Constructing shared professional vision in design work:

The role of visual objects and their material mediation

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Abstract

The design process requires coordination between professions that have different ways of seeing. Using ethnographic data from a building project, this paper explores how architects and engineers mobilize visual objects to coordinate their professional visions around a design issue. The findings articulate the visual practices whereby design professionals move from a *fragmented* towards a *shared professional vision*. In this move, they cease looking at the design issue from within their disciplinary perspective, and begin taking inspiration from each other's. They further adjust the emergent shared professional vision, by iteratively narrowing and broadening its focus. The paper contributes to the practice perspective in design studies, explaining how different ways of seeing are coordinated through practical engagement with visual objects.

Keywords: Architectural design, engineering design, design practice, built environment, visual practices.

A growing body of research in design studies has begun to explore 'designing in the wild' (Ball & Christensen, 2018; Luck 2015; McDonnell & Lloyd, 2009), namely design as it happens in practice, through a focus on what practitioners say and do. This practice-based perspective analyses the situated activities by which design is accomplished in naturally occurring settings, rather than in experimental settings or in the classroom. It acknowledges that design work is embodied, situated and multi-modal in its use of gestural, verbal and visual practices (Luck 2012a). Its analytical attention is directed to the 'here and now' of design work, and "how the characteristics of a setting contingently and in an ongoing fashion feature in what is taking place" (Luck, 2012a: 2).

As they engage in design interactions, architects and engineers exert their *professional vision*. First introduced by Goodwin (1994) in studies of linguistic anthropology, this concept refers to the practices by which professionals *see* and *articulate* phenomena that occur in their perceptual field. Following in Goodwin's (2000) footsteps, scholars of design work used ethnomethodology and conversation analysis to explore the endogenous methods by which professional vision is constructed (Lymer, 2009; Luck, 2012b; Oak, 2009). This involves fine-grained analyses of verbal practices performed by competent members of the profession, including their turn taking at talks (McDonnell & Lloyd, 2009), conversations with visual objects (Luck, 2007), and use of analogies (Murphy, Ivarsson, & Lymer, 2012), stories (Lloyd & Oak, 2018), and gesture (Luck, 2014).

For example, Henderson (1999: 26) explored how collective practices of interacting around visual objects shape the professional vision of engineers, namely their ability "to see and imagine" design solutions. Styhre (2010) suggested that the architect's vision involves seeing through and beyond visual objects, in order to anticipate the practical implications of the building design. Further research examined how architectural students and building users respond to and learn from the architect's vision, through engagement in design critiques (Lymer, 2009) and co-design settings (Luck, 2012b) respectively.

While providing rich explanations of ways of seeing within professions, current research has not yet uncovered how ways of seeing are shared across professions, to construct a *shared professional vision* that accommodates the concerns of different domains. Yet the design process is increasingly distributed and multidisciplinary, requiring design professionals to collaborate across organizational and disciplinary boundaries (Luck, 2015). How is shared professional vision constructed in design settings where diverse professions need to collaborate? Which roles do visual objects play in the construction of a shared professional vision? To address these questions, we draw on data from an ethnographic study of a building project, in which architects and engineers coordinate their

professional visions through a variety of visual objects (e.g., drawings, models and sketches) and the media used in their production (digital and non-digital). This represents an ideal setting in which to explore the intersecting of professional visions and the material mediation of visual objects.

In analysing our ethnographic data, we build on previous studies of 'designing in the wild', and direct our analytical attention to the *visual practices* (Nicolini, 2007) underlying the construction of shared professional vision. Here, the term 'visual practices' refers to practical engagement with visual objects – all the drawings, models and sketches that are mobilized in design work. Our unit of analysis, therefore, are the practices of using visual objects – the emphasis is not on participants using visual objects, but rather on the visual objects in use. This choice of focus acknowledges the centrality of visual objects to the analysis of professional practice (Goodwin, 1994). It makes visual objects centre-stage in the construction of shared professional vision, while at the same time hinting to a complex web of talks and gestures performed over visual objects.

This paper contributes to design studies by developing practice-based explanations of how members of different professions (architecture and engineering) bring their visions into conversation, in way of constructing a shared professional vision around a design problem. It articulates how participants in a design interaction move from fragmented to shared professional vision; and then adjust the focus of such vision. Our findings extend previous studies of 'designing in the wild', by unpacking the visual practices (i.e., visual objects in use) whereby different professions collectively construct ways of seeing and articulating.

Furthermore, this study extends research that has analysed visual objects in design work (e.g., Luck, 2007, 2010; Whyte, Ewenstein, Hales & Tidd, 2007). Whereas previous research has portrayed visual representations as 'boundary objects' (Henderson, 1999), we draw attention to the interplay of human and material agencies in the construction of shared professional vision. By themselves, the visual objects used in our setting could not span boundaries, because they had been produced from within different disciplines and organizations. A shared professional vision, we found, is constructed as professionals look together at design issues, by putting visual objects into conversation, and articulating the disciplinary perspectives that they embody.

We structure our paper as follows. In the next section, we review practice-based studies of professional vision and visual objects. Following a description of data and methods, we show how shared professional vision is constructed through engagement with visual objects. The paper concludes by discussing the significance of our findings for practice-based studies that explore design work across professions. It brings into view the concept of shared professional vision and

unpacks its meaning in relation to relevant concepts such as professional vision (Styhre, 2010), kinds of seeing (Schon & Wiggins, 1992), and design worlds (Schon 1988). It further offers implications for research on visual objects, drawing attention to their limits in spanning boundaries across design professions.

1. Theoretical background

1.1. Professional vision, kinds of seeing and design worlds

First introduced by Goodwin (1994), the concept of *professional vision* denotes the practices of *seeing* and *articulating* as competent members of a profession. Through professional vision, professionals shape events in the perceptual field upon which they focus their attention. For example, archaeologists see traces of ancient civilizations in the excavated dirt; and lawyers turn forensic evidence into a defence strategy. Goodwin (1994) identified three practices of seeing and articulating: *coding*, whereby events within a perceptual field are classified and thus transformed into objects of knowledge; *highlighting*, by which certain events in the perceptual field are made salient; and *producing and articulating visual representations*, whereby events are organized and framed into a knowledge discourse.

Professional vision is not a mechanistic process occurring in the individual's eye or brain, but a socially situated activity accomplished through discursive practices. It is based on collective agreements, learned through professional education, and distributed across multiple actors. It centres on situated interaction with visual objects. These "organize phenomena in ways that spoken language cannot – for example, by collecting records of a range of disparate events onto a single visible surface" (Goodwin, 1994: 611). Two implications follow: First, professional vision extends to encompass features of the physical setting where the action takes place, most notably the visual objects that constitute the profession. Second, professional vision is not just built but also contested among members of the profession, who construct different interpretations of the seen actions, by deploying practices of seeing and saying in ways that suit their agendas.

In studies of design work, scholars explored the professional visions of architects and engineers, uncovering the practices by which such visions are constructed, contested, and re-constructed within the respective professions. Bucciarelli (1994), Henderson (1999) and Ferguson (1992) analysed the situated work of engineers, including their talks around sketches, interaction with physical models, and use of digital media. This research suggests that seeing and reasoning as an engineer involves perceiving information through the eyes, and making such information usable by

relying on a wide array of sensory experiences. Here, "visual objects not only shape the final product of design engineering but also influence the structure of the work and who may participate in it" (Henderson, 1999: 26). The everyday practices of sketching, drawing and modelling, along with the drafting conventions learned in engineering education, construct professional vision, which in turn shape how engineers see and interpret the world.

Styhre (2010, 2011) studied day-to-day work in an architectural practice, exploring how architects engage with visual objects to design and organize a building project. He found that the architect's vision integrates both abstract (e.g., style) and concrete categories (e.g., materials); standing midway between the practical concerns of the construction industry and the aesthetic concerns of the design professions. It is necessarily multifaceted and changing, for being constantly 'calibrated' against the requirements of colleagues, clients, and other relevant groups – i.e., the 'generalized other' of architectural practice. Hence, being a competent architect involves an ability to see as an architect and a non-architect, to see through visual objects (to appreciate architectural qualities of the design) and beyond visual objects (to anticipate practical consequences for users).

Further work suggested that the ability to 'see as an architect' is disciplined through architectural education, most notably through 'architectural critiques' in which students review their design proposals in conversation with an instructor. As they engage in the critique, students demonstrate their disciplinary competency in designing visual objects, as well as in imagining built environments (Lymer, 2009). This is performed through practices of talking and gesturing over visual objects; whereby the students' design is contextualized from the viewpoint of an imagined user or compared to architectural references (Murphy et al., 2012). These embodied practices unfold in interaction between students and instructors; and through linguistic patterns such as questions-and-answers, supportive statements, and humourous comments (Sonalkar et. al. 2016).

Shifting attention from architectural critiques to co-design settings, Luck (2012b) explored the kinds of seeing and reasoning that users activate as they collaborate with architects in the review of design proposals. She found that the boundaries between technical and mundane reasoning blur, since users are capable of noticing mundane implications of the designed spaces, which have architectural implications to the professional's eyes. Furthermore, users embark on a trajectory of learning in 'designerly reasoning' (Luck, 2012b: 562): They demonstrate an ability to re-interpret a design problem, envision alternative solutions, and activate spatial reasoning through their speech, direction of gaze, and embodied actions of touching, pointing, and orienting themselves towards visual objects.

The concept of professional vision echoes Schon and Wiggins' (1992) *kinds of seeing*. Here, designing is intended as "a conversation with materials, conducted in the medium of drawing and crucially dependent on seeing" (Schon and Wiggins, 1992: 135). The basic structure of the design process, *seeing-moving-seeing*, is an interaction of designing and discovering: As architects see through representations of a site and draw in relation to such site, they discover features, qualities and relations that cumulatively produce a fuller understanding of the design problem. In so doing, they uncover unintended as well as intended consequences, which span across multiple domains – often different from those where the design problem and its solution were initially formulated. This leads to further designing: Designers see, move, and see again.

Schon and Wiggins' (1992) distinguish several kinds of seeing, each performing a different function in the design process. All kinds of seeing draw on *visual apprehension* or *literal seeing* – i.e., the perception of marks on a page or screen. Further 'kinds of seeing' include the *apprehension of spatial gestalts*, whereby designers see figures that guide their thinking in terms of objects and their relations; and the *recognition of unintended as well as intended consequences*, whereby designers uncover the domains affected by their design moves. Finally, *appreciative judgments of qualities* enable designers to build appreciative systems against which design solutions are judged and unintended consequences are deemed desirable or not. Although appreciations are subjective, variable and evolving over time, an area of substantial overlap is indicative of the existence of a 'common appreciative system' – i.e., a set of shared appreciations within the design community. As noted by Schon and Wiggins (1992: 139): "how an appreciative system develops and comes to be shared by a group of designers seems to have a great deal to do with the process by which design communities evolve".

An additional kind of seeing in the work of architects and engineers consists of *seeing-as* (Schön, 1988) – i.e., the perception of similarity that precedes verbal articulation (e.g., 'similar with respect to'), and subsequent reflection on such similarity. This kind of seeing is reliant on the *appreciation of spatial gestalts* (Schon & Wiggins, 1992) and involves an ability of designers to 'see' the current problem as like a problem they have previously solved. For example, an architect sees a figure in the lines of a drawing, and traces that figure back to a site they have already encountered. At that point, they can devise appropriate moves following from their reflection on the perceived similarity. If the objects that are seen as similar pertain to different domains of expertise, then 'seeing-as' take the form of *generative metaphors*. These generate "new perceptions, explanations and inventions" (Schön, 1988: 216), enabling practitioners to figure out how to solve novel problems by modelling the unfamiliar on the familiar. In Schön's (1988) example, a group of product development

researchers invented a novel paintbrush by seeing painting as pumping, and applying their knowledge of this familiar domain (pumping) to the unfamiliar (painting).

In summary, *professional vision* (Goodwin, 1994) is understood as a collective capacity of seeing and saying, which emerges as members of a profession interact in a situated context and encounter with visual objects and media. At a more micro level, *kinds of seeing* (Schon & Wiggins, 1992) enable designers to visually apprehend information, and construct its meaning by identifying patterns, relations and qualities that transcend the information itself. The two concepts (professional vision and kinds of seeing) overlap, since they both refer to the visual and verbal practices that designers perform as they engage with visual representations of a design problem. In this paper, we focus on *professional vision* insofar as this construct captures the collective dimension of practices of seeing and saying; and assumes a more macro perspective that encompasses literal seeing and other kinds of seeing. It also underscores the contested nature of such practices, suggesting that members of a profession see and articulate events differently.

While providing interesting insights on practices of seeing and articulating within professions, current research has neglected to explore how professional vision is constructed at the intersection of different professions. In his ethnographic research aboard an oceanographic vessel, Goodwin (1995) did touch on the topic of coordinating professional visions, exploring how oceanographers and geochemists organize to obtain samples from the sea. Yet, the professionals observed by Goodwin (1995) were pursuing different projects, and coordinated only at the boundaries of their respective projects. They did not need to build what might be called a *shared professional vision*, but rather to put diverse visions next to one another, in way of creating a space of 'convergent diversity' (Goodwin, 1995: 247).

Attending to the construction of shared professional vision is important since in many fields, notably in building design, the organization of work requires increasing interdependence between different professions (Luck, 2015). In his seminal work on engineering design, Bucciarelli (1998) talked about *object worlds* to denote areas of technical specializations characterized by different patterns of belief that are grounded in the object of design. Here, design is understood as a social process of negotiating, rather than synthesizing: "As we come to discuss designing as a synthesis of different perspectives, we encounter a contradiction: the structure of object-world thinking cannot comfortably accommodate the different interests of participants […] Designing requires discourse across different object-worlds, a discourse that arches across differences in language" (Bucciarelli, 1988: 164). Yet discourse across object-worlds is loaded with ambiguity, since the same object

embodies different beliefs: “Different participants, each with their own stake in the project, working from within different object worlds, will see the design differently” (Bucciarelli, 1988: 167).

This raises the question of how design professionals come to agree on what has to be built, in spite of the different reasoning, rules and types that they activate to frame the design problem (Schon, 1988). Schon (1988) speculates that *design types* might help participants to talk across the different environments that they inhabit – i.e., their *design worlds*. These are *building types* (e.g., a church), *reference types* (e.g., Richardson’s libraries), *experiential archetypes* (e.g., an inviting space), and *gestalt figures* (e.g., a U-shaped entrance). Since design types are the building blocks of design worlds, familiarity with different types might improve professionals’ ability to speak across different worlds. However, the process whereby designers from diverse professions become aware of each other’s world and work together to develop new ways of seeing (Schon, 1988) is largely unexplored.

In the remainder of the paper, we will attend to this process. We build on the assumption that professional vision includes the vision of others (Styhre, 2011) to explore how such inclusion occurs in practice as diverse professionals interact in a situated context. We further build on research that highlights the centrality of *visual objects* to the design process (Luck, 2010), and leverage *visual practices* (Nicolini, 2007) as analytical lenses to uncover how shared professional vision is crafted through engagement with all the drawings, models and sketches that constitute the design professions. Our research questions are: How is shared professional vision constructed in design settings where diverse professions need to collaborate? Which roles do visual objects play in the construction of a shared professional vision? Before we address these questions, in the next section we introduce the concepts of *visual objects* and *practices* and their *material mediation*.

1.2. Visual objects, visual practices and material mediation

Visual objects (e.g., drawings, models and sketches) are central to the professional visions of architects and engineers, insofar as they shape the formation and articulation of their design intentions (Luck 2007, 2010, 2012b). Visual objects are produced and reproduced through different media (Harty & Whyte, 2010; Lanzara, 2009; Dourish & Mazmanian, 2013), taking on material forms that range from digital to non-digital, and from two to multi-dimensional. Such differences notwithstanding, all visual objects can be seen as the concrete materials through which the object of design (e.g., building) is imagined, manipulated and evolved (Ewenstein & Whyte, 2009). As visual objects are used to stabilize some aspects of the design and advance others, the object of design becomes progressively more defined.

The extant literature uses various terms to refer to visual objects. For example, in Building Research & Information's Special Issue on *Visual Practices: Images of Knowledge Work* (Whyte & Ewenstein, 2007), we found 'visual artefacts' (Nicolini, 2007), 'visual materials' (Whyte et al. 2007), and 'visual representations' (Henderson, 2007). Such terms are used not to denote different types of objects, but to assign different connotations to all the 'plans, sections, models, sketches, photos and slide shows [that] are the everyday focus of many knowledge-intensive activities in the design, construction and management of the built environment (Whyte & Ewenstein, 2007: 3). We choose the term *visual object* (Nicolini, 2007) to emphasize connection to practice studies that discuss 'visual representations as objects' (Ewenstein & Whyte, 2009: 8), with particular attention to their roles as *boundary objects*.

In collaborative design, visual objects were found to span boundaries by drawing members of different professions into conversation (Henderson, 1991, 1995) and mediating among their conflicting logics (Bechky, 2003). As such, they serve as boundary objects – i.e., "objects which both inhabit several intersecting social worlds and satisfy the information requirements of each of them". Being "*plastic* enough to adapt to local needs and constraints […] yet *robust* enough to maintain a common identity across sites" (Star & Griesemer, 1989: 393), visual objects are characterized by *interpretive flexibility* (Star, 2010). This is the characteristic of being interpreted from different perspectives, while remaining meaningful across such perspectives. The interpretive flexibility of visuals as boundary objects is particularly important at the stage of conceptual design, when design professionals need to coordinate their efforts across different disciplines and knowledge domains (Luck, 2010).

Visual objects are distinct from other objects used in design work – e.g., the equipment, standards and forms that constitute the material infrastructure (Star, 1999; Nicolini, Mengis & Swan, 2012) for project delivery. Visual objects are 'artefacts of knowing' (Ewenstein & Whyte, 2007) with both symbolic and tangible properties: "First, they communicate meaning symbolically. This helps to articulate, exchange and understand design ideas. Second, they are manifest in practice as material entities, often physical artefacts, with which practitioners can interact as they generate knowledge individually or collectively" (Ewenstein & Whyte, 2007: 82). This makes visual objects central to knowledge sharing and development in design work: They provide material instantiations of the design concept, and make it amenable to further work.

By virtue of their symbolic and tangible properties, visual objects are a distinct type of boundary objects. Carlile (2002: 452) argues that maps, models and prototypes are the only type of boundary

objects that supports not just the translation, but also the *transformation* of knowledge. By drawing on, altering or manipulating visual objects, professionals are able to negotiate the knowledge used at a boundary, and to validate such knowledge across their different disciplines. In his study of new product development, Carlile (2002) shows how professionals across design engineering and manufacturing engineering used maps, models and prototypes to transform their current approach to a cross-functional problem, by altering the knowledge used to define the product design and its manufacturing process. Visual objects thus span not just *semantic boundaries* caused by differences in ways of seeing and articulating, but also *pragmatic boundaries* related to conflicting agendas in design work. This is not directly supported by use of other types of boundary objects such as repositories, standardized forms and methods (Carlile, 2002), which lack the interactive properties of visual objects.

By spanning semantic and pragmatic boundaries, visual objects enable professionals from diverse design worlds to articulate their ways of seeing and to jointly imagine a not-yet-existing state of things (e.g., building). This is performed in situated settings, as visual objects entwine with the gestural and verbal actions of design professionals, and the physical spaces in which they are embedded (Henderson, 1999; Luck, 2014; Murphy et al., 2012; Roth & Jornet, 2018). In a study of collaborative work between museum designers, curators and educators, Jornet and Steier (2015) found that gestural and verbal actions animate visual objects, making them relevant for the organization of subsequent action. For example, iconic gestures augment visual objects by enabling articulation of ways of feeling in the yet-to-be building. More generally, gestural and verbal actions over visual objects afford intelligibility by producing common lived-in situations that bring together professionals from diverse design worlds. Here, visual objects become an embodied means for inter-disciplinary work.

While much research has focused on the boundaries spanned by visual objects, less attention has been paid to their material characteristics (Ewenstein & Whyte, 2009: 8). In this respect, Whyte et al. (2007) distinguish between *fluid* and *frozen*: While fluid visuals are open and unfolding, frozen visuals are unavailable for change. They are referred to, but remain unchanged throughout the design interaction. Fluid and frozen visuals attend to different roles in design work: Fluid visuals support collective sensemaking, definition of the design problem, and exploration of knowledge; whereas frozen visuals enable keeping records of design decisions, mobilizing consensus around design proposals, and disseminating knowledge to other stakeholders. This distinction is not absolute, as visual objects can be *unfrozen* and *refrozen* depending on the aims of design work. The

patterns of freezing and unfreezing visual objects play an important role, setting the tempo and direction of design work.

To articulate the materiality of design work, Roth & Jornet (2018) suggest using a 'fluid ontology' based on change or process rather than an object-oriented ontology based on a set of single objects mobilized in design work. Here, design work unfolds from fluid to frozen and back to fluid again, since frozen objects are turned into objects of further design through social interactions in an ever changing world. This emphasises 'material flows' (including visual objects, and the gestures and talks performed over visual objects) that continue changing even when the design object (e.g., building) is released and used. A fluid ontology captures the dynamic characteristics of design work, without rejecting reference to 'objects' (e.g., boundary objects) in design studies. It confers primacy to movement and change; which echoes the notion of 'freezing and unfreezing' (Whyte et al. 2007) in design work.

Freezing and unfreezing are examples of visual practices. In this study, we define *visual practices* (Whyte & Ewenstein, 2007) as practical engagement with visual objects, which encompasses the aesthetic, bodily and sensorial experience of using visual objects in professional settings. The unit of analysis to understand visual practices, therefore, is visual objects 'in use' – i.e., how visual objects are used in practice (Nicolini, 2007). Here, the focus is not on professionals using visual objects, but on the visual objects themselves. Through this analytical lens, visual objects become centre stage, without being disentangled from bodily, gestural and verbal actions. According to Nicolini (2007: 578), visual objects: "emerge and express their performative power only when they are used within a specific activity and in conjunction with other elements".

Visual practices, in particular, do not stand in opposition to, but are entwined with verbal practices. This entwinement is implicit in Goodwin's (1994) suggestion that the *production* and *articulation* of visuals are central to professional vision. In order to perform their roles in design work, visual objects need to be made sense of, as part of a broader professional discourse. In turn, this suggests "the somewhat paradoxical possibility that visual practices are by definition not only visual, and that the visual part is in fact only the emergent part of a much more complex 'iceberg'" (Nicolini, 2007: 578). It is by aiming at this 'emergent part' that we intend to uncover an underlying 'iceberg' of verbal, gestural and bodily expressions.

Two implications follow from this conceptualization of visual objects and practices: First, a focus on visual objects in use rejects the deterministic assumption that the material characteristics of visual objects support (or hinder) any given action. Rather, the attention is placed on how visual

objects work along or in conflict with the other elements that participate in unfolding actions. Second, a focus on visual objects in use brings to the fore aspects of process and timing. The capacity of visual objects to participate in the design process depends on when they are used in such process (Nicolini, 2007). This analytical lenses resonate with Goodwin's (2000: 162) suggestion to not explore visual objects as self-contained entities, but rather to analyse "how they are constructed, attended to, and used by participants as components of the endogenous activities that make up the lifeworld of a setting".

Visual objects and practices are entrenched with their media of representation. As explained by Goodwin (2000: 165), "the structure of visual signs, including their possibilities for propagation through space and time, can be intimately tied to the medium used to construct them". For example, the architect's ability to see through and beyond visual objects (Styhre, 2010) is tied also to media such as paper and pencil, computer displays, and cardboard scraps (Martin, 2012). *Material mediation*, often taken for granted in everyday practice, becomes manifest when the introduction of new media causes disruption in professional vision, changing how information is seen and used (Lanzara, 2009; Henderson, 1999).

In design work, material mediation becomes visible as digital modelling is introduced to combine information spread across 2D drawings, texts and repositories (Harty & Whyte, 2010). The digital medium has not replaced but rather supplemented traditional techniques of imaging and visualizing. Concept generation continues to be executed through handmade sketches, while digital models are used to coordinate subsequent stages of the design process. Yet the shift towards digital modelling is far from unproblematic, requiring architects and engineers to reconfigure their visual practices. Architects, for example, are seeking to accommodate digital design, without losing the artistic flair of handmade design (Groleau, Demers, Lalancette, & Barros, 2012).

2. Methods

2.1. Research setting

Our research involved direct observation of design work carried out in an architectural studio in the UK. The first author conducted fieldwork in this setting, focusing on the design of an energy centre commissioned by a University. The new facility was expected to supplement the University's electrical and thermal generation capacity, providing a combined heat and power (CHP) plant fired by natural gas. The client's brief, in particular, required the architectural studio to carry out a full design and build service, from option appraisal to technical design and contractor appointment

(RIBA Stages A-H)[2]. The architects were in charge of preparing the planning application, liaising with local authorities, and leading the design team. This comprised engineering consultants, project managers, cost consultants, and health and safety coordinators.

2.2. Data collection and analysis

The data collection spanned the entire timescale of the design project (September 2012 – February 2013), involving direct observations of design meetings between architects and their consultants. For the purposes of this paper, we performed in-depth analyses of a design meeting, in which architects and engineers gathered to review design details before issuance of the Stage D report (a detailed report for submission to planning authorities). This meeting was selected for two reasons: Firstly, it consists of a design interaction in which architects and engineers coordinate their professional visions to address a number of design issues. Secondly, it involves use of a wide range of visual objects and media – ranging from sketches drawn with pencil on paper to a 3D digital model projected on a large screen. Data collected during this meeting include field notes, along with 4 hours 30 minutes of audio-recording, 123 still images, and 21 videos for a total of 1 hour 3 minutes of video-recording. The dataset also includes documents used by research participants – i.e., drawings produced before and during the meeting, minutes of previous meetings, and a Stage D report of another project (used as an exemplar in the design meeting).

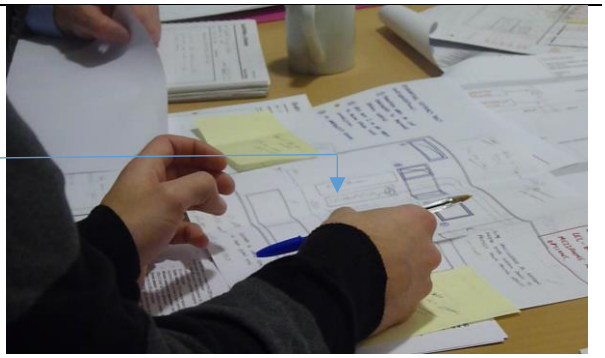
The analysis of data was informed by practice-based theory, and more precisely by the ethnomethodological suggestion to look at the practices and resources by which competent members of a community produce a social order (Goodwin, 2000). From an ethnomethodological perspective, data is presented through examples that re-produce the unfolding action, although there is no obligation to follow a chronological order in the presentation of examples (Martin, 2012). Analytically, data "is interrogated to uncover and explicate the methods and practices through which *the participants* organise and reason about their work. In this way the concentration is on describing the 'ethnomethods' (the actors endogenous methods) rather than fitting the data to extrinsic theoretical categories" (Martin, 2012: 594). Since professional vision is constructed in conversation with visual objects, our analysis was focused on visual practices, but also encompassed other practices (gestural and verbal) unfolding around visual objects.

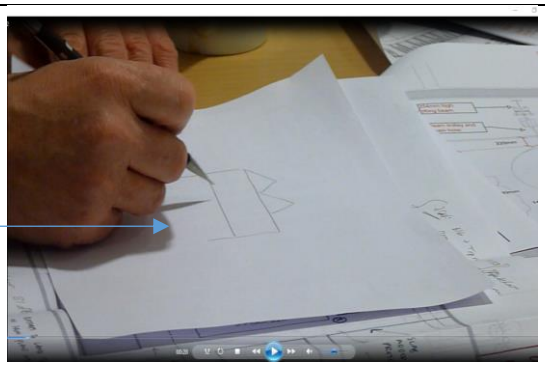
To analyse data, we followed a three-step approach: Firstly, we organized data in a 'multimodal table' matching the meeting transcript with the photographs and videos taken in the field; as well as

[2] The Royal Institute of British Architects (RIBA) Plan of Work organizes the design-build process into different Work Stages (RIBA 2007).

with the visual objects produced and consulted by participants (e.g., drawings). By matching data across multiple modes (verbal and visual) and technologies of representation (photographs and videos), we evoked the richness of visual objects and media used in the field. This enabled us to keep the focus on visual objects in use (i.e., visual practices), and at the same time to use such objects as 'pointers' to a network of interconnected bodily, gestural, and verbal practices. In so doing, we resisted the temptation to assign analytical priority to verbal data (i.e., transcript), and to prematurely transform visual data into verbal data (e.g., coding). Table 1 is an excerpt from our multimodal table, offering a glimpse of our own ways of seeing and articulating the visual objects in use.

Secondly, we analysed this data with a focus on detecting ways of seeing and articulating design issues. Switching across transcripts, photographs, and videos, we identified the visual objects in use whereby participants articulated their professional vision. This involved revisiting the multimodal table, using highlighters to manually code the design issues at stake, the participants using visual objects, and the types of visual objects in use. Thirdly, we built on this analysis of practice to develop written accounts of how participants used visual objects to construct shared professional vision, and to adjust the focus of such vision. By reflecting on our accounts, we articulated higher-level findings that are applicable to a wide range of research settings, beyond the design meeting that we observed.

TIME	SPEAKER	TRANSCRIPT	VISUAL OBJECTS IN USE
…	…	…	
00:11:46	Structural engineer	Sorry ... So this one's the case with the biggest silencer. If you lifted that and you can turn that underneath and bring it…[*using pen to show movements*] if you've got that on trolleys, you've got that extra space that you can turn it and then bring it on to here.	 Structural engineer commenting on drawing (Drawing: CEC 6K63 Mezzanine access options)
00:12:00	Junior architect	Swing it out.	
00:12:01	Senior architect	Mhm.	
00:12:02	Structural engineer	So that's the theory.	

00:12:03	Service engineer	Right. Yeah, you could lift it up, get a trolley underneath, and bring it out. If you can do that, that's all right.	
00:12:14	Junior architect	But essentially, you're saying that you're only ever using the lifting beams just to get something out of the way. So you're not manoeuvring stuff with the lifting beams. So if it is a case of….	
00:12:25	Structural engineer	You know, I think with the lifting beams, it's generally just….	
00:12:28	Junior architect	Up and down?	
00:12:28	Structural engineer	Up and down. And once you get them down, you put them on the wheels and then you do….	
00:12:35	Senior architect	So this block and tackle current rolling….	**VIDEO 1 [duration: 07:59]**
00:12:39	Service engineer	I keep wondering if…I mean just a security idea. You know, I mean, what we've got is in fact the [inaudible 00:12:47]. Say we've got something that looks like that, or something like that [*starting sketch on A4 paper*], is it…does it…what does it look like in cross-section? Does it…?	 Service engineer sketching on A4 paper
00:12:57	Junior architect	Sorry about that. That middle gable moves to the left hand side.	
00:13:00	Service engineer	Here? [*correcting the position of the gable on his sketch*]	
00:13:01	Junior architect	Yeah.	
00:13:02	Service engineer	So it's like that?	
00:13:02	Senior architect	To the valley…?	
00:13:04	Service engineer	The valley between them, yes. Sorry about that. But I mean if we were talking about…but we're not. So we're talking about somewhere in the middle, in the valley, are we?	

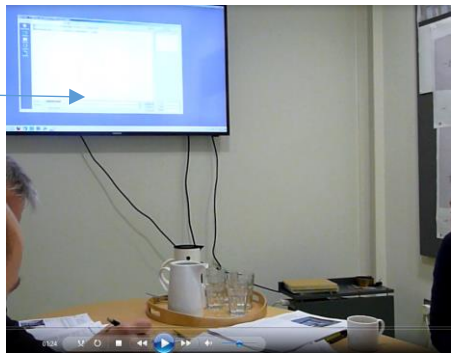
00:13:14	Senior architect	I think 3D-viewed… [the junior architect] has drawn… [*junior architect loads 3D model on screen*]	 3D model loaded on screen
00:13:14	Service engineer	It must [be] about in the valley here [*continuing to sketch*]	
…	…	…	

Table 1. Excerpt from multimodal table matching photographs, videos, and transcript

3. Findings

3.1. Constructing shared professional vision in the energy centre design meeting

Our findings suggest that the construction of shared professional vision unfolded in two moves: The first involves moving away from fragmented professional vision, in order for participants to see and articulate the design issue together[3].The second consists of adjusting shared professional vision, through an iterative move whereby professionals narrow their focus to design details, and then expand such focus to include design solutions developed by others. In the design meeting that we observed, the first move was accomplished in the non-digital space, as professionals engaged in visual practices of *referencing across representations* and *sketching while talking*. The second move, on the other hand, involved professionals shifting to the digital space to perform visual practices such as *zooming-in on design details* and *browsing the digital archive*.

In the next sections, we illustrate the visual practices observed in our design meeting, through two accounts in which participants move away from fragmented professional vision, and then adjust the focus of shared professional vision. Following the ethnomethodological tradition (Martin, 2012), our accounts re-produce the action unfolding in the design meeting, but do not follow a strictly chronological order in the presentation of examples. Since participants tackled a number of design issues, we selected examples that best illustrated the visual objects and practices leading to the construction of shared professional vision. Our aim, in fact, was not to follow development of a given design issue, but instead to articulate the broader moves involved in the construction of shared professional vision. Table 2 provides an overview of such moves; and of the visual objects and practices observed in the design meeting.

[3] The terms *fragmented* and *shared professional vision* emerged from our analysis of the design meeting. These terms will be unpacked in sub-section 3.2.

MOVES	PROFESSIONAL VISION	VISUAL PRACTICES	VISUAL OBJECTS IN-USE
From fragmented to shared professional vision (in the non-digital space)	*Fragmented professional vision*	*Referring to local representations*: Architects and engineers represent the design issue through visual objects produced within different disciplines and organizations. Architectural and engineering drawings compete to serve as boundary objects, without any of them succeeding in spanning boundaries.	Architectural and engineering CAD drawings (printouts)
	Shared professional vision	*Referencing across representations*: Architects and engineers put their representations of the design issue into conversation, using their fingers and pens to draw connections.	Sketch on notepad, architectural CAD drawing (printout)
		Sketching while talking: Architects and engineers sketch and talk to make collective sense of the design issue. A new representation of the design issue (i.e., sketch) emerges out of the information spread across architectural and engineering drawings.	Sketch on tracing paper, underlying architectural CAD drawing and engineering CAD drawing (printouts)
Adjusting the focus of shared professional vision (in the digital space)	*Narrowed shared professional vision*	*Zooming-in on design details:* Architects and engineers inspect digital drawings to focus on details of the building design, while leaving other aspects out of their perceptual field.	Digitalized drawings
	Broadened shared professional vision	*Browsing the digital archive*: Architects and engineers consult the digital archive to bring into view design solutions envisioned by other professionals. Albeit distant in space and time, such solutions can be brought to bear on the design issue at stake.	Stage D report developed for another building project commissioned by the same client.

Table 2. Moves, professional vision, visual practices and visual objects in-use in the design meeting

3.1.1. From fragmented to shared professional vision

At the beginning of the design meeting, professional vision was fragmented across disciplinary and organizational perspectives: The participants were proposing design solutions while looking at their own representations of the design issue. This meeting was attended by two architects (a senior and a junior architect) and two engineers (a structural and a service engineer), sitting at the opposite sides of a table. The participants gathered at the architects' studio, in a meeting room separated from the architects' office space by a glass wall. The room was equipped with a computer connected to a screen mounted over the table (Figure 1). Here, architects and engineers were discussing access options to the energy centre, with particular attention to forklifts. These needed to safely approach the mezzanine and lift the CHP (combined heat and power) installations for maintenance purposes. The design team was challenged to provide sufficient space for forklifts, while at the same time reducing the building height (in order to contain budget expenditure).

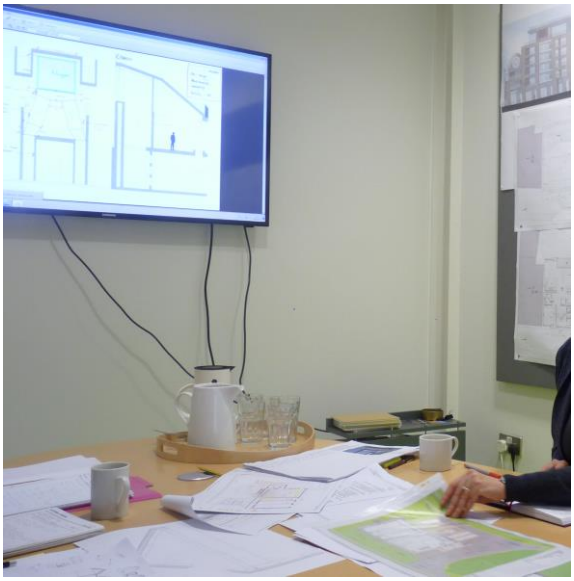


Figure 1. The work setting

To address this design issue, the participants were referring to visual objects that they had produced beforehand. The architects had displayed on the table their plans, elevations and sections; along with a large folder containing all the drawings to be included in the planning application. The junior architect, in particular, had prepared a 3D model, which he was ready to navigate on the large screen. As the engineers unfolded their drawings, the table became replete with visual objects representing – from different perspectives – the mezzanine floor with plant installations. On the one hand, the architectural drawings expressed the appearance and disposition of building components (e.g., CHP installations). On the other hand, the engineering drawings conveyed pre-construction

information about mechanical and electrical systems, and were densely annotated with technical explanations (Figure 2).

Figure 2. Architectural (top right) and engineering drawings (bottom left)

As the meeting progressed, an imaginary line divided the table – the engineering drawings on the left and the architectural drawings on the right, each turned upside down to face the other side of the table. From both sides, participants attempted to advance the local vision, by literally pushing their drawings across the dividing line. Here, participants engaged in visual practices of *referring to local representations*. They were attempting to frame the design issue through the visual objects of their professions. They were attached to their visual objects, to the point of being reluctant to engage with other representations of the design issue. The service engineer, for example, avoided to engage with an architectural plan that was offered by the senior architect, and instead was searching his briefcase for an engineering drawing. He apologized as the conversation was interrupted by his search, but he justified himself by noting:

> That's the sketches I've got. Sorry you've probably got better ones here, but well, they're yours [laughter]. So, better versions of them but, I mean, that's what we're talking through…

He then called attention to his drawing, while the senior architect glanced over it (Figure 3). The service engineer moved on to articulate his design solution, by sketching under the eyes of the other participants. The structural engineer tried to participate, pointing his finger or pen at parts of the sketch and adding a few comments along the lines of his colleague's proposal. The senior architect glanced now and then at the sketch that was taking shape from the pencil of the engineer; and listened while keeping her focus on the architectural drawing. The whole scene was punctuated by repeated attempts, on the part of the junior architect, to direct attention towards the 3D model that he was navigating and projecting on the screen. Such attempts interrupted the service engineer

while he was sketching: He temporarily shifted his gaze away from the sketch, and then recalled the attention of the other participants by continuing to articulate his sketch.

Service engineer: Does everybody know what I'm (talking about)? It's a bit scribbled on drawings. Sorry. But that's where you're lifting the kit off [*showing point in engineering drawing*]….

Figure 3. Referring to local representations

Here, the articulation of professional vision was mediated by visual objects produced within disciplinary and organizational boundaries. Although participants shared an understanding of the design issue, their articulation of such issue was enmeshed with the visual objects they owned – the paper-and-pencil sketch for the engineers, the 2D drawings for the senior architect, and the 3D model for the junior architect. In a sense, they were 'looking apart together' – meaning that they were committed to moving towards shared professional vision, but they were still living within the boundaries set by their own visual objects. These objects competed to serve as boundary objects, without any of them being "robust enough [to carry] common meaning across sites" (Star & Griesemer, 1989: 393).

The construction of shared professional vision started as participants began to put visual objects into conversation, and to look together at the information spread across such objects. By so doing, participants were able to make collective sense of the design issue at hand. We identified two visual practices (and associated verbal and gestural practices) by which they made the transition from fragmented to shared professional vision. The first practice, *referencing across representations*, enabled participants to put their visual objects into conversation, and hence to see through each other's objects. This practice consists of participants using their pens or fingers as pointers to connect representations produced within different boundaries. We observed one example, in which architects and engineers were exploring options for forklift access, while lowering the height of the

building. Here, the service engineer was proposing a design solution to reduce the height of the roof by 75 mil., but the junior architect rebutted that this space was 'fairly critical' since the roof had an acoustic deck. He noted this by referencing across an architectural drawing and an acoustics sketch (Figure 4). The service engineer, therefore, abandoned the design solution for which he had advocated:

Junior architect: Those [are] the three penthouses, and the acoustic line [*showing in an acoustic sketch on his notepad*] … either it happens underneath the roof here or actually it's... it has an acoustic deck just here [*pointing to an architectural drawing*] on top of those beams – which would make the 75 mil. fairly critical.
Service engineer: Ah. Okay.

Figure 4. Referencing across representations

The second practice, *sketching while talking*, involves building shared professional vision through a sketch, which is progressively refined in conversation. In one instance, sketching (and the associated talking) enabled participants to achieve shared professional vision around design details of a gas pipe. Here, the engineers contributed technical specifications to assist the architects in their attempts to minimize the visual impact of the gas pipe. At this stage, the table was replete with architectural and engineering drawings. Therefore, the sketch was necessary to synthesize information spread across multiple drawings, and to conscript diverse visions into a single and narrower space.

The senior architect initiated the sketch by superimposing tracing paper to an architectural drawing of the building envelope. She then referenced an engineering drawing of the plant room to identify a partition line, and copied it onto the tracing paper. While talking aloud to give sense of her signs on tracing paper, she sketched the wall around the partition line. The structural engineer intervened to suggest a point where the gas pipe could get through, while the junior architect was inspecting the 3D model to get more precise measurements of distances. As participants were talking together to explore entry options for the gas pipe, the sketch began to take shape from multiple hands interacting on tracing paper. As visible from Figures 5a and b (and the corresponding excerpts), architects and engineers contributed by making annotations on the sketch, using their pens or fingers to highlight some of its parts, and nodding to approve each other's remarks.

Senior architect: So definitely you can't go there? [If a brick] pokes in…. What I was asking is whether we could try and put the pipe behind the zinc panel [*using her pen to bold a circle representing the pipe*].
Junior architect: Hum, that's… that's 102.5 [*moving his pen over to indicate length*].
[*Structural engineer nodding and pointing with his pen*]
Senior architect: A bit of cavity?
Junior architect: The cavity is 120 – I believe.
Senior architect: So we've got quite a bit of space. Is that a 100-mil. pipe, or is it…?
Structural engineer: I think it could be bigger than that... It's a huge gas station. What do you think is the maximum?
Junior architect: I think that one's got a break at 125. I think that's 120 [*annotating measures on the sketch*].

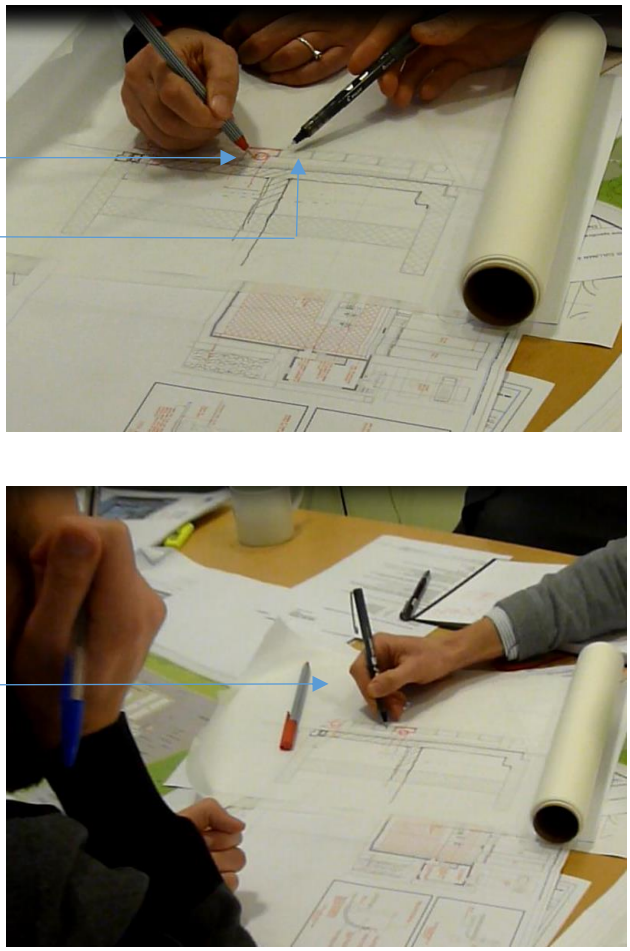


Figure 5a and 5b. Sketching while talking

3.1.2. Adjusting the focus of shared professional vision

Once a design issue was inscribed within the shared professional vision, participants iteratively adjusted its focus. The digital medium, in particular, proved instrumental for narrowing shared professional vision. In one example, participants were reviewing acoustic requirements with a view to facilitating access to the acoustic ceiling. They explored different solutions, such as straightening the attenuators of supply ducts, building a straight wall in the penthouses or putting an acoustic shroud at the point of connection with the supporting structure. The conversation started around an architectural section of the penthouses, annotated with hand-written comments. But as soon as the junior architect loaded a digitalized sketch of the attenuators, participants left the table and gathered around the screen.

The process of narrowing shared professional vision was realized as participants engaged in visual practices of *zooming-in on design details*. By using the computer to zoom-in on digital drawings,

participants could focus together on details of the design problem. While the sketch was readily available as a printed document on the table, participants felt the need to load it as a digital file and engage in conversation around the computer screen. By addressing the need for increased focus, the digital medium became the fulcrum of interaction, shifting attention away from the drawings spread over the table. It also required participants to shift their gaze from a horizontal (drawings on the table) to a vertical setting (screen on the wall), and to change their disposition in the meeting room by standing up around the screen.

At the beginning, the engineers stood in the back while the architects were looking closely at the screen, passing their fingers and pens over to discuss changes in the angle of the attenuators (Figure 6). As they intended to make a point around the design issue at hand, participants switched their places and alternated to gain a closer position to the screen. The difference between the digital and non-digital space is striking: While the table covered with drawings provided a synoptic view on the project, the screen showed a detailed view of a design element. Unlike the physical drawings on the table, the digital copies (nested in folders) could be inspected only in sequential order, or by splitting the screen view into multiple windows.

Senior architect: You still need something here. If this [*the attenuator*] was straight, you'd still be drawing up and have to make the ceiling…
Junior architect: No, because it would affect [inaudible] it's not straight [*pointing at the angle of the attenuator*] and that would affect so much [inaudible] how your partition goes up to the other side; so there's no chance of [inaudible] breaking up beneath the attenuator…

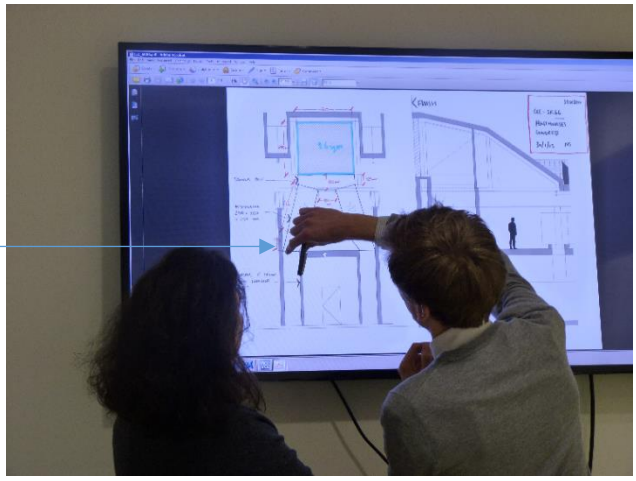


Figure 6. Zooming-in on design details

Yet the digital medium enabled participants to not just narrow, but also broaden shared professional vision by literally bringing into the conversation visual objects pertaining to other projects. The broadening of shared professional vision was achieved by engaging in visual practices of *browsing the digital archive*. By so doing, participants widened their horizons beyond the project at hand, and found inspiration in the vision of others. In one instance, participants decided to include in the Stage D report a 'statement of intentions' for each discipline (architectural design, engineering structures and services), in order to guide contractors in developing detailed design. Through the office

Intranet, the senior architect accessed the Stage D report of another building that the architects had designed a few years before, for the same client who commissioned the energy centre.

Although the two projects were different, the document was suggested as a reference, not just for presenting the same structure as a stage report, but also for reflecting the aesthetic requirements of the client. It was brought to the meeting by the digital medium, as the senior architect navigated the report and participants looked at the screen. It broadened the participants' shared professional vision by including the engineering experience of another firm. The senior architect, in fact, invited the engineers to consult the 'structures' section, and initiated a conversation around the engineering concepts articulated in this section. She promised to email the document to her engineer colleagues, 'as a kind of guide' (Figure 7):

Senior architect: This is a Structures section, which was made by [engineering company] [*browsing the digital archive and opening a file*]
Service engineer: So that's their kind of concept – yeah? [*looking at the drawing on the screen*]
Senior architect: Yeah, they have a kind of concept for that (overlapping conversation). They used to [inaudible] that ground issue with some structural integration. I will email this to everyone…
Service engineer: All right.
Senior architect: …as a kind of guide. I'm not to say that this is the ultimate perfect document either [but it may be useful for] what you're doing. This [engineering company] did their bit in one particular way, and you might want to do it in another way, or a better way...

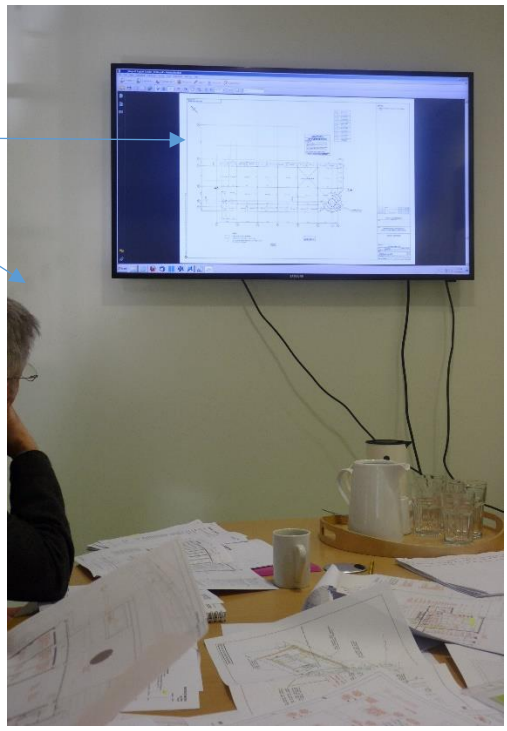


Figure 7. Browsing the digital archive

3.2. A practice perspective on constructing shared professional vision

By reflecting on our accounts, we articulated higher-level findings of how shared professional vision is constructed through practical engagement with visual objects. These findings are applicable to a wide range of design settings in which professionals from different disciplines need to coordinate their ways of seeing and articulating. In the next paragraphs, we unpack the construction of shared professional vision, by articulating the different states of professional vision

– from fragmented to shared and adjusted – and the visual practices and media whereby professionals move across such states.

Constructing shared professional vision involves shifting away from a *fragmented professional vision*. This can be described as a state in which professionals are committed to look together for a design solution, but their professional visions are separated across boundaries. Here, their visual practices consist of referring to local representations, which represent the design issue from within disciplinary and organizational conventions. Rather than engaging with each other's professional vision, they attempt to advance and establish their ways of seeing and articulating, mobilizing the visual objects of their professions. This was visible in the meeting that we observed, when architects and engineers pushed their drawings towards the other side of the table – as in an imaginary contest to articulate the design issue.

The shift towards shared professional vision begins as professionals articulate the meaning of visual objects, in an attempt to span the boundaries of their design worlds. *Shared professional vision* can be characterized as a state in which professionals are 'looking together' – meaning that they share ways of seeing and articulating, which in turn provides the basis for putting diverse expertises at work. We identified two visual practices by which professionals shift from fragmented to shared professional vision, namely referencing across representations and sketching while talking. Albeit involving different actions over the visual material, both practices consist of putting into conversation visual objects from different design worlds, in order for professionals to see and articulate together. In the first practice, professionals draw connections across visual objects (e.g., with their fingers), identifying pieces of information that expand their current articulation of the design issue. In the second practice, they produce a novel representation of the design issue (i.e., sketch), which integrates and recombines the perspectives represented by visual objects from different design worlds.

After laying the foundations for shared professional vision, participants adjust it through an iterative move of narrowing and broadening its focus. A *narrowed shared professional vision* is a state in which professionals 'focus together' – i.e., they collectively look at aspects of the design issue, while leaving other aspects out of their perceptual field. This is performed as professionals engage in visual practices of zooming-in on design details, to see and articulate their implications for the design solution. A *broadened shared professional vision*, on the other hand, is a state in which professionals find inspiration in the vision of others, by consulting design solutions produced in previous projects. They do so, we found, through visual practices of browsing their digital archive.

This provides access to visual objects which – albeit distant in time and space – bear a connection to the design solution that is being developed.

Visual objects play an important role in the construction of shared professional vision. However, they can sustain the shift from fragmented to shared professional vision only when they are put into conversation by design professionals. In a state of fragmented professional vision, visual objects are mobilized as non-human allies to push forward local ways of seeing and articulating. They compete to become boundary objects, without any of them being robust enough to succeed. The very fact that they are produced *within* the boundaries of a given profession hinders their ability to span boundaries *across* different professions. As professionals draw connections across visual objects from different professions, what emerges is not a boundary object, but a multiplicity of visual objects that converge to sustain the construction and adjustment of shared professional vision. Such objects are connected into an ever-changing configuration: While single objects can be discerned for analytical purposes, they are best conceived of as an amalgam of visual objects.

The construction of shared professional vision, in particular, is enabled by an interplay of fluid and frozen visuals. Fluid visuals (e.g., sketches) provide a shared space where different perspectives, conventions, and languages can be negotiated and integrated. Frozen visuals (e.g., drawing print-outs) participate in the construction of shared professional vision by making information from any given design world available for use. This was visible in the meeting that we observed, as frozen visuals such as drawing print-outs were placed under tracing paper to input information into the emergent sketch. While this fluid visual (sketch) took on a central role in the design interaction, frozen visuals (drawing print-outs) participated in its production and supported the negotiation of ways of seeing and articulating between design worlds. Yet the boundaries between fluid and frozen visuals are not clearly demarcated and instead are ‘in-flux’, since visual objects are continuously unfrozen and refrozen in their use.

We also found that the same visuals perform differently depending on the process and timing at which they are mobilized. In our case, for example, digital drawings performed differently at the beginning and end of the design meeting. Initially, they did not invite participants to engage in conversation across their design worlds, when the junior architect was trying to draw attention to the computer screen. Later on they became the fulcrum of conversations, when they were mobilized to adjust the shared professional vision emerging from the visual objects spread over the meeting table. This is in line with practice theory (Nicolini, 2007), which rejects the deterministic assumption that affordances are inscribed into the characteristics of visual objects. It also supports

the suggestion that visual objects are fluid or frozen depending on how they are being used in the design process (Whyte et al., 2007).

Our findings shed further light on material mediation. We found that *non-digital media* sustain the move from fragmented towards shared professional vision, offering an overall view where different representations of the design issue can be accommodated. In the meeting that we observed, this was performed with multiple drawings unfolded one next to each other on the table, and media such as pens, pencils and tracing paper readily available for making annotations, connections and sketches. For example, the sketch of the gas pipe (Figures 5a and b), realized on tracing paper and annotated with multiple pens, enabled participants to synthesize information scattered across architectural and engineering drawings, and hence to leverage insights from different design worlds. While the transition from fragmented towards shared professional vision could be realized also in a digital environment (e.g., through Building Information Modelling), the use of architectural and engineering print-outs – spread out on the meeting table – enabled participants to simultaneously maintain multiple views of the design problem (rather than opening/closing files or splitting views on screen); and to use pens to swiftly inscribe their different yet complementary views.

We further found that *digital media* sustain the adjustment of shared professional vision, through the narrowing and broadening of its focus. The digital medium, in fact, enables professionals to magnify design details and gather their measurement information (this resulting in a narrowed shared professional vision). In the meeting that we observed, this was evident as participants stood up from the table and gathered around the screen to zoom-in on details of the acoustic attenuators. The digital medium also provides access to digital archives, whereby design solutions developed by other professionals can be brought into the conversation and used as inspiration (this resulting in a broadened shared professional vision). For example, the senior architect in our design meeting used the digital medium to access the Stage D report of another project, which had been previously realized for the same client. While the narrowing and broadening of shared professional vision could be performed also in the non-digital space (e.g., with drawings at different scales and a physical archive), the digital medium offers increasing level of measurement details and stores large amounts of project data.

To conclude, the construction of shared professional vision results in design solutions that leverage insights from different design worlds. This requires professionals to not just share, but also to negotiate, harmonize and recombine insights. They do so by articulating unfolding, inter-disciplinary and inter-organizational ways of seeing through use of a wide range of visual objects.

What emerges is not the vision of a novel profession, but a novel vision that integrates aspects of different professions. In the meeting that we observed, for example, professionals developed access options by integrating architectural and engineering considerations. It should be remarked that constructing and adjusting shared professional vision excludes imposing ways of seeing and articulating. This might lead to (forced) agreement on a course of action, but would not lead to development of design solutions in settings that require the coordination of different professional visions.

4. Discussion and Conclusion

Our paper builds on the practice perspective in design studies (e.g., Ball & Christensen, 2018; Luck, 2012a; McDonnell & Lloyd, 2009) to articulate how design professionals use visual objects for building shared professional vision. Previous research examined the professional vision of architects (e.g., Styhre, 2010) and engineers (e.g., Henderson, 1999), the disciplining of architectural vision in educational settings (e.g., Murphy et al. 2012), and its calibration against the concerns of users (Luck, 2012b). We draw on this body of research to explore how 'ways of seeing' are constructed *between*, rather than *within* professions. Through ethnomethodological analyses, we investigate the construction of shared professional vision as it happened 'in the wild' (Luck, 2015) – i.e., as a situated practice, embedded in the material world, and unfolding in the here-and-now of design interaction.

Our findings show continuity with previous research on professional vision, placing the emphasis not on the cognitive processes underlying human actions, but on the practical accomplishments of such actions (cf. Luck, 2012a). However, focusing on the intersections *between* professions brings into view a different context; and a different set of practical accomplishments for constructing ways of seeing. Unlike the actors involved in educational or participatory settings (Lymer, 2009; Murphy et al., 2012, Luck, 2012b), the professionals in our meeting had balanced power, knowledge, and control of visual objects. Our analyses reveal the actions that they undertook to see from each other's perspective, coordinate local representations, and adjust their focus. Here, shared professional vision emerges as being central to coordinating different ways of seeing.

The primary contribution of our paper, therefore, consists of introducing the concept of *shared professional vision* to elaborate on the ways of seeing and articulating that emerge at the intersection between design professions (e.g., architecture and engineering). We note that constructing a shared professional vision involves recombining insights from different professional visions (Goodwin, 1994) so as to address the design problem at hand. This is performed by putting

into conversation visual objects produced within different professions; and articulating emergent, inter-disciplinary and inter-organizational ways of seeing. A shared professional vision involves not just sharing insights from different professional visions, but also integrating, negotiating and recombining such insights. What emerges is a novel vision that accommodates aspects of different professions.

Professional vision and shared professional vision are different constructs. The term 'professional vision' refers to the practices of seeing as a competent member of a profession (Goodwin, 1994; Lymer, 2009; Styhre, 2010). The term 'shared professional vision', on the other hand, refers to the situated practices of constructing ways of seeing across professions. It implies the co-presence of professionals from different disciplines and organizations, who share and negotiate their knowledge to address a design issue. While it has been noted that professional vision (e.g., the architect's vision) needs to take into consideration the vision of other professions (e.g., the engineer's vision) (Styhre, 2010), this inclusion is performed within the boundaries of a given profession, and does not build on situated practices of sharing and negotiating knowledge across different ways of seeing and articulating.

The concept of shared professional vision builds on a long-standing tradition of research in collaborative design, which recognizes the challenges of doing design work when participants come from different professions, and have different understandings and interests. In particular, it draws on Bucciarelli (1988), Schon (1988), and Schon and Wiggins' (1992) suggestions that design is a social more than cognitive process, existing only insofar as it is constructed in social interaction. It recognizes the involvement of "many different kinds of participants" (Schon 1988: 182) in the design process to tackle the fundamental problem of how they achieve "agreement about things to be built in the face of different ways of framing design situations" (Schon 1988: 189). It does so by articulating how design professionals use visual objects to span the different 'design worlds' (Schon, 1988) or 'object-worlds' (Bucciarelli, 1988) that they inhabit.

In his ethnographic study of engineering design, Bucciarelli (1988) identified the discourse types (e.g., constraining, naming, deciding discourses) used in negotiating among different 'object worlds' or 'worlds of technical specializations'. We acknowledge that visual objects are central to design discourse and explore their use in practice, including the process and timing of their deployment. This leads us to articulate the visual practices of constructing a shared professional vision, through a focus on the visual objects in use (including bodily, gestural and verbal actions performed in such use). By so doing, we acknowledge Bucciarelli's (1988: 164) remark that the

different interests of participants cannot be comfortably accommodated within the structure of object-world thinking; and unpack the practices by which professionals enlist visual objects to negotiate among their different interests. Compared to Bucciarelli's (1988) analysis of discourse types, our work brings into view visual objects and the media used for their production and fruition.

Our findings are relevant also with respect to Schon and Wiggins' (1992: 145) work on ways of seeing and particularly their preoccupation with understanding how designers develop "new ways of seeing". The articulation of shared professional vision, in fact, involves the construction of a new way of seeing that integrates insights from diverse professional visions. We explicate how designers from diverse professions become aware of each other's ways of seeing through conversation with visual objects; and then mobilize such objects to construct shared professional vision. The process of constructing shared professional vision echoes Schon and Wiggins's (1992: 154) suggestion that design is "a reflective conversation with materials whose basic structure – 'seeing-moving-seeing' – is an interaction of designing and discovering". Initially, professionals see through the visual objects that constitute their diverse professions. As they perform design moves with visual objects, they discover consequences that span across their design domains. An understanding of such consequences, in turn, constitutes the basis for constructing shared professional vision.

Our empirical data, finally, offers insights also with respect to Schön's (1988) work on design worlds and types. It suggests that visual practices of *referencing across representations* and *sketching while talking* enable participants to work across design worlds. It further confirms Schön's (1988) proposal that familiarization with the 'design types' of different professions enables spanning the boundaries of design worlds: For example, the Stage D report used in our design meeting can be thought of as a 'reference' (i.e., a design type) that enables the senior architect to communicate her expectations to the engineering consultants. The sketch produced by the senior architect can be thought of as a 'spatial gestalt' (i.e., a design type) insofar as it represents basic figures that facilitate understanding across design worlds. Our work, therefore, provides an answer, albeit partial, to Schön's question (1988: 189) of how design types might help participants to communicate across their design worlds.

Compared to previous accounts of professional vision, our work is distinct in its analytical emphasis. While sharing an ethnomethodological sensitivity (cf. Luck, 2012a), we focus on visual practices (Nicolini, 2007) – i.e., the visual objects in use whereby professionals organize designing. Such focus acknowledges that professional vision is lodged in the visual objects of design work (Goodwin, 1994). It further brings visual objects centre stage, without downplaying gestural and

verbal actions: Our accounts, in fact, show how visual practices intertwine with gesture and talk in the construction of shared professional vision. For example, the visual practice of *referencing across representations* is performed by seeing connections across local representations, pointing with fingers and pens to show such connections, and simultaneously articulating their implications through talk. This adds to work that placed analytical emphasis on the bodily and verbal practices whereby designers articulate their professional visions (Murphy et al., 2012; Luck 2012b; Lymer, 2009; Oak, 2009; Sonalkar et al. 2016). While Jornet and Steier (2015) note that gestural and verbal actions afford intelligibility across design worlds, we add that visual objects come to embody shared professional vision as they are articulated through gesture and talk.

Given its focus on visual objects in use, our paper offers insights also for scholars interested in visual objects, and more precisely in their role as boundary objects across disciplines and organizations (Ewenstein & Whyte, 2009; Henderson, 1991; Luck 2010). While this previous work highlighted the boundary-spanning capacity of visual objects, our findings indicate that a boundary object did not emerge out of the plethora of representations available in design work. Nevertheless, the construction of shared professional vision was possible as professionals connected visual objects, and orchestrated the diverse perspectives that they embodied. Shared professional vision builds not on boundary objects but on the interplay of human and material agencies, which is performed in visual practices of *referencing across representations*, *sketching while talking*, *zooming-in on design details*, and *browsing the digital archive*. This echoes Jornet and Steier's (2015) finding that boundary objects do not perform by themselves, but rather are animated and made salient by the bodily movements of participants.

Drawing on recent work by Roth and Jornet (2018), we further note the analytical challenges of using 'object-concepts' in ethnographic research of design work: In our observations, visual objects unfolded continuously, making it for a constantly changing environment. While single objects can be distinguished for analytical purposes, they are best conceptualized as an amalgam that is incessantly evolved, shifted across media, frozen and unfrozen. Given this changeability, a fluid rather than object-oriented ontology (Roth & Jornet, 2018) seems promising to capture the dynamic process of constructing shared professional vision. Further research, therefore, might investigate how a fluid ontology could be operationalized for the analysis of visual practices – i.e., visual objects in use. This involves developing an analytical approach that overcomes the divide between fluid and frozen visuals, human and non-human actors, verbal and nonverbal practices; and instead focuses on capturing their unbounded entanglement and continuous unfolding in time and space.

The plurality of visual objects in use and their constant unfolding, in particular, challenges the analytical use of the notion of boundary object, which assumes a relatively stable object – neatly identifiable in analytical practice (Ewenstein & Whyte, 2009; Jornet & Steier, 2015; Roth & Jornet, 2018). A few scholars suggested to re-conceptualize boundary objects as continuously unfolding (Ewenstein & Whyte, 2009; Roth & Jornet, 2018) and entwined with bodily engagements (Jornet & Steier, 2015). Future work should build on this to explore how visual objects enable design professionals to achieve intelligibility and co-orientation towards a design object, in spite of their plural and unstable form. This might involve re-thinking visual objects in terms of multiples (rather than single objects), and questioning how the relations between such objects enable the performing of design work.

Further research should also explore the construction of shared professional vision in different design settings. For example, scholars should consider settings in which professionals from different design worlds struggle to articulate a shared professional vision; or settings in which a shared professional vision is constructed and then de-constructed by the same professionals involved in design work. This would bring into view the challenges encountered in moving away from a fragmented professional vision, and might lead to discovering different moves underlying the construction of shared professional vision. Other scholars might consider settings in which professionals impose and accept a local professional vision (instead of engaging in the construction of a shared professional vision). This would shed light on the conditions required for a professional vision to become centre-stage in collaborative design, and explain why and how other professional visions become silenced.

Finally, our work has practical implications for design professionals. It provides an account of how different perspectives are integrated in a shared professional vision; and sheds light on the moves leading to the construction of shared professional vision. Design professionals are advised to not rely on local representations for spanning boundaries, but rather to engage in visual practices for putting such representations into conversation. They should also consider that, although the industry is moving towards complete implementation of Building Information Modelling, non-digital media retain a fundamental role in the construction of shared professional vision.

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None

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