between change and stability, participation and reification (Whyte et al. 2007, 2008). This resonates with Orlikowski's (2000: 411) considerations on technological artifacts in-use: "the stability of the technology and its applications is only provisional." By attending to instances in which artifacts are provisionally frozen or stabilized, we can foreground their consequences on boundaries and knowledge work.

Further research has indicated that conflicts, politics, and tensions can surround artifacts in-use (Nicolini et al. 2012). It has suggested that material artifacts (including visual artifacts) can be implicated in power struggles through which knowledge becomes legitimated (or delegitimated). In a study of occupational groups within a manufacturing firm, Bechky (2003a) found that authority over artifacts (engineering drawings and machines) can reinforce boundaries and strengthen beliefs about the legitimacy of a group's work. For instance, the use of drawings supported the jurisdiction of engineers; by controlling drawings, engineers gained the power to determine when other groups (e.g. assemblers and technicians) could participate in the design process.

Adding to this, Barley et al. (2012) suggested that artifacts can be 'crafted' to shape the meanings that will be developed by others. Kaplan (2011) found that PowerPoint slides enable both collaborative efforts to negotiate meaning *and* cartographic efforts to adjudicate interests. On the collaborative side, PowerPoint sustained the transformation of knowledge by creating a collective space for discussion, recombination, and adjustment of ideas (Kaplan 2011: 321). Yet PowerPoint slides also supported cartographic efforts to draw boundaries, enabling document owners to make inclusions and exclusions – and hence control access to knowledge.

While these are important advances, what remains to be explored are the various ways in which visual artifacts can be used to manipulate boundaries; in particular, to reveal or conceal important differences between the actors. This is not just a theoretical gap *per se*, but also a missed opportunity to deepen our understanding of political dynamics in knowledge work. We now turn to a revealing case that allows us to foreground practices of visual artifacts use and the political aspects involved.

Case, Data and Methods

Fieldwork and critical incident

This study builds on fieldwork carried out within an architectural firm appointed to design an energy center. The approach to the fieldwork was open-ended and informed by a broad interest in visual artifacts and knowledge work. The focus on pragmatic boundaries became explicit after a critical incident was observed in the field. During a project meeting, the client voiced their dissatisfaction with the building design and stopped submission of the planning application. This incident brought into view the different interests of actors and their stakes in the design project. Using this episode as a starting point, we identified instances of boundaries and directed our attention to the visual artifacts in-use.

The setting

Based in the UK, the architectural firm in which we conducted our fieldwork is a medium-sized company with operations in private housing, public building, and urban planning (at both the

national and international level). This firm is widely acclaimed by architectural critics and has received prestigious awards. Taking distance from modern 'starchitects,' the firm's leaders pride themselves on designing buildings that respond creatively to their contexts and on placing people at the center of the design process.

The energy center project was commissioned by the estate office of a university. It consisted of designing a combined heat and power (CHP) plant that could increase the university's existing supply of energy and allow for future extensions to biogas. This project involved several organizations, namely the architectural firm, the client organization, as well as engineering and management consultancies. The project followed the RIBA (Royal Institute of British Architects) Plan of Work, which organizes the design process into three stages: design concept (Stage C), design development (Stage D), and technical design (Stage E). This is preceded by a preparation stage (Stage A/B) involving identification of the client's needs and objectives, development of the design brief, and appointment of consultants.

The controversial nature of this project stemmed from misinterpretation of the design brief, which led the architects and their clients to develop conflicting expectations of the building design. This became clear at a late stage in the project, when the clients realized that the architectural design countered their ambition to minimize the visual impact of the building. At this point, the clients advanced new requests, which had repercussions not just for the architectural design but also for the acoustic, mechanical, and structural engineering. The planning application was delayed by several months, requiring both the architects and the clients to commit further resources and engage in substantial rework. Such difficulties notwithstanding, they managed to design a state-of-the-art energy center that was later featured in architectural reviews.

This project provided an ideal setting for studying pragmatic boundaries and visual artifacts in knowledge work. Firstly, it required actors from across various organizations to integrate different types of knowledge into a common output (i.e. building design). Here, pragmatic differences concerning the building design generated boundaries to sharing and assessing knowledge. Secondly, dealing with boundaries in this project involved a wide array of visual artifacts. While it might be objected that visual artifacts are more prominent in architectural firms than in other types of firms,

this choice of setting was instrumental to foreground the phenomenon of interest. The findings will be applicable to project management, strategy making, and other settings in which visual artifacts are used intensively to deal with boundaries.

Empirical material

Data collection followed the general recommendations of ethnographic work (Van Maanen 1988) and was informed by a concern to get close to the visual artifacts used by participants. The first author conducted fieldwork in the architectural firm, covering the entire timescale of the energy center project (September 2012 – February 2013) from preparation (Stage A/B) to design concept (Stage C), design development (Stage D), and technical design (Stage E). Over a six-month period, she spent one day a week in the architectural firm. She became involved in the life of the firm by eating lunch with the architects and attending cultural and social events hosted at the firm.

Following the architects, she traveled fortnightly to the client's headquarters to observe project meetings of the design team (comprised of architects, consultants, and their clients). She was also granted access to the online platform used to share, revise, and approve design proposals. During observations of project meetings, she took extensive photographs and notes. The notes were revisited later during the day while memories from the field were still fresh. All project meetings were audio-recorded and relevant episodes were transcribed verbatim. The video-recorder on the digital camera was activated to capture interactions with visual artifacts (e.g. hand-drawn sketching), which were difficult to document through notes or photographs alone.

The internal meetings of the architects were also documented through photographs, field notes, and audio- and video-recordings. In addition, data collection at the architectural firm involved observation of silent work performed at the computer (e.g. digitalization of hand-drawn sketches). Here, informal conversations with the architects were instrumental in keeping track of progress in design work and making sense of the visual artifacts taking shape on the screen. Table 2 shows the extent and uses of our dataset. Observations were the primary source of data, while documents and interviews corroborated the interpretations emerging from their analysis.

Insert Table 2 about here

Data analysis

The analysis focused on understanding the role of visual artifacts in dealing with pragmatic boundaries. Our approach was informed by a practice-based humanist perspective and was concerned with developing theoretical explanations of the observed activities (Feldman and Orlikowski 2011). In so doing, we set out to avoid two types of methodological reductionism. First, we strove not to reduce visual artifacts to texts or talk (cf. Boxenbaum et al. 2018) and instead to foreground their uses in practice. Second, we set out not to confine the study of visual artifacts to isolated interactions, thereby avoiding the problem of 'interactional reductionism' (Nicolini, 2009: 1396). Rather than engaging in micro-ethnographies of single episodes (Streeck and Mehus 2004), we sought multiple instances in which visual artifacts became implicated in dealing with boundaries. As described below, the analysis involved three steps.

Preliminary analysis and selection of episodes. At first, our attention was captured by the critical incident in which the clients voiced their disapproval of the architects' design. Bringing into view the conflicting nature of knowledge work, this incident pushed us to focus on boundaries. We then revisited our dataset to find related episodes of design work that revealed pragmatic differences among the actors involved. To this end, we conducted a preliminary analysis of meeting transcripts, fieldnotes, and video recordings, searching for interactions that hinted at differences in interests, priorities, and viewpoints. We then used the analytical categories of *difference*, *dependence*, and *novelty* (Carlile 2004, Majchrzak et al. 2012) to identify and characterize boundaries. We named the boundaries at stake (e.g. showing vs. hiding features of the building) and associated photographs of visual artifacts in-use (e.g. hand-drawn sketches of the redesigned building). As we matched the photographs with transcripts and videos, we were able to display visual artifacts as they were used in practice and to appreciate their involvement in the interaction of participants.

We then took a closer look at the visual artifacts in-use. For each episode identified, we analyzed different aspects of visual artifacts: their content (e.g. an architectural proposal); changes in

their content (e.g. revisions to the architectural proposal); their type (e.g. a hand-drawn sketch); shifts across types (e.g. from hand-drawn sketch to computer drawing); the organizational loci of their production, consumption, and revision (e.g. the architectural firm); their displacements across organizational loci (e.g. from the architectural firm to the project meeting); their centrality in the interaction of the design team; and their approval by the client.

As we delved further into the analysis, we noted that visual artifacts were not always central to dealing with boundaries. In some cases, participants addressed their differences mainly through dialogue where visual artifacts remained in the background (i.e. lesser centrality in the interaction of the design team). We therefore decided to focus on episodes in which visual artifacts were mobilized to the point of becoming the fulcrum of interactions – as evidenced by multiple changes in their contents, shifts across types of visual artifacts, and displacements across organizational loci. Here, visual artifacts were actively manipulated to deal with boundaries.

Analysis of visual artifacts at pragmatic boundaries. We revisited these selected episodes to interpret how visual artifacts became mobilized in dealing with pragmatic boundaries. We examined the visual artifacts used in each episode (through transcripts, photographs, and videos) and traced connections across episodes to appreciate evolution of the boundary at stake. While focusing on observational data, we drew on documentary sources about the project and informal conversations with the actors to support our emerging interpretations. We also used our contextual knowledge of the project to better understand the pragmatic interests at stake.

We identified different patterns of using visual artifacts. We first examined how visual artifacts were evolved through patterns of freezing and unfreezing (Whyte et al. 2007, 2008) and questioned the implications of such patterns for knowledge work. We identified instances in which visual artifacts were provisionally frozen on one side of the boundary and made unavailable for change to actors on the other side of the boundary. We then traced connections to related instances in which visual artifacts were unfrozen and opened up for inquiry. Relatedly, we observed how the freezing-unfreezing of visual artifacts was associated with additional patterns – i.e. their control by the actors and their loci of production and consumption. For example, the provisional freezing of

visual artifacts was associated with actors retaining control of such artifacts. Here, visual artifacts were produced on one side of the boundary and then circulated to the other side for consumption.

Finally, we analyzed how the patterns identified (freezing-unfreezing, control, loci) produced effects on the boundaries at stake and on knowledge work. Iterating back and forth between data and theory, we mobilized the analytical categories of traversing and transcending boundaries. In analyzing our episodes, we questioned whether the visual artifacts in-use enabled actors to resolve or downplay their differences. We noted how different patterns in the freezing-unfreezing, control, and loci of visual artifacts made boundaries more or less visible, enabling actors to bring up and traverse differences or to cover and transcend them. We further observed that the different patterns in the freezing-unfreezing, control and loci of visual artifacts impacted knowledge work, enabling actors to push for closure around a given view or give voice to different views.

Development of a theoretical framework. We strove to develop practice-based, theoretical explanations of the observed episodes. By reflecting on the patterns that emerged in the previous step, we identified different practices of mobilizing visual artifacts at pragmatic boundaries, which we labelled as surfacing, bridging, preventing, and minimizing. We then wrote vignettes that exemplified each practice and its outcomes. This enabled us to refine our findings. In particular, drawing comparisons across examples led us to identify different types of boundaries at stake (i.e. latent and manifest). We finally reflected on and moved beyond the case at hand to articulate findings of wider applicability. These are summarized in our inductively derived theoretical framework presented in Table 4 (Discussion section).

Findings: Dealing with Pragmatic Boundaries in the Energy Center Project

We identified four practices in which visual artifacts are used to deal with pragmatic boundaries: surfacing, bridging, preventing, and minimizing. Table 3 offers examples of these practices, characterizing the boundaries at stake and the visual artifacts in-use.

Insert Table 3 about here

The following vignettes elaborate specific examples, illuminating the uses and effects of visual artifacts across various instances of pragmatic boundaries. The first three vignettes illustrate boundaries between the architects and their clients – concerning the visual appearance of the building, the design revisions to be undertaken, and the relationship between form and function. The final vignette showcases the backstage work of crafting a planning application by which the design team managed their boundary with the planning authorities. Across such instances of boundaries, visual artifacts were used in different ways (leading to surfacing, minimizing, bridging, and preventing boundaries). To facilitate understanding of the boundaries at stake and their unfolding, the vignettes start with a background section that summarizes relevant events and conclude with an outcome section that elaborates on the effects of visual artifacts.

Vignette #1. Surfacing: Seeing through visual artifacts

Background. The architects and their engineering consultants attended a meeting at the client's headquarters. Here, the client's project manager reported that the director of the estate office was dissatisfied with the building design – the main problem being its visual impact on the landscape. Albeit perplexed by this concern, the lead architect and two junior architects responded by sketching a building envelope that expressed a more rural appearance and broke down the building mass. After the engineers left, the architects met the director. In what follows, we show how the inspection and manipulation of visual artifacts enabled the architects and the director to surface and traverse their pragmatic differences regarding the visual appearance of the building.

Surfacing. As he walked in the meeting room, the director voiced his dissatisfaction. He expressed a desire for a building design that was more suited to the landscape: "The building that I anticipated … would be much more connected with the copse and the shape of the land … much more rounded … I've seen [proposals] for gas turbine stations where [they've used] bright colors and lots of glass to try and make the thing invisible. I always felt, really, what I was trying to get on this site is something that's almost disappearing into the woodlands …."

In response, the lead architect showed the sketch that she had drawn a few minutes before (as she was informed that the building was too imposing). This was well received by the director: "I think

that looks much better now; I would have the structure extending out…." He added: "We were expecting to have perhaps a slightly more landmark building … something that was a bit of a statement but clearly designed to sit in that particular location." The lead architect argued that form making was constrained by the mechanical components of the building: engines, silencers, and transformers. Their heights did not fit the rounded form sought by the director. It was like putting "a square peg into a round hole."

Inspection of multiple artifacts such as building elevations, site maps and plans surfaced further differences related to the visual appearance of the building: its cladding, roof, and colors. For example, the lead architect felt that timber cladding was most suitable, based on her aesthetic judgment and experience: "…because we've experience of [designing] buildings with timber cladding … [we know] that they look quite good against a wooded background," whereas the director emphasized aspects of durability and cost: "I don't like timber on the external surface of buildings … [It] weathers very badly. You'll get wind patterns on the side of the building and [it'll] start to stain."

The director then asked for more understanding of the visual impact of the building: "While I didn't particularly like the scheme, I would like to have seen a sketch-up model. And particularly what the visual impact would be along this road, looking [from] this way." The lead architect showed printouts from a sketch-up model, remarking that they did not print out well and that the scaling was not correct. In inspecting the printouts, the director articulated the difference between the objective of the architects and his own: "I suspect that your objective … [is] quite different from mine. You're trying to show the building and I'm trying to hide the building."

Pointing to a site plan, the lead architect explained: "We're trying to show what's there. The planting is there. And the building sits there. So, [the planting] isn't hiding the building. From the beginning we have known that it's a big building and you can't hide it." A junior architect added that glazing (advocated by the director to achieve transparency) was not feasible due to the acoustic and heating requirements of the building and remarked there was little scope for creating a rounded form given the height requirements for mechanical ventilation. As this and other differences became articulated, the lead architect concluded: "I guess the problem is that we haven't understood your brief … we're listening now and trying to understand what you're looking for."

Through further dialogue around visual artifacts, some misunderstandings were clarified – for example, regarding glazing and colors. In inspecting site maps and plans, the lead architect noted: "If we went for something with bold colors, it could be the wrong move in terms of how this [the building] is seen in the context of future [developments]. The director agreed and explained that his remarks were made with reference to "a particular plan I'd seen … a glazed building with bold colors." He acknowledged that maintenance of glazing was rather problematic; and concluded that "[glazing and bold colors] are not maybe appropriate." Still, he remarked as follows: "I'm just concerned that I don't think I can sell this project to the university in that particular design."

The lead architect then articulated the rationale behind her design choices. Using her hand-drawn sketch as a reference point, she explained how the design team approached the challenge of "breaking down the [building] form and still meeting all the functional requirements." The director stepped in to question her design choices and pursue further reductions in the visual appearance of the building. For example, he asked if there was "any reason why the building is not flipped?" and gestured over a site plan to suggest rotating the building and tucking its mechanical components behind a tree line. The lead architect replied: "To get vehicle access." The director, however, pushed back on her explanation and reiterated that the building did not fit the site. After further discussion, he concluded: "My view is to pause for reflection for a couple of days. Maybe we don't go on with the planning application next week."

The lead architect then used images of exemplar buildings (available on the junior architect's mobile phone) as a source of inspiration to try and get closer to the desired form of the energy center. The director participated actively, using his iPad to gather information and later on getting printouts. Considering various exemplars, the lead architect made the following observation: "[The challenge] everyone's dealing with when they're trying to design this [type of building] is the skin ... they're not big transparent buildings because of the noise [attenuators] … How can you make the skin more interesting? The one at … University is quite interesting. It has a very nice cladding system. They've done a pitched roof all the way across, I think to break up the mass." The director showed interest and asked for further information on the cladding.

The lead architect continued while switching to her hand-drawn sketch: “We’re just sketching that now because potentially there’s a way to deal with what [the building] has to do inside but [still] break down its masses.” The director found the architect’s sketch reminiscent of a well-known building. He observed: “When you think about [our task], that’s exactly what they had on that site.” The lead architect agreed and added: “That sits in a wood as well...” The director continued: “… and what they’ve done is, they’ve tucked the building into that corner there with... a pitched roof very… very similar to that ... I think it’s light-clad using details very… very similar to that” (referring to the architect’s sketch).

The director then focused his attention on the architect’s sketch and suggested the following: “Perhaps going for a sunken pitched roof, extending it so that we diminish the profile … extending the building out but getting the...” The lead architect completed his sentence: “… getting the eaves lower, I think it would be a good thing. It’s still quite a tall building. But it feels like it’s getting that down” (pointing at the roof ridge). She then revised her sketch, adjusting the shape of the roof to lower the eaves. After leaving the room, the director returned with printouts of the building exemplar he mentioned beforehand and made comments on its cladding. He then engaged in further discussion with the lead architect, referencing slides of a site plan on his iPad.

Outcome. Inspection and manipulation of visual artifacts enabled the participants to *surface* and *traverse* boundaries. By using multiple artifacts (e.g. building elevations and site plans), participants surfaced various differences, explored their details, and clarified some misunderstandings. By looking at printouts from the sketch-up model, in particular, the director saw the main difference at stake: the architects’ objective was to show the building, whereas his objective was to hide it. As the director was able to better articulate his dissatisfaction with the building design, the boundary to be traversed became more visible and defined.

This interaction around visual artifacts, in turn, enabled identification of design solutions that traversed different positions. A hand-drawn sketch was produced to summarize emergent understandings of the redesigned building. Other artifacts were used to advance the hand-drawn sketch: the site plan provided background information, while images of exemplar buildings were used as a source of inspiration. They enabled the director to articulate his design ambitions and brought out

design solutions for breaking down a large form. The hand-drawn sketch became the fulcrum of the design interaction and was evolved fluidly by all the actors involved. Through collaborative, *fluid* use of visual artifacts, the director was actively involved in the search for viable solutions. This resulted in a common understanding of the design problem and solution to be sought (e.g. changing the shape of the roof).

Vignette #2. Minimizing: Contextualizing and rendering the drawings

Background. Although he was generally approving of the architect's sketch, the director was aiming for substantial revisions to the building design, especially reductions of the building masses. The architects discussed this issue in a follow-up conversation with the client's project manager. Unlike the director, the architects felt there was limited scope to further reduce the building masses and wanted to reach closure around the building design. The following vignette illustrates how the architects minimized and transcended pragmatic differences concerning design revisions. As a result, the design team proceeded with the planning application.

Minimizing. The client's project manager asked the architects if they knew how to react to the director's comments. The lead architect answered: "I've got one idea that we could draw up." The client's project manager suggested reducing the front elevation, but the lead architect interrupted him to express her concerns. Looking back at the previous meeting, she felt that use of printouts from the sketch-up model made the director overestimate the visual impact of the building. She commented: "Part of [the solution] might be just rendering our drawings properly. We've had this [issue] before with … [a government adviser]. They were saying, 'you can't do that.' And all we did was a colored pencil drawing over the exact same design. Then, they were saying: 'So much better.' And they were listening to us. I know that sometimes the way things are presented … can make [the building] look cruder and harsher than it actually is."

The client's project manager replied: "It needs softening. And I'm not quite sure we can always do that with software rendering…." The lead architect countered: "The sketch-up software is very crude. We have better software in the office. But I need to line up the resources to do that." Furthermore, the printouts that she had shown to the director were work-in-progress, as indicated by

the ‘draft image’ watermarks. As the lead architect had tried to explain to the director, the sketch-up model had not printed out well; it was in a vivid green that made the colors and shades look unnatural. Also, it did not accurately show the massing of the trees. The thicket, as she had remarked, was wider and would therefore have screened the building more than the drawings indicated.

Still, the client’s project manager emphasized revising the building design. He made a suggestion: “I [was wondering] whether we actually need that space on the top floor. And whether you could bring it down to a single story, just to break up the length of the [building].” But the lead architect observed: “I think there’s a point where it can start looking quite bitty[1] as well … And trying to keep it to a simple form or a symmetrical form, it helps this type of building.” She then considered lowering the building and breaking up its massing but noted how this would trigger functional issues. The client’s project manager in turn speculated about reverting to a previous design and using sheet materials to break down the front of the building. This option, however, caused revisions to the back of the building and further issues in terms of distance from the flues.

The lead architect then considered making the building longer. But she concluded: “We don’t want to make the footprint bigger. Because we start ending up with more costs and planning issues. We’re pretty close to the limit.” She also expressed concerns about the director’s suggestion to use brick cladding: “If it was a brick building … I think [it would] look boxier”; then she reiterated her preference for timber cladding. She felt that the timber created a nice contrast with the base, conferring a sense of movement and verticality to the facade. Yet, she made the following remark: “But I guess [the director] doesn’t like the way timber grays down.” The participants then discussed different options for brick cladding.

At the end of the meeting, the client’s project manager observed that the director did not fully understand the engineering aspects of the building design; nevertheless getting his sign-off was crucial for the design team. From informal conversations with the lead architect, we made sense of how she would approach the director’s comments: rather than struggling to further reduce the building masses, she would polish her drawings and sketches to show that the building fit the landscape. It

[1] A colloquial expression in British English. ‘Bitty’ means ‘fragmented’ or made up of different ‘bits’ that do not fit well together (Cambridge Dictionary, https://dictionary.cambridge.org/).

appeared that the lead architect would accommodate the director's requests as much as possible, but further reductions of the building masses were difficult. As she explained to the client's project manager (in a subsequent meeting): "We're trying to keep the height down but there's a point at which the building has to work." At this point, playing around with the building height would only escalate costs, as changes to the architectural drawings involved revising and coordinating all the drawings of mechanical systems.

Design work was carried out at the architectural studio. The junior architects were tasked with finishing and digitalizing the hand-drawn sketch produced in the meeting with the director, as well as completing and rendering the previous drawings. Their efforts were directed at "beautifying the building" (lead architect). The junior architects worked side by side, keeping different versions of the building on their screens. One developed the building envelope based on the lead architect's hand-drawn sketch, while the other inspected plans, sections, and elevations from the previous scheme (which had been rejected by the director). They coordinated to adjust the building envelope while saving what could be salvaged from the previous scheme. They fit the existing plans of mechanical components into the redesigned envelope and then searched for materials that expressed a rural aesthetic and smoothed out the visual appearance of the building.

This design work resulted in the preparation of a slides deck to be circulated to the director. The document included architectural plans, sections, and elevations that illustrated the "design concept reviewed." Textual explanations were used to put the design concept into context and reinforce its adherence to the comments received. For example, the first page showed pictures of exemplar buildings, accompanied by the following text: "We have listened to the comments about the design tabled at our meeting … and have responded with an alternative approach. We have drawn inspiration from rural vernacular buildings, buildings set in the landscape, like [those] which [were] cited as a good example."

The subsequent slides included four options for the building design, conveyed through perspective drawings of the building facade. All drawings were rendered at a high-quality level to show that the building fit the surrounding trees and field. The first option consisted of a rendered version of the previous scheme. Although rejected by the director, this was included in the slides deck

as a baseline option. The three ensuing options consisted of rendered versions of the architect's sketch – the only difference being the choice of materials for cladding. This slide deck was sent for review to the director. He opted for the revised design with a zinc roof and red bricks (without requesting further reductions of the building masses).

Outcome. The lead architect leveraged visual artifacts to *minimize* and *transcend* pragmatic differences concerning design revisions. From experience, she knew that rendered drawings would have persuaded the client about the building presence. Design work was shifted from the project meeting to the architectural studio. Here, the architects strove to contextualize and render the building – i.e. to position it more effectively on the site and to represent it more accurately. By so doing, the lead architect reduced the need for further redesign. Instead, she digitalized the hand-drawn sketch she had produced beforehand and preserved many of the previous drawings.

She then put together a slide deck for the client. Architectural drawings and textual explanations were entwined to illustrate the revised design and suggest its adherence to the client's comments. Furthermore, perspective drawings were used to convey slightly different options for the building design – i.e. different choices of construction materials. In this slide deck, the building design became provisionally *frozen*: only construction materials were left open for discussion. This freezing move reaffirmed the lead architect's viewpoint. She was confident that the visual appearance of the building was adequate vis-à-vis its functional requirements and accordingly leveraged her knowledge of visual artifacts to smooth over the issue at stake and push for closure.

Vignette #3. Bridging: Switching across multiple drawings

Background. As design work progressed to a technical stage, the architects encountered a new challenge: they realized that inclusion of the mechanical systems triggered changes in the internal layouts, which in turn affected the building form. They became concerned that an expansion of the building mass (albeit necessary to accommodate the mechanical components and hence ensure the building's function) would be met with resistance from the client. While the client's priority was to reduce the building mass, the lead architect flagged the issue of functional requirements in a meeting with the client's project manager, an estate office manager, and two engineering consultants. In what

follows, we show how switching across multiple drawings enabled these actors to bridge and traverse different perspectives by finding a compromise between form and function.

Bridging. As participants started discussing the agenda and minutes, the meeting table became full of visual artifacts: architectural drawings of the building plans, elevations, and sections; and engineering drawings of mechanical systems. The conversation focused on installation of the combined heat and power (CHP) components. The engineering consultants and the junior architect talked and gestured over an engineering drawing. As they pointed out, adding the acoustic attenuators to the CHP chambers required joining the penthouses and their louvers (which had been designed to break down the building mass) into a bulkier unit. The lead architect pointed at a building elevation and remarked: "This is what we have been battling with ... It makes the building look massive rather than industrial."

As the client's project manager asked for clarifications, the lead architect picked a 3D model printout from the table. Annotating the drawing with a red-felt tip pen, she showed how joining the penthouses and their louvers would affect the form of the building. She commented: "That's why we're trying to look at ways of … breaking down the mass of this piece [so that] we've got some lights and shadows in between the bulky bits of the building. But we need to discuss it together to get it right." She then speculated: "If we take that (pointing at the louvers on the elevation) all the way down…" and annotated a section to show a potential reduction in the height of the penthouse roof. The client's project manager mumbled, pointing at the drawing: "But that changes the angle, slightly into…." After a pause, the lead architect admitted: "We are back [at the point] when the building was felt a bit blocky."

She continued exploring solutions with the client's project manager, using the input of the engineering consultants. The architectural and engineering drawings, spread out on the meeting table, enabled the participants to switch across internal and external perspectives and to experiment with both. Throughout the meeting, the participants tried reductions in the building mass while cross-checking the internal layouts, and then revised the internal layouts to look for reductions in the building mass. This experimentation was achieved through a concerted interplay of annotations on

drawings. Floor plans were marked to show alternative arrangements of internal components, sections and elevations were annotated to simulate changes in the building mass.

For example, a design proposal emerged as multiple drawings were discussed and annotated. This consisted of straightening up the acoustic attenuators and adjusting the building elevation accordingly. The lead architect noted the implications: “Then we are also talking about putting doors ... And these (red-lining external doors on the elevation) are starting to become more articulated ... They are vertical elements that architecturally give a bit more character [to the gables] because you’ve got this kind of expression of the three chambers.” Looking at the roof, she commented: “There’s at least some light and shadow between these things (pointing at the louvers on the elevation). It’s just a bulkier, larger piece of roof. There’s a functional issue other than the sensitivity of how it looks.” And suggested, after a pause: “But if that’s what it needs to do, I suppose you can…”

However, some concerns arose regarding forklift access for maintenance and replacement of the CHP installations. The participants then shifted their attention to an engineering drawing and started looking for alternative configurations of the floor plan. As a potential route for forklift access was found, the lead architect annotated technical drawings with red arrows. She then asked: “Are we getting to some sort of sense in terms of the top and bottom [floors]? Does it make sense (pointing at a pile of annotated drawings)?” To address this question, the participants engaged in a collective testing of the route access, checking measures on engineering drawings to imagine lifting, swinging, and removing the mechanical components. The client’s project manager noted that the space was still too tight to maneuver: “They can’t … drive to get onto that platform. You’ve got to make sure that they can get by there … with an item on their forklift.”

An engineering consultant then suggested increasing the head height in the mezzanine. The lead architect, however, noted that this would cause the roof to appear even bulkier. After further discussion, she eventually asked: “are we getting stuck or do we think…?” As they tried moving on from this impasse, the participants encountered additional uncertainties. The mechanical drawings were not entirely accurate, as the exact size of the transformers varied across suppliers (a tender had yet to be submitted). Such uncertainties constrained design work, making it difficult to commit to a design solution. Hence the participants kept their options open, describing best- and worst-case

scenarios (depending on the size of the mechanical components) as well as short- and long-term plans (based on the requirements of the RIBA Work Plan).

Through close engagement in the design interaction, the client's project manager experienced the challenges of allowing for maintenance access while reducing the mass of the building. As he felt that design work could not progress any further, he compromised on the form of the building. This led the design team to make some strong points. By stabilizing the form of the building as in the annotated drawings, they called a halt to the proliferation of design options and scenarios. Also, they constrained the contractors to design mechanical components within the framework set by the architectural drawings. This cleared uncertainties and shifted the onus of detailed design onto the contractors. In the words of the participants:

> Lead architect: "We're doing this [to address] the issue of what's seen from the footpath. So just reducing the massing […] It's [still] a bit…"
> Client's project manager: "I think we need to leave it, because we can't solve that."
> Lead architect: "The critical thing for planning application is whether … we have enough confidence in the form of the building to put it in for planning [permission]. And the contractors then will have that as a [design] constraint … to make their installations work with this massing. If you feel confident that… […]
> Client's project manager: "We should ask them to allow for the design and removal of the third unit [i.e. CHP] that goes in … We want them to give us a strategy of how they do it."

Outcomes. The lead architect attempted to resolve issues related to the form and function of the building. She invited the client's project manager and the engineering consultants to co-develop design options by interacting with a multitude of drawings. This enabled participants to *bridge* and *traverse* different perspectives on the building design by finding a compromise between prioritizing its form or function. In the design interaction, options were proposed as individual sentences, questions, or speculations; and then explored collectively through coordination of architectural and engineering drawings. This led to consensual adoption of design solutions: the participants decided to pursue only minor improvements in the building form; this enabled accommodating functional requirements.

Visual artifacts were *fluidly* changed throughout the design interaction. Annotations (e.g. redlines) were used to experiment flexibly with changes in the form and function of the building, and to coordinate multiple drawings. It was by switching across multiple drawings and perspectives that the client's project manager realized the design constraints and appreciated the issues at stake. Adding mechanical components caused an expansion of the building mass (form), while attempts to reduce the building mass triggered access problems (function). Rather than insisting on reducing the building mass, he searched for a compromise between form and function. By stabilizing the form as in the annotated drawings, the client's project manager accepted improvements – albeit limited ones – in the visual appearance of the building. He then shifted the onus of designing access options onto the contractors. This enabled the participants to eliminate uncertainties related to the size of mechanical components and move on with their design work.

Vignette #4. Preventing: Crafting the planning application

Background. As the building design was provisionally approved by the client, the design team focused on preparing the planning application. The internal boundaries of the design team faded away, while their external boundaries towards the planning authorities came into view. The design team was united by a pragmatic interest in obtaining the planning permission, by preventing and transcending the arousal of objections, queries, or requests from the planning authorities. They knew that the pragmatic interests of the planning authorities were different – e.g. they sought to limit the number of planning permissions and obtain as much detail as possible on planned developments. The efforts of the design team spanned across several meetings and involved several iterations as the design concept was reworked in response to the various concerns raised by the clients. In the next vignette, they decide what features of the building to foreground (or background) and consider how their use of visual artifacts might impact the planning permission.

Preventing. The architects and engineers met with the client's project manager to review the planning application. They focused on the drainage and landscape drawings, discussing what features should be included and their visibility at different scales. An engineering consultant inquired whether the choice of drainage system (e.g. down pipes) would affect the planning drawings. The lead

architect remarked that “this is not a huge feature of the building” and clarified the requirements for the planning application. She suggested: “A larger scale would show these elevations at one to a hundred. So that’s the level of detail….” She then advised: “You don’t have to specify the exact make and manufacture [for] planning.”

As the conversation shifted to the site plan, the lead architect proposed designating one of the parking spaces for disabled access. Although there was no specific requirement under the Disability Discrimination Act, she felt this revision might put the planning application in a favorable light. She explained to the client’s project manager: “I know it is exempt under the [DDA] … It’s just that thing about planning and what you’re trying to convey. And I think it’s probably better to show a few spaces, as opposed to [leaving the] full parking unmarked. If we show a disabled bay...” The revision itself was unproblematic; it required only widening one parking space for disabled access and marking the drawings accordingly.

In a follow-up meeting, the design team focused on crafting a Stage D report for planning permission. This detailed document aimed at persuading the planning authorities of the sustainability of the building design. Visual artifacts such as drawings, models, and sketches were assembled to offer a complete overview of the building, and textual descriptions were entwined to articulate design principles and tie different aspects of the design together. To finalize the various sections of the report, the lead architect gathered information from all parties. For example, she asked the client’s project manager about the university’s plan for expanding to biomass. As she explained, she had written something along these lines in the draft document and needed “to get the story straight in terms of what goes on in the implications.”

Throughout the design interaction, the client’s project manager reiterated the importance of getting the planning permission. The lead architect remarked: “We’ve got various coordination activities to do, to get the design finalized [as] intended.” She then asked an engineering consultant to put together a list “that picks up how the preliminaries are done, [as] a standalone document to [be attached to the] report. The engineering consultant agreed: “We’ll do the prelims all in all. That will have to be…” and the lead architect completed: “coordinated well.” She emphasized that different

aspects of the building design should be put together in a consistent manner, avoiding contradictions or oversights.

An engineering consultant stepped in to explain how he would develop the acoustics section, in the face of the uncertainty that surrounded this aspect of the building design. As noise levels varied depending on the manufacturers of the mechanical components (to be selected at a later stage), he suggested using cut-off values rather than detailed calculations: "We're trying to only agree limits rather than discharge any planning condition. We're saying 'this is what we're aiming for' and we'd like them to buy into that – so at least again you've got the surety [of] moving forward. The local authority [will be] happy with what we're proposing."

In a subsequent meeting of the design team, the lead architect clarified the rationale to follow in preparing drawings for the Stage D report. For example: "This drawing is going into the planning application. So it needs … It's got to have the kind of [explanation] to assure them [the planning authorities] that we're doing that sustainable drainage… It's nearly there …" Throughout the meeting, the participants discussed how design choices should be presented to get the planning permission. The lead architect steered the discussion. This involved anticipating the concerns of the planning authorities and adjusting the application drawings accordingly.

For example, the lead architect made the following observation: "As to the drawing of this [mechanical] plant, they might be interested in more details of how that looks like visually. We've got to... on our sketch-up views, they're just like masked objects." She then gathered suggestions on how to represent the mechanical components (which would have been selected for purchase at a later stage). She decided *not* to include sample photographs (as they might raise further questions). Instead, she noted that coloring provided a range of options, since the mechanical components were to be painted (at least in part). In inspecting the sketch-up model, she noted: "I imagine a darker color for [the mechanical components], so that they don't stick out like a bit of white appliance in the landscape…" She remarked: "But I don't want to make any promises in the planning [application] if it's actually … a special [color] that's impossible to get." An engineering consultant reassured her and agreed to double check with manufacturers.

Outcomes. The planning permission was eventually granted. In preparing the planning application, the design team mobilized visual artifacts to prevent the emergence of pragmatic boundaries. By rescaling drawings, changing color palettes, and indicating cut-off values rather than exact calculations, the design team sought to *prevent* and *transcend* the concerns of the planning authorities. They crafted a consistent 'big picture' of the yet-to-be building. The assembling of visual artifacts in the stage report and their entwinement with textual explanations aimed to appeal to the planning authorities. This involved emphasizing some aspects that were likely to evoke a positive response and de-emphasizing other aspects that were likely to raise questions. Hence, visual artifacts performed the political work of strengthening the voice of the design team and silencing contradicting views that might be raised by the planning authorities.

Overall, the architects stabilized the building design into a document that anticipated and addressed relevant questions. Throughout the design interaction, visual artifacts became assembled and *frozen* into a comprehensive overview of the building. Other visual artifacts were consulted to provide information that was useful in preparing the Stage D report. Yet other visual artifacts were excluded to prevent the arousal of questions from the planning authorities.

Discussion

The main contribution of our study is to advance understanding of the political aspects of knowledge work by revealing the various ways in which visual artifacts can be used to manipulate the visibility of pragmatic boundaries. By so doing, our analysis also helps to move the conversation on visual artifacts beyond their role as epistemic objects that sustain (or hinder) knowledge work. We will elaborate on these contributions below.

Advancing research on the political aspects of knowledge work

Previous research has shown that organizational actors can devise different approaches to address pragmatic boundaries in knowledge work (Carlile 2004, Kellogg et al. 2006, Langley et al. 2019). In particular, it has highlighted how actors can either traverse or transcend boundaries by engaging in various forms of dialogue (Majchrzak et al. 2012, Kellogg et al. 2006, Faraj and Xiao

2006, Mengis et al. 2012, Tsoukas 2009). However, the use of visual artifacts to deal with pragmatic boundaries has so far been undertheorized. This is a missed opportunity for deepening our understanding of the political aspects of knowledge work.

Our analysis sheds light on these important aspects. In Table 4, we offer an inductively derived theoretical framework that elucidates the role of four practices of visual artifacts use: surfacing, bridging, preventing, and minimizing. Although our analysis is limited to a specific setting, the higher-order findings presented here offer general insights into the political dynamics of knowledge work. They explicate how actors can aptly use visual artifacts to adjust the visibility of boundaries, with effects on the issues at hand and their power relations. With due caution, this can be generalized to various settings of knowledge work (e.g. project management, strategy making, or change management) in which pragmatic differences are especially heightened and visual artifacts are used intensively by knowledgeable actors.

Insert Table 4 about here

As shown in Table 4, the practices of surfacing, bridging, preventing and minimizing differ according to the approach used and the type of boundaries. Our analysis also reveals three constitutive elements of the practices: the freezing-unfreezing of visual artifacts in-use, their loci of production and consumption, and their control by the actors. These elements shape the practices as well as their effects on pragmatic boundaries and knowledge work. *Surfacing* enables actors to elicit and traverse boundaries that are still latent, while *bridging* enables them to highlight and traverse boundaries that have become manifest. In these practices, visual artifacts are evolved fluidly; actors on both sides of the boundary share control of the visual artifacts in-use and engage in a co-located interaction around them. Both practices make boundaries more visible and lead to balanced participation in knowledge work (at least provisionally), as actors integrate different interests into a common understanding (surfacing) or find a middle ground between conflicting positions (bridging).

Preventing and *minimizing*, on the other hand, enable actors to preempt and transcend boundaries that are still latent (preventing) or to downplay and transcend boundaries that have become

manifest (minimizing). In these practices, visual artifacts are controlled by actors on one side of the boundary; they become provisionally frozen into a seemingly definitive representation to be consumed by actors on the other side of the boundary (rather than co-produced with them). Both practices make boundaries less visible and enable actors to enforce closure in knowledge work, by assembling a big picture that prevents the expression of different views (preventing) or creating appealing representations that smooth over controversial aspects (minimizing). Knowledge work is advanced unilaterally and power imbalances are reinforced. Such effects are, however, provisional as knowledge work evolves continuously. The four practices intertwine and unfold over time, shaping the power relations between actors and the outcomes of their knowledge work.

These findings have important implications for research on the political aspects of knowledge work. In particular, we suggest a dynamic political perspective on knowledge work that challenges predominant understandings of pragmatic boundaries. While emphasizing the social construction of boundaries and their unfolding in time (Langley et al. 2019), much research on knowledge work tends to portray boundaries as relatively stable demarcations between community or occupational groups (e.g. Carlile 2002, 2004; Kellogg et al. 2006). On the contrary, our findings underscore the dynamic nature of boundaries; they point to visibility and invisibility as specific mechanisms through which boundaries are constituted and evolved throughout knowledge work.

Furthermore, our findings help to move research beyond the traverse or transcend approaches in knowledge work (Faraj and Xiao 2006, Majchrzak et al. 2012, Mengis et al. 2018). In previous research, traversing and transcending have been portrayed as alternative ways to deal with boundaries (Majchrzak et al. 2012: 951). Specifically, engagement in the transcend approach has been explained with reference to the challenges posed by post-bureaucratic settings of knowledge work that make resolution of differences difficult or even undesirable (Kellogg et al. 2006). Our findings, however, reveal that the two approaches can be entwined in the same project, offering complementary rather than alternative ways of dealing with pragmatic boundaries. This suggests that traversing and transcending are emergent actions that unfold as organizational members adjust the visibility (and invisibility) of their boundaries.

Relatedly, our findings extend previous accounts of transcending and traversing boundaries. While the transcend approach has usually been portrayed as a collaborative mode (e.g. Kellogg et al. 2006, Majchrzak et al. 2012), we show how it might also involve political attempts at enforcing a given perspective or silencing different perspectives. We articulate two practices whereby such attempts are realized – minimizing and preventing. We further show how political aspects are at play in traversing boundaries: the practices of surfacing and bridging, in fact, are not harmonious (not even while giving voice to multiple views and promoting balanced participation). Instead, they may involve tensions as actors compete to shape the common understanding or shift the middle ground. In our surfacing vignette, for example, the lead architect and the director clashed as they mobilized visual artifacts to articulate and traverse the boundary at stake. While they experienced tensions, they were able to build common understanding. This resonates with research suggesting that common understandings result from power struggles rather than voluntary agreements (Contu and Willmott 2003, Jacobs et al. forthcoming, Nicolini 2011, Sorsa and Vaara 2020).

Hence, our work overcomes the dichotomy between the traverse and transcend approaches and offers a dynamic view of how boundaries are dealt with as actors recursively engage in practices of surfacing, bridging, preventing, and minimizing. It also extends previous research that has foregrounded power struggles in knowledge work (e.g. Nicolini 2011) but paid less attention to their entwinement with visuality and materiality. Specifically, we suggest that control of visual artifacts is crucial to gaining power in knowledge work. The actors who control visual artifacts can take the lead in knowledge work and relegate others to the role of spectators rather than makers of knowledge. To regain power in knowledge work, disempowered actors need to reclaim control of visual artifacts, for example by shifting their loci of production from a dislocated to a co-located space.

Our findings are relevant for various settings of knowledge work in which organizational actors face contested issues in and around boundaries. For example, actors involved in strategy work might engage visual artifacts (e.g. charts, tables, and slides) to gain a better understanding of their pragmatic differences or to bridge their divergent positions on a future course of action. They might also collate visual artifacts into strategy plans that prevent the emergence of different views or smooth over controversial issues. A focus on the dynamics by which actors make boundaries more or less

visible can open new avenues to organizational scholars who are concerned with contested issues arising, for example, in complex projects, policy making, or strategic change.

Future research could extend our theoretical framework by comparing cases from across multiple organizations and settings. For example, it could explore cases in which visual artifacts are less widely used or actors are less visually literate than in our setting. Analysis of such cases would enable us to identify different practices of mobilizing visual artifacts and/or to gain understanding of specific technologies for dealing with boundaries. Relatedly, future research could explore whether patterns of freezing and unfreezing are applicable to other objects used to deal with boundaries (and the implications thereof). This could lead to important insights, for instance concerning digital platforms used to coordinate work across boundaries.

Finally, our theoretical framework of visual artifacts in-use lays the foundations for further research on the political dynamics of knowledge work. Future research could explore the conditions under which given practices or combinations thereof are successful and sustainable over time. It could adopt for example an actor-network-theory perspective (Latour 2005) to trace the connections between different practices of mobilizing visual artifacts at pragmatic boundaries. This could lead to discovering emergent combinations of practices and to unveiling their effects on the visibility (and invisibility) of the boundaries at stake. For example, bridging might prove more difficult after repeated, unsuccessful attempts at minimizing; here different patterns of freezing and unfreezing of visual artifacts may be required to address the boundary at stake.

Advancing research on visual artifacts in-use

Our work also has more general implications for organizational research on visual artifacts (Boxenbaum et al. 2018, Meyer et al. 2013, Ewenstein and Whyte 2009). Although previous research has acknowledged the contested nature of knowledge work and the role of artifacts in spanning boundaries (Carlile 2002, Kellogg et al. 2006, Majchrzak et al. 2012), it has backgrounded their political use. The focus has been placed on the collaboration that unfolds around artifacts (Höllerer et al. 2019, Meyer et al. 2013, Nicolini et al. 2012), especially in the build-up of common understanding (Carlile 2002) and the pursuit of an object of inquiry (Ewenstein and Whyte 2009). On the contrary,

our analysis has zoomed in on the political role of visual artifacts, revealing how their uses can shape power relations among actors.

An understanding of the political role of visual artifacts complements and challenges the prevailing focus on the epistemic role of visual artifacts (e.g. Carlile 2002, Ewenstein and Whyte 2009, Kellogg et al. 2006). While foregrounding different practices of using artifacts, this previous research has consistently underscored their role in developing and integrating knowledge. For example, Carlile (2002) suggested that objects, models, and maps (which we understand as visual artifacts) enable transforming knowledge across boundaries, whereas Kellogg et al. (2006) emphasized their role in assembling rather than transforming knowledge (especially in highly volatile environments, where negotiating differences might be unfeasible). We suggest that visual artifacts are not just integrating devices (Carlile 2002: 453) or boundary-spanning mechanisms (Kellogg et al. 2006: 40) but also political allies in knowledge work; they can be mobilized to manipulate the visibility of boundaries and alter the power relations between actors.

Our findings on the loci of production and consumption have further implications for research on visual artifacts. First, our accounts of surfacing and bridging support previous findings on visual artifacts as conscription devices that enlist participation in co-located interactions (Ewenstein and Whyte, 2009; Henderson 1991). Second, our accounts of preventing and minimizing extend research that has begun to explore how visual artifacts are crafted 'behind the scenes' to shape the meanings their audiences will develop (Barley 2015, Burke and Wolf 2021, Pollock, 2012). This previous research found, for example, that actors anticipate and counter resistance from their audience by adding robust data and attaching data sources to visual artifacts (Barley et al. 2012). We suggest additional modes for shaping the meanings developed on the other side of a boundary, e.g. assembling visual artifacts into a big picture that prevents different views or producing appealing representations that smooth over controversial issues.

Our political perspective resonates with but extends research that has begun to uncover the role of visual artifacts in power plays and political attempts to shape meanings across boundaries (Barley et al. 2012, Bechky 2003a, Kaplan, 2011). Previous research has highlighted the politics surrounding individual types of visual artifacts. For instance, Bechky (2003a) has shown how

engineering drawings can be used to reinforce boundaries and consolidate the position of a dominant group, while Kaplan (2011) has demonstrated how PowerPoint slides can be mobilized in cartographic efforts to draw boundaries and delimit the scope of a strategy. We extend this previous work by developing a theoretical framework that accounts for *multiple* visual artifacts and their unfolding across boundaries. This framework draws attention to the plurality and dynamism of visual artifacts in-use, revealing how they enable actors not only to reinforce (Bechky 2003a) and draw (Kaplan 2011) boundaries, but also to adjust their visibility – and hence to conceal or reveal differences in interests, priorities, and viewpoints.

Finally, our theoretical framework has implications for research on knowledge visualization (e.g. Eppler and Platts 2009) that has classified visual artifacts based on their visual characteristics and the type of knowledge work they sustain. In contrast to this research, we consider visual artifacts not as entities *per se* but view them as embedded in social practices. We challenge the assumption that a given artifact will sustain (or hinder) a given action and instead suggest that the same artifacts can produce different effects on knowledge work depending on the situated actions in which they are mobilized. Hence, we contend that a focus on visual artifacts in-use (or in-practice) is essential to understand their effects on pragmatic boundaries and knowledge work.

Future research could explore additional practices of using visual artifacts at pragmatic boundaries. For example, future scholars might study instances of active deception, in which visual artifacts are used to deliberately mislead others. Here, visual artifacts could be used fluidly to create the false impression of a collaborative interaction; boundaries might be transcended by distorting the meanings produced by others. Relatedly, future scholars might explore instances of enforcing dogma, in which visual artifacts are used to impose acceptance of a set of principles or decisions. In these instances, visual artifacts could be provisionally frozen to frame one's viewpoint as an incontrovertible truth; boundaries might be traversed by inducing one group to blindly conform to the views of others. Hence, exploration of these practices might lead to enriching our understanding of the political role of visual artifacts, while also revealing different patterns of freezing-unfreezing and their effects on boundaries.

Conclusion

Our work has explored the ways in which visual artifacts are mobilized at pragmatic boundaries. Drawing on a practice-based humanist perspective, we show how visual artifacts in-use have effects on the boundaries at stake and on knowledge work. In particular, our inductively derived theoretical framework illuminates the role of specific practices – such as surfacing, bridging, preventing, and minimizing – in these processes. The main contribution of our study is to advance understanding of the political aspects of knowledge work by revealing how visual artifacts can be used to manipulate the visibility of boundaries. By so doing, it also helps to move research on visual artifacts forward. We hope that scholars will find our framework inspiring and conducive to further research on visual artifacts and their political use.

References

Barley WC (2015) Anticipatory work: How the need to represent knowledge across boundaries shapes work practices within them. *Organ. Sci.* 26(6):1612–1628.

Barley WC, Leonardi PM, Bailey DE (2012) Engineering objects for collaboration: Strategies of ambiguity and clarity at knowledge boundaries. *Human Comm. Res.* 38(3):280–308.

Bechky BA (2003a) Object Lessons: Workplace artifacts as representations of occupational jurisdiction. *Amer. J. Sociol.* 109(3):720–752.

Bechky BA (2003b) Sharing meaning across occupational communities: The transformation of understanding on a production floor. *Organ. Sci.* 14(3):312–330.

Boland RJ, Lyytinen K, Yoo Y (2007) Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. *Organ. Sci.* 18(4):631–647.

Boxenbaum E, Jones C, Meyer RE, Svejenova S (2018) Towards an articulation of the material and visual turn in organization studies. *Organ. Stud.* 39(5-6):597–616.

Brown JS, Duguid P (1991) Organizational learning and communities-of-practice: Toward a unified view of work, learning and innovation. *Organ. Sci.* 2(1):40–57.

Burke GT, Wolf C (2021) The process affordances of strategy toolmaking when addressing wicked problems. *J. Management Stud.* 58(2):359–388.

Carlile PR (2002) A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organ. Sci.* 13(4):442–455.

Carlile PR (2004) Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organ. Sci.* 15(5):555–568.

Cecez-Kecmanovic D, Galliers RD, Henfridsson O, Newell S, Vidgen R (2014) The sociomateriality of information systems: Current status, future directions. *MIS Q*. 38(3):809–830.

Comi A, Whyte J (2018) Future making and visual artifacts: An ethnographic study of a design project. *Organ. Stud.* 39(8):1055–1083.

Contu A, Willmott H (2003) Re-embedding situatedness: The importance of power relations in learning theory. *Organ. Sci.* 14(3):283–296.

Cook SDN, Brown JS (1999) Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organ. Sci.* 10(4):381–400.

Dodgson M, Gann DM, Salter A (2007) "In case of fire, please use the elevator": Simulation technology and organization in fire engineering. *Organ. Sci.* 18(5):849–864.

Elkins J (1999) *The Domain of Images* (Cornell University Press, Ithaca, NY).

Eppler MJ, Platts KW (2009) Visual strategizing: The systematic use of visualization in the strategic-planning process. *Long Range Planning* 42(1):42–74.

Ewenstein B, Whyte JK (2007) Visual representations as 'artefacts of knowing'. *Building Res. Inform.* 35(1):81–89.

Ewenstein B, Whyte JK (2009) Knowledge practices in design: The role of visual representations as 'epistemic objects'. *Organ. Stud.* 30(1):7–30.

Faraj S, Xiao Y (2006) Coordination in fast-response organizations. *Management Sci.* 52(8):1155–1169.

Feldman MS, Orlikowski W (2011) Theorizing practice and practicing theory. *Organ. Sci.* 22(5):1240–1253.

Henderson K (1991) Flexible sketches and inflexible data bases: Visual communication, conscription devices, and boundary objects in design engineering. *Sci. Tech. Human Values* 16(4):448–473.

Henderson K (1995) The political career of a prototype: Visual representation in design engineering. *Soc. Problems* 42(2):274 –299.

Henderson K (1999) *On Line and On Paper: Visual Representations, Visual Culture, and Computer Graphics in Design Engineering* (MIT Press, Cambridge, MA).

Höllerer M, van Leeuwen T, Jancsary D, Meyer R, Andersen T, Vaara E (2019) *Visual and Multimodal Research in Organization and Management Studies* (Routledge, New York / London).

Jacobs C, Kreutzer K, Vaara E (forthcoming) Political dynamics in organizational identity breach and reconstruction: Findings from the crisis in UNICEF Germany. *Acad. Management J.*

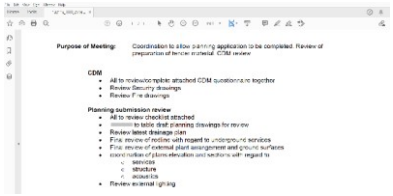
Kaplan S (2011) Strategy and PowerPoint: An inquiry into the epistemic culture and machinery of strategy making. *Organ. Sci.* 22(2):320–346.

Kellogg KC, Orlikowski WJ, Yates J (2006) Life in the trading zone: Structuring coordination across boundaries in postbureaucratic organizations. *Organ. Sci.* 17(1):22–44.

Knorr Cetina K (1997) Sociality with objects: Social relations in postsocial knowledge societies. *Theory, Culture Soc.* 14(4):1–30.
Knorr Cetina K (1999) *Epistemic Cultures: How the Sciences Make Knowledge* (Harvard University Press, Cambridge, MA).
Langley A, Lindberg K, Mørk BE, Nicolini D, Raviola E, Walter L (2019) Boundary work among groups, occupations, and organizations: From cartography to process. *Acad. Management Ann.* 13(2):704–736.
Latour, B (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford University Press, Oxford, UK).
Law J, Singleton V (2005) Object lessons. *Organization* 12(3):331–355.
Leonardi PM (2011) When flexible routines meet flexible technologies: Affordance, constraint, and the imbrication of human and material agencies. *MIS Q.* 35(1):147–167.
Levina N, Vaast E (2005) The emergence of boundary spanning competence in practice: Implications for implementation and use of information systems. *MIS Q.* 29(2):335–363.
Majchrzak A, More PH, Faraj S (2012) Transcending knowledge differences in cross-functional teams. *Organ. Sci.* 23(4):951–970.
Mengis J, Nicolini D, Swan J (2018) Integrating knowledge in the face of epistemic uncertainty: Dialogically drawing distinctions. *Management Learning* 49(5):595–612.
Meyer RE, Höllerer MA, Jancsary D, van Leeuwen T (2013) The visual dimension in organizing, organization, and organization research: Core ideas, current developments, and promising avenues. *Acad. Management Ann.* 7(1):489–555.
Miettinen R, Samra-Fredericks D, Yanow D (2009) Re-Turn to Practice: An Introductory Essay. *Organ. Stud.* 30(12):1309–1327.
Nicolini D (2009) Zooming in and out: Studying practices by switching theoretical lenses and trailing connections. *Organ. Stud.* 30(12):1391–1418.
Nicolini D (2011) Practice as the site of knowing: Insights from the field of telemedicine. *Organ. Sci.* 22(3):602–620.
Nicolini D (2012) *Practice Theory, Work and Organization* (Oxford University Press, Oxford, UK).
Nicolini D, Mengis J, Swan J (2012) Understanding the role of objects in cross-disciplinary collaboration. *Organ. Sci.* 23(3):612–629.
Okhuysen GA, Bechky BA (2009) Coordination in organizations: An integrative perspective. *Acad. Management Ann.* 3(1):463–502.
Orlikowski WJ (2000) Using technology and constituting structures: A practice lens for studying technology in organizations. *Organ. Sci*. 11(4):404–428.
Orlikowski WJ (2002) Knowing in practice: Enacting a collective capability in distributed organizing. *Organ. Sci.* 13(3):249–273.
Pinch TJ, Bijker WE (1984) The social construction of facts and artefacts: Or how the sociology of science and the sociology of technology might benefit each other. *Soc. Stud. of Sci.* 14(3):399–441.
Pollock N (2012) Ranking devices: The sociomateriality of ratings. Leonardi PM, Nardi BA, Kallinikos J, eds. *Materiality and Organizing: Social Interaction in a Technological World* (Oxford University Press, Oxford, UK), 91–112.
Schatzki TR (2002) *The Site of the Social: A Philosophical Account of the Constitution of Social Life and Change* (Penn State University Press, University Park, PA).
Sorsa V, Vaara E (2020) How can pluralistic organizations proceed with strategic change? A processual account of rhetorical contestation, convergence and partial agreement in a Nordic city organization. *Organ. Sci.* 31(4):839–864.
Streeck J, Mehus S (2004) Microethnography: The study of practices. Fitch KL, Sanders RE, eds. *Handbook of Language and Social Interaction* (Lawrence Erlbaum, Mahwah, NJ), 381–404.
Tsoukas H (2009) A dialogical approach to the creation of new knowledge in organizations. *Organ. Sci.* 20(6):941–957.
Van Maanen J (1988) *Tales of the Field: On Writing Ethnography* (University of Chicago Press, Chicago, IL).
Whyte J, Ewenstein B, Hales M, Tidd J (2007) Visual practices and the objects used in design. *Building Res. Inform.* 35(1):18–27.
Whyte J, Ewenstein B, Hales M, Tidd J (2008) Visualizing knowledge in project-based work. *Long Range Planning* 41(1):74–92.

Wolbers J, Boersma K (2013) The common operational picture as collective sensemaking. *Journal of Contingencies and Crisis Management* 21(4):186–199.
Yakura EK (2002) Charting time: Timelines as temporal boundary objects. *Acad. Management J.* 45(5):956–970.
Zeiss R, Groenewegen P (2009) Engaging boundary objects in OMS and STS? Exploring the subtleties of layered engagement. *Organization* 16(1):81–100.

TABLE 1. Types of visual artifacts used in design work

Type	Example[2]	Description	Elements (picture, text, notation)
Perspective sketch		Provides a three-dimensional representation of the building with an artistic flair. Can be used to convey the look-and-feel of the building.	Predominantly pictorial (triggering the act of looking)
Photograph		Provides a realistic representation of relevant objects – e.g. building exemplars, construction materials, site features. Can be used for reference purposes and to substantiate the design concept.	Predominantly pictorial (triggering the act of looking)
Meeting agenda		Represents items to be covered in project meetings (text is organized in a bullet-point or numbered format). Often annotated for individual actions and used to check progress in the meeting.	Predominantly textual (triggering the act of reading)
Gantt chart		Outlines the project plan, with key activities charted over time. Often annotated to revise the project plan and coordinate activities.	Predominantly notational (triggering the act of deciphering)

[2] The photographs were taken by the authors on the field; drawings and documents are reproduced with permission from the architects.

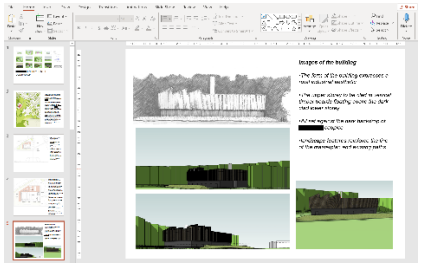
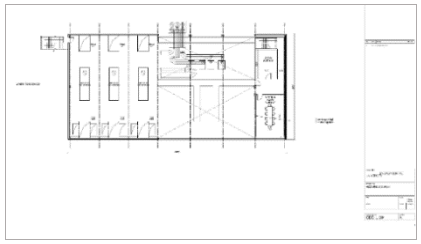
PowerPoint (design concept)		Provides an over-view of the design concept by collating drawings and texts. Can be shown to clients in face-to-face meetings and circulated as a digital file.	Picture and text (triggering the acts of looking and reading)
Stage report (design concept)		Provides a detailed view of the design concept by collating drawings and texts. Can be used for reporting purposes and consulted to develop future projects.	Picture and text (triggering the acts of looking and reading)
Site plan		Provides an aerial view of the site, showing the planned developments (includes title, scale, and symbols). Can be red lined and annotated with design considerations.	Picture, text, and notation (triggering the acts of looking, reading, and deciphering)
CAD drawing		Provides detailed views of building plans, sections, and elevations (includes drawing title, number, and scale). Can be printed out on a large size for use in project meetings.	Picture, text, and notation (triggering the acts of looking, reading, and deciphering)

TABLE 2. Data sources and uses

	Description	Extent	Uses
Observations	*Project meetings*: The architects, engineers and clients meet fortnightly to make decisions on the energy center project.	Ca. 14 hours 31 minutes of observations (audio-recorded), resulting in ca.1122 photographs, 4 hours 31 minutes of video-recording, 74 pages of field notes (hand-written, single-spaced), 406 pages of transcript (single spaced)	Identify instances of pragmatic boundaries; appreciate the context of production and consumption of visual artifacts; understand the uses of visual artifacts in dealing with boundaries.
	Design work: The architects advance the building design. They hold internal meetings to discuss progress (consultants may join).	Ca. 96 hours of observations, resulting in ca. 835 photographs, 22 hours 15 minutes of audio-recording, 1 hour 37 minutes of video-recording, 36 pages of field notes (hand-written, single-spaced), 188 pages of transcript (single spaced)	Understand the architects' pragmatic concerns; appreciate the context of production and consumption of visual artifacts; understand the uses of visual artifacts in dealing with boundaries.
	Cultural and social events at the architectural firm: 2 evening talks (1 of which attended as presenter), 1 brown bag seminar, 1 open doors event, 1 inaugural party (for refurbished office space)	Ca. 20 hours, 5 pages of field notes (hand-written, single-spaced)	Familiarize with the organizational context; clarify uncertainties regarding the observed work; discuss emerging interpretations.
Documents	*Project-related:* Design brief, Stage A/B report (preparation), Stage C report (concept design), minutes of project meetings, agenda of project meetings, architectural drawings, engineering drawings, online platform for project work, case study (written by the architects)	Ca. 237 pages, 21 slides	Understand the project requirements; identify visual artifacts in-use.
	Organization-related: 2 books on the architects' work (authored by architectural critics), 9 videos of public talks given by the founder architect, architects' website, client's website, consultants' websites	495 pages (books), 2 hours 51 minutes of publicly available videos, 5 websites	Familiarize with the organizational context of the architectural firm and the other firms involved in the project; understand the architects' approach to design.
	Other project: Case study of a building that the architects had previously designed for the same client (written by the architects)	3 pages	Understand the architects' approach to design; understand the client's design requirements.
Interviews	*With lead project architect*	Ca. 1 hour of semi-structured interviews, ca. 1 hour of informal conversation (during a design innovation conference), brief and frequent informal conversations during field work	Clarify uncertainties regarding the observed work; understand power relations among participants; discuss emerging interpretations.
	With junior project architects	Brief and frequent informal conversations during field work	Clarify uncertainties regarding the observed work.
	With all project architects (lead and junior)	Ca. 9 hours of informal conversations during trips to the client's headquarters	Clarify uncertainties regarding the observed work.
	With project participants	Ca. 8 hours of informal conversations during breaks of projects meetings	Clarify uncertainties regarding the observed work; understand the power relations among participants.

TABLE 3. Examples of surfacing, minimizing, bridging, and preventing boundaries in key episodes

Example[3]	Pragmatic boundary at stake (novelty, difference, dependence)	Uses of visual artifacts[4]
Surfacing*	*Conflicting interests concerning the building design:* The director of the estate office requires the architects to improve the visual appearance of the building (novelty). This request reveals different interests that hinder design work: the director wants to hide the building in the landscape, while the architects want to show 'what is there' (difference). The director's request causes the architects to redesign the building envelope and at the same time ensure that mechanical components fit (dependence).	The inspection of multiple artifacts (e.g. printouts from a *sketch-up model*, *site plans* and *building elevations*) enables actors to surface their different interests. Their use also leads to articulating and resolving some misunderstandings. A *hand-drawn sketch* is produced to summarize emergent understandings and build up common ground. The sketch is evolved fluidly through participation of all actors. The boundary at stake is surfaced and traversed.
Surfacing	*Different views on maintenance access:* The design team undertakes a new task, i.e. a construction design management (CDM) review (novelty). The CDM coordinator suggests providing maintenance access to the mezzanine, while the lead architect notes there is no specific requirement in the design brief (difference). Accommodating this request causes the architects to expand the internal layouts, which in turn triggers changes in the building envelope (dependence).	Inspection of multiple artifacts (e.g. *CDM checklist, site plan,* and *3D sketch up model*) leads to surfacing the boundary at stake. The architects and their engineering consultants take the concerns of the CDM coordinator into consideration and search for a design solution. Throughout the interaction, *architectural and engineering plans* are evolved fluidly. The boundary at stake is surfaced and traversed.
Minimizing*	*Conflicting interests concerning design revisions:* The director of the estate office aims for substantial revisions to the building design, especially reductions of the building masses (novelty). This leads to conflicting interests: while the directors' requests re-open design work, the lead architect would rather reach closure (difference). Further reductions of the building masses, in fact, are difficult given the functional requirements of the building (dependence).	The architects improve the *architectural drawings* to persuade the client of the appropriateness of the building presence. They contextualize the building in the surrounding environment and render the drawings at a high quality. The rendered drawings are then assembled and frozen into a *slides deck* to be circulated to the client. The building design becomes largely frozen; only construction materials remain open for discussion. Through this artifact (slides deck), the remaining concerns are minimized and transcended.
Minimizing	*Different views on visual impact:*[5] A public body rejects the building design, arguing that the planned development imposes excessively on the landscape (novelty). The architects, on the other hand, feel the building design fits nicely in the surrounding environment (difference). The rejection from the public body triggers negative consequences for the architects, calling for substantial revisions at a point in which the building design was reaching closure (dependence).	The architects revise the *planning application*. Instead of making changes to the building design, they improve the *architectural drawings*. They use the same drawings but adjust their coloring to confer a more lightweight impression. The revised drawings are then collated and frozen into a planning application. The architects minimize and transcend the concerns of the public body, using coloring techniques to counter their impression that the building is too imposing.

[3] The asterisk denotes examples that are elaborated in the vignettes.
[4] The visual artifacts in-use are in italics.
[5] This refers to another project realized by the lead architect.

Bridging*	*Conflicting priorities regarding form and function*: The architects face new challenges as they realize that inclusion of the mechanical installations causes an expansion in the building form (novelty). While the clients are generally concerned about the building form, the architects draw attention to meeting functional requirements (difference). This causes an impasse: adding the mechanical components results in a bulkier building. Reducing the building mass, in turn, constrains the space available for the mechanical components (dependence).	The architects, engineers, and client's project manager use multiple drawings to coordinate internal and external views of the building (*architectural drawings* of building plans, elevations, and sections, and *engineering drawings* of mechanical systems). Annotations (e.g. redlines) are used to experiment with changes and coordinate drawings at different scales. Visual artifacts are fluidly evolved throughout the interaction. Hence actors bridge and traverse their differences, finding a compromise between form and function.
Bridging	*Different views on the design concept:* The lead architect presents the conceptual design to the client's project manager and estate office manager (novelty). While the architects propose use of timber cladding, roof lights, and a green roof, their clients raise concerns about maintenance costs, leakage risks, and weathering of materials (difference). This creates negative consequences for the lead architect, as the building envelope will have to be redesigned (dependence).	The lead architect shows a *PowerPoint presentation* and a *digital model* of the building concept. As the clients raise concerns about features of the building design, the participants switch across *architectural* and *engineering drawings* (which become fluidly evolved). They bridge and traverse differences, finding a compromise between opposing positions. It is decided to search for alternative cladding, to get rid of the roof lights, and to use an accessible green deck.
Preventing*	*Anticipated differences concerning the planning permission:* The design team faces a new task, i.e. to prepare a planning application for building permission (novelty). The team members share a pragmatic concern to prevent queries from the planning authorities. They anticipate the interests of the planning authorities to be different, i.e. to limit the number of planning permissions and obtain as much detail as possible on planned schemes (difference). Preparation of the planning application involves securing building permission while at the same time providing transparent information (dependence).	The architects, engineers, and client's project manager craft the *planning application*, focusing on the *Stage D report* of detailed design. Some visual artifacts (e.g. *drawings*, *models,* and *sketches*) are included in the report and assembled to provide a comprehensive overview of the building. Other visual artifacts (e.g. *sample images* of mechanical components) are excluded from the report (to avoid arousing questions by the planning authorities). By making inclusions and exclusions, the architects freeze the building design into a document that aims to prevent and transcend the concerns of the planning authorities.
Preventing	*Anticipated differences concerning the visual impact*: The design team faces a new task, i.e. to obtain approval from the university's building committee before proceeding with the planning application (novelty). The team members share a pragmatic concern – to get sign off. They anticipate multiple requests from the university's committee (difference). To obtain sign-off, the design team will have to coordinate multiple and different aspects of the building design (dependence).	The design team considers visual artifacts to present to the university's building committee (e.g. *perspective drawings* and *3D printouts*). They cover various aspects concerning the building's form and function. The lead architect offers to prepare a *building model* to show to the committee members. The aim is to freeze the building design into a *planning document* that prevents and transcends the concerns of the university's committee members.

TABLE 4. Theoretical framework: Practices of using visual artifacts to deal with pragmatic boundaries

Practice	Approach to and type of boundaries	Freezing-unfreezing of visual artifacts	Loci of production and consumption	Control by the actors	Effects on boundaries (visibility/invisibility)	Effects on power relations and knowledge work
Surfacing: Inspecting and manipulating visual artifacts to elicit differences and build common understanding.	Traverse approach. Boundaries are unarticulated or unexpressed (i.e. latent).	Visual artifacts are fluidly changed by actors on both sides of the boundary. Their inspection and manipulation enable actors to identify as-yet unarticulated differences, clarify misunderstandings, and co-create solutions.	Visual artifacts are co-produced and -consumed in a co-located setting.	Actors share control of visual artifacts and contribute to their co-production.	Boundaries are made visible; differences become more defined. This enables their discussion and traversing.	Power is balanced as different views are expressed (at least temporarily). Common understanding is developed and solutions are co-created.
Bridging: Switching across multiple visual artifacts to appreciate differences and find a middle ground.	Traverse approach. Boundaries are apparent and articulated (i.e. manifest).	Visual artifacts are fluidly changed by actors on both sides of the boundary. They offer multiple views that enable actors to appreciate different positions and acquiesce on a middle ground.	Visual artifacts are co-produced and -consumed in a co-located setting.	Actors share control of visual artifacts and contribute to their co-production.	Boundaries are highlighted and then traversed. This involves seeking middle ground between different positions.	Power imbalances are redressed and conflict is resolved (at least temporarily). Actors resolve their impasse in knowledge work by finding a middle ground.
Preventing: Crafting a 'big picture' that anticipates and prevents the emergence of differences.	Transcend approach. Boundaries are unarticulated or unexpressed (i.e. latent).	Visual artifacts are manipulated by actors on one side of the boundary. They become provisionally frozen into a 'big picture' that anticipates and prevents the expression of different interests, priorities, and viewpoints.	The production and consumption of visual artifacts are dislocated across boundaries.	Actors on one side of the boundary own visual artifacts and control their production.	Boundaries are prevented from becoming visible: differences are anticipated and their articulation preempted.	Power imbalances are strengthened as differing views are anticipated and silenced. Knowledge work is advanced by reaching closure around a given (dominant) view.
Minimizing: Crafting and polishing visual artifacts to reduce the visibility of differences at stake.	Transcend approach. Boundaries are apparent and articulated (i.e. manifest).	Visual artifacts are manipulated by actors on one side of the boundary. They become provisionally frozen into appealing representations that smooth over controversial aspects.	The production and consumption of visual artifacts are dislocated across boundaries.	Actors on one side of the boundary own visual artifacts and control their production.	Boundaries are made less visible and then transcended. This involves minimizing and explaining away the differences at stake.	Power imbalances are strengthened as differing views are downplayed and aligned with a given view. Knowledge work is advanced by reaching closure around a given (dominant) view.