

# Infrastructure as a Home for a Person: A Phenomenological Interpretation of Star and Ruhleder's Relational View

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**Abstract.** Star and Ruhleder's (1996) influential 'relational view' of infrastructure is usually understood to mean that infrastructure is a relation between technologies and organizational practices. However, a significant part of their original proposal has been overlooked - that infrastructure becomes a home for somebody. In this paper, we give an alternate interpretation of this relational view by focussing on the relation between a person and their infrastructure, rather than on the relation between technologies and practices. We use Heidegger's (1962) phenomenology in *Being and Time* to theorize what a home entails, and a novel data collection method to study infrastructuring empirically from a person's perspective. On this basis, we give new theoretically grounded interpretations of infrastructure and infrastructuring. Empirically, we identify two modes of infrastructuring not previously distinguished. The perspective sheds new light on a number of key themes and debates in the literature and on infrastructuring in practice.

*Keywords:* infrastructure, infrastructuring, Heidegger, hermeneutic circle, reflective diary, empirical case

## 1. Introduction

In IS and related disciplines, infrastructure has traditionally been understood as a technical or socio-technical system that underlies and supports practices which ‘run on top’ of it (Carse, 2017; Lee & Schmidt, 2018). Against this view, Star and Ruhleder (1994, 1996) have proposed their ‘relational view’ of infrastructure which has become increasingly influential in IS and beyond (Barrett & Walsham, 2004). However, it has also been characterized as highly ambiguous and even incomprehensible (Lee & Schmidt, 2018).

In the literature section that follows, we show that the relational view has been predominantly interpreted to mean that infrastructure is a relation between technologies and practices, although the nature of the relation is debated. However, a significant part of Star and Ruhleder’s (1996) original proposal has been ignored - that infrastructure becomes a home for somebody (ibid. 114). Turning our focus to this part, we ask: What does it mean for infrastructure to be a home for a particular person? What is the process of bringing technologies and practices into this home?

To address these questions, we propose an alternate interpretation of the relational view by focussing on the relation between a person and their infrastructure, rather than on the relation between technologies and practices. We use Heidegger’s (1962) phenomenological account of everyday absorbed activity to theorize what a home for a person would entail. Empirically, we employ a novel data collection method using the reflective diary of a novice professional undergoing hands-on training to study infrastructure from a person’s perspective.

Starting from Star and Ruhleder’s (1996) assertion that infrastructure is a home for a person and interpreting this through Heidegger’s analysis of the way people become at home in their world, we show (see ‘Theoretical Framework’) that, from the perspective of such a person, infrastructure is a person’s world of involvements with equipment, others and meanings, and we interpret the continual process of bringing new technologies and practices into their world as ‘infrastructuring’ (Star & Bowker, 2002; Pipek & Wulf, 2009).

Additionally, our empirical enquiry uncovered two modes of infrastructuring not previously distinguished in the literature. Exploratory infrastructuring is the accommodation of new technologies and practices as an outcome of a person’s everyday coping activities. Emancipatory infrastructuring is an outcome of less frequent situations where the world loses its familiarity for a person and produces anxiety about identity. These may be used by a person to challenge their entrenched meaning structures, and this represents an alternate route to accommodating new technologies and practices.

The main contribution of our work to the IS discipline is the development of a new approach to the relational view of infrastructure based on the perspective of a person at home in infrastructure. Our approach sheds a different light theoretically and empirically on a number of key themes and debates in the literature, including on the ‘relation’ that is central to the relational view, the causal status of breakdown in infrastructuring, the role of mood in infrastructuring, the scale of infrastructure, and the ontological status of infrastructure and infrastructuring. It also suggests a novel approach to infrastructuring in practice.

## 2. Literature Review

The scope of this review is works that adopt and aim to contribute to the relational view of infrastructure proposed by Star and Ruhleder (1996), who defined it as follows:

*“... infrastructure occurs when local practices are afforded by a larger-scale technology, which can then be used in a natural, ready-to-hand fashion. It becomes transparent as local variations are folded into organizational changes, and becomes an unambiguous home — for somebody. This is not a physical location nor a permanent one, but a working relation — since no home is universal ...”* (Star & Ruhleder, 1996, p. 114)

In contrast to the traditional view of infrastructure as a technical substrate underlying and supporting a practice (Carse, 2017; Lee & Schmidt, 2018), there is almost complete consensus in this literature that the relational view implies that a technology and practice are related in some manner to form an infrastructure. In this way, infrastructure is interpreted to be a relation, not a thing. However, there is no consensus about the nature of this relation. One view is that infrastructure occurs when a technology and a practice have become ‘entangled’ so that they no longer have an individual existence (Almklov et al., 2014; Karasti & Blomberg, 2018), similar to the notion of sociomateriality (Orlikowski & Scott, 2008). A second view is that infrastructure occurs when practices and technologies are connected to each other in an open-ended process of forming a socio-technical system (Pipek & Syrjänen, 2006; Bossen & Markussen, 2010). In the following two sub-sections, we analyse the literature according to which of these two views is adopted.

### 2.1. Infrastructure as entanglement of technologies and practices

The majority of studies that we classify in this group (see Table 1) use the concept of ‘infrastructural inversion’ (Bowker, 1994; Bowker & Star, 1999) to expose how power asymmetries and biases are inscribed into material

form as a result of the entanglement of practices and technologies (Clement et al., 2012; Ribes & Polk, 2012; Schwenkel, 2015; Wagenknecht & Korn, 2015; Baumgardt, 2018; Gui & Chen, 2019; Ramakrishnan et al., 2020; Williams et al., 2020), including the purposeful use of breakdowns as a normative tool to expose power asymmetries (Clement et al., 2012; Jackson, 2014; Schwenkel, 2015; Wagenknecht & Korn, 2016; Baumgardt, 2018). In line with this concern, scholars have shown how the work that goes into maintaining infrastructure is often rendered invisible and thus intentionally devalued (Clement, 1993; Jackson, 2014; Schwenkel, 2015). Some authors have thematised entanglement, as such, by showing how the various elements that form an infrastructure mutually constitute one another (Iannacci, 2010; Almklov et al., 2014). Methodological concerns associated with understanding infrastructure as a large-scale phenomenon have been extensively addressed by Karasti and Blomberg (2018). There are a number of contributions in this group from outside of the IS field which are noteworthy as they shed critical light on the common notion of breakdown as making visible infrastructure (Schwenkel, 2015; Baumgardt, 2018; Ramikrishinan et al., 2020). The role of affect in exposing power asymmetries inscribed into infrastructures is also highlighted (Ramikrishinan et al., 2020).

**Table 1: Studies that view infrastructure as an entanglement of technologies and practices**

Star, 1999	Describes methods used in her own research to uncover traces of power asymmetries inscribed into infrastructures
Ribes & Lee, 2010	Propose to use infrastructural inversion to bring to the fore the activities that hold together the functioning of an infrastructure
Iannacci, 2010	Shows that institutional facts are entangled with an information infrastructure
Clement et al., 2012	Uses the concept of breakdown normatively to make infrastructure visible and expose power asymmetries
Ribes & Polk, 2012	Show how a medical infrastructure inscribes understandings of what AIDS and AIDS patient are
Almklov et al., 2014	Show how infrastructure and practice mutually constitute one another
Jackson, 2014	Argues that repair work has innovative potential for infrastructure development and shows how such work is intentionally devalued
Schwenkel, 2015	Shows how the decay of infrastructure reproduces the hierarchical stratification of society and how local responses to such neglect reveal an emancipatory potential
Wagenknecht & Korn, 2016	Use hacking to uncover power structures inscribed into a mobile communication infrastructure
Karasti & Blomberg, 2018	Propose a number of ethnographic techniques to analyse an infrastructure into its parts
Baumgardt, 2018	Argues for a more nuanced analysis of moments of breakdown, focusing on 'micro-modes' of breakdown to overcome the binary distinction between infrastructure visibility and invisibility
Gui & Chen, 2019	Show how frequent breakdowns of the US healthcare infrastructure necessitate infrastructuring work by its users, which exposes their weak bargaining position
Plantin & Punathambekar, 2019	Summarize the relational view to propose that this tradition can be usefully fused with the field of media studies
Ramakrishnan et al., 2020	Point out the role of affect in situations of decay, repair, and maintenance, and how affect makes visible power asymmetries inscribed into infrastructure
Williams et al., 2020	Show, through inspecting health apps, how certain standards are used to reinforce biases against groups of people

## 2.2. Infrastructure as an ongoing process of connecting technologies and practices

For studies that we classify in this group (see Table 2) a dominant topic is the conflict-laden and political nature of infrastructure development (Bossen & Markussen, 2010; Sanner et al., 2014; Bødker et al., 2017; Parmiggiani, 2017; Ulriksen et al., 2017; Introna et al., 2019). Power and conflict are studied as they occur in developing infrastructure and not as exposed through ex post analysis of infrastructure into its components. Consequently, this strand of the literature is more concerned with practical questions, for example with proposing tools and methods for actively involving users in infrastructure development (Pipek & Wulf, 2009; Young & Lutters, 2017; Ludwig et al., 2018; Simonsen et al., 2020). One concern is to show that users can and often do play an active role in infrastructure development (Karasti & Syrjänen, 2004; Pipek & Syrjänen, 2006; Pipek & Wulf, 2009; Karasti, 2014; Erickson & Jarrhadi, 2016). Another is that infrastructure, due to its withdrawn nature, needs to be made visible as a design object for its users (Neumann & Star, 1996; Pipek & Syrjänen, 2006; Pipek & Wulf, 2009; Karasti, 2014). Breakdowns are understood as productive in this regard since it is assumed that they make infrastructure visible for its users and possibly designers (Pipek & Syrjänen, 2006; Pipek & Wulf, 2009; Holeman & Barrett, 2014; Karasti et al., 2018; Mikalsen et al., 2018). The literature has also addressed methodological questions, including how to cope with the large scale of infrastructure and the possibly active, while often unintended, role of researchers in infrastructure development processes (Parmiggiani, 2017; Karasti, et al. 2018).

Neumann & Star, 1996	Connect the concepts of infrastructure and participatory design to point out a fundamental 'paradox', namely that good infrastructure is invisible while PD requires it to become visible
Karasti & Syrjänen, 2004	Describe two cases of community-based infrastructuring understood as artful integration of everyday materials, tools, methods, and practices
Pipek & Syrjänen, 2006	Develop the concepts of 'in situ design' and 'point of infrastructure' to argue that users can and do engage in meaningful infrastructuring
Pipek & Wulf, 2009	Develop practical ideas for tool and method support for in situ design
Vaast & Walsham, 2009	Shows that similarities across practices and a positive feedback between a new and an extant infrastructure helped to successfully establish a new infrastructure
Bossen & Markussen, 2010	Show how artifacts and practices came together to be more tightly integrated in an IS implementation project and how this resulted in increased dependencies and vulnerabilities
Mark & Su, 2010	Show that for mobile workers infrastructure never resides in the background but always needs to be re-assembled on the fly
Karasti, 2014	Reviews the literature that has developed in the wake of Susan Star's work (with Karen Ruhleder and Laura Neumann) to argue that users can and should be involved in infrastructuring
Sanner et al., 2014	Show the fragility of infrastructuring understood as extending an existing infrastructure
Erickson & Jarrhadi, 2016	Show how mobile workers engage in a kind of ongoing infrastructuring
Bødker et al., 2017	Show the messy, power-laden and conflictual process of participatory infrastructuring
Holeman & Barrett, 2017	Show how 'material back-talk', a form of breakdown, is characteristic of how an IT artefact becomes entangled with a particular context of use
Parmiggiani, 2017	Shows how infrastructuring can be studied ethnographically by the researcher aligning with infrastructurers
Ulriksen et al., 2017	Show how power relations and politics shape infrastructuring processes
Young & Lutters, 2017	Use the concepts of points of infrastructure and infrastructure inversion to support the development of a scientific infrastructure
Karasti et al., 2018	Discuss the role of breakdown and of identities in infrastructure development processes
Ludwig et al., 2018	Elaborate the concept of resonance activities as an essential component of in situ design
Mikalsen et al., 2018	Use the infrastructuring lens to describe and analyse a large implementation project
Introna et al., 2019	Show how the introduction of a new order entry system led to the re-negotiation of roles of medical professional groups and how this was inscribed into the materiality of the system
Simonsen et al., 2020	Describe how an implementation project traced the dependencies between different practices in a hospital

### 2.3. Main themes and debates

From a synthetic perspective, we distinguish five main themes in the literature characterised by core debates.

1. *The relation that constitutes an infrastructure*: As shown above, there are multiple views on the nature of the relation that is assumed to constitute infrastructure. This is indicative of the ambiguity of Star and Ruhleder's proposal, as observed by Barrett and Walsham (2004). Thus, the very nature of the 'relation' to which the relational view refers (Lee & Schmidt, 2018) is still under debate.

2. *Making infrastructure visible*: Since infrastructure is considered to reside invisibly in the background (Star & Ruhleder, 1996), making infrastructure visible is seen to be a precondition for exposing power asymmetries and biases inscribed into infrastructure, as well as for involving users in its design. However, there is disagreement about how to achieve this end. Infrastructure inversion (Bowker, 1994; Bowker & Star, 1999) is a popular strategy (Karasti & Blomberg, 2018), while in participatory design approaches to infrastructure development, breakdown plays this role (Pipek & Wulf, 2009; Jackson, 2014; Karasti, 2014; Ludwig et al., 2018).

3. *The scale of infrastructure*: While the literature does not generally require that infrastructure be a large-scale phenomenon (Pipek & Wulf, 2009), it is typically characterized as such (Star & Ruhleder, 1996; Star, 1999; Ribes, 2014). Large scale presents a methodological challenge for ethnographic research methods that are supposedly limited to local phenomena (Williams & Pollock, 2021, cf. Karasti & Blomberg, 2018). From a pragmatic perspective, it presents a problem for aligning the interests of heterogeneous user groups (Bossen & Markussen, 2010; Young & Lutters, 2017; Mikalsen et al., 2018).

4. *The ontological status of infrastructure*: Star and Ruhleder's characterization of infrastructure as a relation and not a thing has triggered a significant debate. In a recent assessment, Lee and Schmidt (2018) characterize

Star and Ruhleder's approach, particularly their dictum that infrastructure is a relation not a thing, as unintelligible. Some authors take the ambiguous ontological status of infrastructure as a characteristic of infrastructure itself. For example, Karasti and Blomberg (2018) speak of the "chimerical quality" of infrastructure and suggest that researchers should accept that infrastructures, as objects of inquiry, exist only partially (ibid., p. 257), and Parmiggiani (2017) has argued that researchers are co-constructing infrastructure in the process of studying it. Furthermore, the perspectival nature of infrastructure is debated. It has been argued that infrastructure means different things to different people (Parmiggiani, 2017; Karasti & Blomberg, 2018; Karasti et al., 2018), implying that infrastructure is some objectively describable entity but is just interpreted differently from different perspectives; others argue that "what infrastructure is" actually depends on a person's perspective (Plantin & Punathambekar, 2019).

5. *The move to the gerund*: The literature has increasingly embraced a processual view of infrastructure, manifest in the use of the gerund form 'infrastructuring' rather than infrastructure (Karasti & Blomberg, 2018). This usage goes back to a paper titled "How to Infrastructure" by Star and Bowker (2002) who, however, neither used nor defined the term in that paper. The term often denotes a process of connecting or integrating some technology and practice (Bossen & Markussen, 2010). However, other usages are noteworthy. These include infrastructuring as referring to user-driven rather than designer-driven infrastructure development (Pipek & Wulf, 2009); as coping with breakdown situations (Gui & Chen, 2019); as a form of collective action aimed at social innovation and democratic participation (Karasti, 2014); as an alternative design approach (Karasti et al., 2018); and as IT implementation in general (Mikalsen et al., 2018). Lee and Schmidt (2018) have therefore characterized the term as a loose heuristic which lacks a proper theoretical foundation.

## 2.4. Literature gap analysis

While the literature has enthusiastically embraced Star and Ruhleder's proposal, it has neglected important aspects of their approach. Close inspection of Star and Ruhleder's (1996) definition of infrastructure reveals six constitutive elements:

1. Infrastructure is an occurrence, a happening; it becomes manifest as a 'when', not a 'what'
2. It marks the moment when a global technology becomes transparent in use
3. It occurs when local practices and global technologies are modified in a certain manner
4. It has the character of a home
5. It is personal: it becomes a home for someone
6. This home is transient and requires work to persist

The literature so far has addressed elements 1 – 3 only, with 3 receiving most attention and 1 largely avoided if not repudiated. Elements 4 – 6 have not received any sustained attention. While element 5 suggests that the perspective of an infrastructure user might be important, the literature has explored mainly the perspectives of a researcher interested in uncovering traces of power asymmetries in infrastructure, or that of a professional or user designer interested in extending an infrastructure. Studying infrastructure from the perspective of a person for whom it is a home may have far-reaching but as-yet unexplored consequences for our understanding of infrastructure and the kind of involvement 'users' have in infrastructure development processes.

In this paper, we propose to approach Star and Ruhleder's seminal proposal, not by focusing on the relation between technologies and practices as in the past, but instead by focusing on the relation between a person and their infrastructure, namely that it is a home. To study what such a home entails requires a phenomenological approach to both developing a theoretical framework, and to collecting empirical data. Furthermore, our theoretical framework must conceptualize how extant technologies and practices can become a part of the kind of holistic nexus of familiar entities that would provide comfort, security and purpose implied by infrastructure as a home. We address these requirements in the next two sections.

## 3. Theoretical Framework

In *Being and Time* (Heidegger, 1962), Heidegger's radical point of departure from tradition was to build his philosophy on an analysis of everyday human absorption in purposeful activity, which he terms *being-in-the-world* (ibid., p. 53), in contrast to the usual Cartesian dualism of a thinking subject who deliberates on a separate external world (Spinosa et al., 1997). This orientation to how people normally dwell in their world makes Heidegger's phenomenology ideal as a theoretical framework for theorizing infrastructure as a home for a person.

The hyphens of being-in-the-world denote that this most basic mode of human existence entails an intimate and holistic relation of people to their world. We begin by giving a brief account of this holistic relation and reveal it as being at home in a familiar world. We then demonstrate that being-in-the-world is an active form of interpretation taking the form of a hermeneutic circle, which we will later use in the empirical part. Finally, we

return to Star and Ruhleder's (1996) proposal from this Heideggerian perspective and reconceptualize infrastructure and infrastructuring on this basis.

### 3.1. How Heidegger conceives a person's relation to their world: Being-in-the-world

Heidegger does not treat people as corporal human bodies; his focus is on the characteristic way that people *are* in their world, what he calls their *being* (Heidegger, 1962, pp. 1-15). This differs in essential ways from the way that a rock, for instance, is in the world. Firstly, people are always striving, especially to become some particular kind of person. This is because people are oriented to the future in a way that the rock is not. Their existence, in a sense, is always being *thrust ahead* of them, which Heidegger calls *projection* (ibid., p. 185). This striving or projecting is more than just desiring: what they strive for is a particular kind of existence that, while never really achieved, will define essentially who they are. Heidegger terms this their *for-the-sake-of-which* (ibid., p. 116), and it also provides the basis for how they understand their world (ibid., p. 182).

Secondly, people are 'grounded' in a way that a rock is not, which Heidegger calls their *thrownness* (ibid., p. 174). People find themselves *always already* in a world, not in the sense of being *in* a certain location, but as already having a multitude of on-going worldly *involvements*. Being thrown into a world of things and others means that what the person might conceive of striving for, has to a large degree already been decided by the society they were born into, or by the practices they have later given themselves over to. On the other hand, thrownness gives the world a certain familiarity and solidity (ibid., p. 173). People *already* know their way around this world and so can encounter entities and be affected by them. Consequently, things and others *matter* in a way they cannot for a rock (ibid., p. 177).

This in turn means that people do not encounter familiar things around them as meaningless *objects* separate from their own existence. Rather, they 'take them in hand' as *equipment* for some task, in order to fulfil some project, that itself forms a part of their own existence. Equipment, as distinct from an object like a rock, is always involved in a chain of *in-order-to* references (ibid., p. 97) to other equipment, tasks and purposes forming an inseparable *referential whole* (ibid., pp. 115-119). Furthermore, these in-order-to references ultimately terminate at the for-the-sake-of-which the person exists and uses equipment, which we met above.

So far, we have spoken of 'people' in general. For these people who share a for-the-sake-of-which and encounter equipment in characteristic ways, Heidegger uses the term 'the they' (ibid., p. 165). But what if a particular such person asks: "who am I?". Heidegger argues that for the most part – in everyday involvements – I *am* just as they *are* (ibid., p. 167). In other words, most of the time we shrink away from our own 'self' and fall back under the sway of a 'they self', particularly when we are consumed by our everyday activities, projects and goals. The payoff is dwelling in the familiar homeliness of everyday public familiar life with others. What we are then 'in' is Heidegger's notion of 'world'. A person's world is the totality of their understandings of how to encounter and use equipment and how to negotiate inhabiting a public world with others. This holistic way that people are always involved in and defined by their world, is Heidegger's notion of being-in-the-world.

We can enquire how a person in this most basic mode of existence would experience being-in-the-world. By virtue of the holistic nature of equipment, their enviroing world would not be encountered as a discrete collection of individuated things and others, but rather as a referential whole of in-orders-to (equipment), ultimately referring to and serving their for-the-sake-of-which (identity and purpose). However, by virtue of the familiarity of equipment (ibid., p. 97), this world of equipment and purposes would be largely withdrawn from explicit attention. Furthermore, their own sense of self would be lost to practical absorption in tasks and goals, rather than an explicit for-the-sake-of-which. In short, the person would be at home in a familiar world.

### 3.2. Being-in-the-world as active interpretation

Heidegger views taking up and using equipment as an act of interpreting one's world (ibid., p. 189). It is not a mental or intellectual interpretation: it is interpreting by doing – of finding out what something 'is' by putting it to use, ultimately in support of (for the sake of) one's own existence. Heidegger calls this active interpretation *discovering* an entity *as* equipment (ibid., p. 117).

Projection and thrownness are then two contrasting acts of such active interpretation. Projection is the act of discovering new entities as equipment on the basis of some *possible* way of being oneself, while thrownness is the act of squaring any new interpretation with the material and public world that the person *already* inhabits. Projection is rejuvenating, while thrownness is conservative. But they are not really separate because being already delivered over to some particular shared way of being in a public world (thrownness) provides the *basis* upon which any understanding of self can be projected, while projection of self provides an understanding of the referential whole of equipment and the for-the-sake-of-which that *constitute* the world. Thus, projecting and thrownness have a certain circularity, depicted in Figure 1. They form a *hermeneutic circle* (Heidegger, 1962, p. 194; Gadamer, 1989, p. 270) in which each is the interpretive pre-condition for the other.

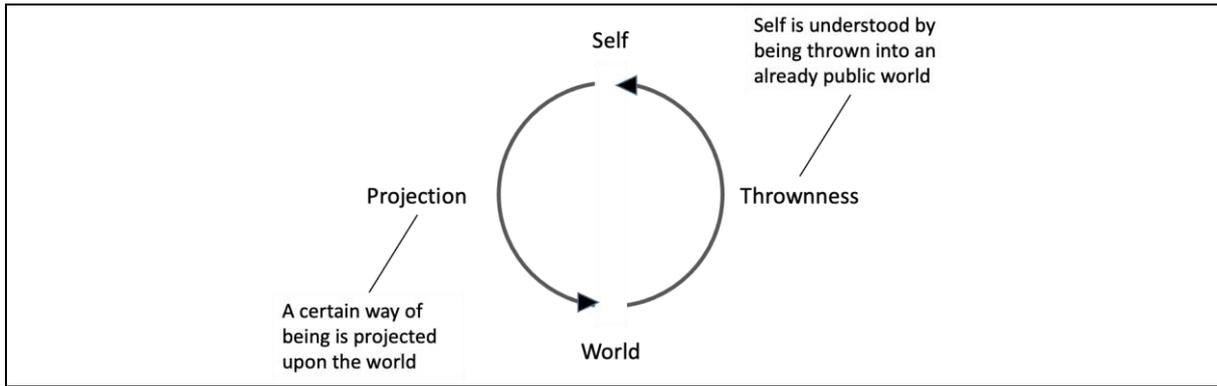


Figure 1. The Reflexivity of Projection and Thrownness

However, because this interpretation is active the hermeneutic circle plays out over time. Figure 2 elaborates the separate moments of projection and thrownness in such an active interpretation (which will be used later in the empirical part). Starting from the top of the circle, an understanding of how equipment hangs together [1] actively pre-conditions the discovery of an entity as equipment [2], which in turn is the precondition for actively putting equipment to use [3], which in turn is the pre-condition for encountering the serviceability (or lack thereof) of equipment for a task at hand [4], which in turn is an active pre-condition for coping in a public material world [5], which in turn is the basis for having an identity and purpose [6], which in turn actively pre-conditions projecting an understanding of how equipment hangs together [1]..., and so forth.

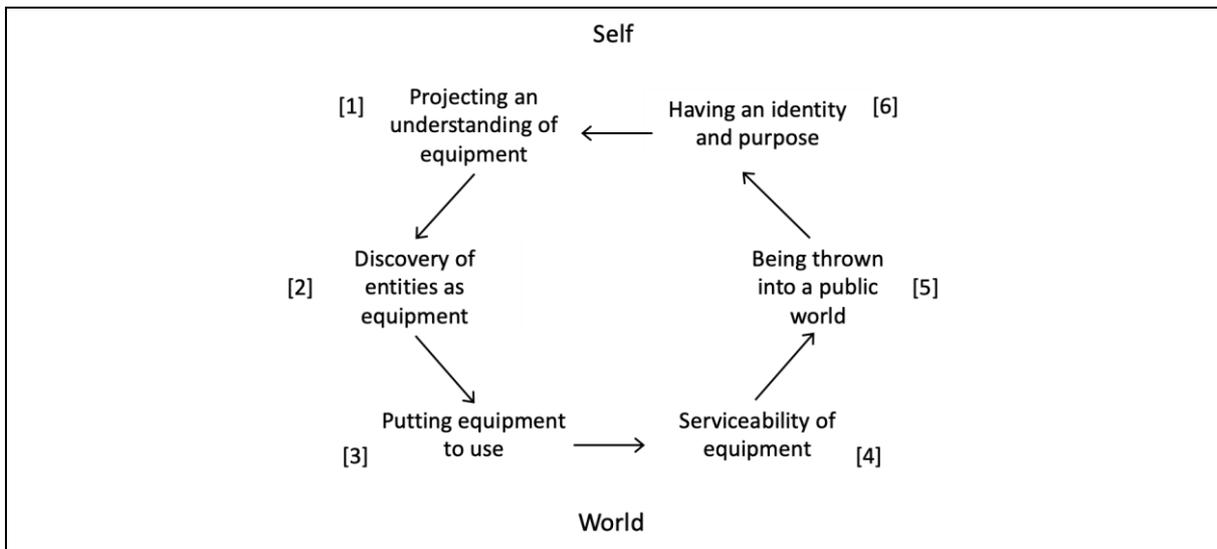


Figure 2. Moments of Active Interpretation in the Hermeneutic Circle of Being

On rare occasions the hermeneutic circle may be broken. When this happens, the world loses its usual familiarity, and the self can be loosened from the grip of the ‘they’. The resulting ‘uncanniness’ of the world (ibid., p. 233) manifests as a mood of anxiety (ibid., p. 229). A person may let this pass and return to the hermeneutic circle. Or else they may face anxiety resolutely and come to ‘own’ their self with renewed authenticity. They then return to the hermeneutic circle understanding the world in a new light. We will illustrate instances of this in the case analysis later.

### 3.3. Star and Ruhleder’s proposal from a Heideggerian perspective

With the insights of the previous sub-sections, we can now return to Star and Ruhleder’s (1996) definition of infrastructure (see literature section, numbering as there) and reframe it from our Heideggerian perspective: Infrastructure occurs (1) when a person is at home in their world (4) in the transparent use of some technology (2) as equipment toward the identity and purpose of some practice (3), and this at-homeliness is both personal (5) and is brought about by active interpretation (6).

First, note we are not assuming that the person is already enrolled in the practice in question. This is ambiguous in Star and Ruhleder’s wording. If the person were already enrolled in the practice, simply adopting the technology might produce a home. In that case infrastructure might be created by putting the technology in some kind of relation to an existing practice, as assumed by many authors (see the literature section). However, the

more general case is that an unfamiliar new technology will be closely associated with certain practices for its use that are also unfamiliar. Indeed, this was true for Star and Ruhleder's (1996) actual case, and our own, and may be quite general. Therefore, in what follows we take both the particular technology and the particular practice as exogenous.

Second, note that for Heidegger a technology is not the same as a person's equipment and, similarly, a practice is not the same as a person's identity and purpose (for-the-sake-of-which). It is the transparent use of *equipment* toward an *identity and purpose* that constitutes a home for a person according to Heidegger, not the technology and practice, as such. A particular technology only becomes a person's equipment, and a particular practice only becomes part of a person's identity and purpose, when they have *been brought into* the person's world by the action of the hermeneutic circle.

Third, the person's identity and sense of purpose will be incrementally changed by the process of bringing the technology and the practice into the hermeneutic circle. This is a feature of interpretation more generally: the interpreter's self-understanding is always affected by an act of interpreting (Gadamer, 1989, p. 371; Ricoeur, 1981, p. 105). Further, by virtue of the thrownness of being-in-the-world, others who share the person's world not only legitimate any changes but will also be incrementally changed by them. This is because equipment and identity are part of a public world. Together, these two points mean that the process of bringing a technology and a practice into a person's world really has no end: as the person's self and their world are incrementally changed, so further new technologies and practices come onto their horizon.

### 3.4. Infrastructure and infrastructuring

Our Heideggerian analysis of Star and Ruhleder's proposal thus leads us to two conclusions.

1. Infrastructuring can be understood as the process of accommodating particular technologies and practices into a particular person's world through the dynamics of the hermeneutic circle. But this process is never complete because the person and their world move on *as a result of* the process. This makes infrastructuring a *strong* process, one of continual becoming (Tsoukas & Chia, 2002). Furthermore, this makes infrastructuring an active form of *interpretation* by a person of the given technologies and practices *as* part of their world. Therefore, infrastructuring is best studied from the person's inhabited point of view. Infrastructuring is a definite but unending becoming of a person and their world. This is just being-in-the-world as conceived by Heidegger.
2. Heidegger's analysis of being-in-the-world implies that in the most basic mode of existence, every person is at home in their world. Therefore, Star and Ruhleder's claim implies that *every person's world is their infrastructure*. Their infrastructure has *already* occurred for them and continues to do so. Therefore, infrastructure is not the unachieved outcome or goal of infrastructuring. Infrastructure is continually 'there', but it is also being changed as the person infrastructures their world. Furthermore, infrastructure is not a relation between particular technologies and practices because these must lose their identity as these particular technologies and practices to become equipment and identities for the person. Infrastructure 'is' only in relation to a particular person (or way of being). These characteristics would be distinctly odd for a technical thing. But they are quite natural for a *world* as conceived by Heidegger.

We conclude that by applying Heidegger's phenomenology to Star and Ruhleder's relational view of infrastructure, infrastructure and infrastructuring are revealed to be equivalent in nature to Heidegger's 'world' and 'being-in-the-world', respectively.

## 4. Method

In the previous section, we conceptualized infrastructuring as the work of accommodating particular technologies and practices into the world of a particular person. We now consider how we can make empirical observations of infrastructuring from a particular person's inhabited point of view.

### 4.1. General remarks about suitable research subjects and setting

We first argue that novices to a profession undergoing early practical on-site training provide potentially ideal research subjects and settings to give a first-person account of infrastructuring as it happens.

1. *The situation of a novice provides a manageable instance of infrastructuring.* The novice initially encounters the technologies and practices of their chosen profession on the horizon of their world. They may have some familiarity with them as part of their general or textbook knowledge. However, the technologies and practices of the profession at this stage are not part of their own infrastructure because they are not yet equipment that is transparently available, nor part of the identity that gives meaning to what they do. Their task is precisely to make these technologies and practices part of their world, toward "doing, understanding and feeling" in the way that a competent practitioner does (Reckwitz, 2002, p. 249-250).

This process might be understood as one of novices *learning* the profession by apprenticeship. But characterizing the novice experience as learning is an account of what happens from the perspective of an *external observer*. From the novice's own person-centered view, novices are simply doing, understanding and feeling how they generally do in their own world except that certain technologies and practices on the horizon of their world are in the process of becoming a useful and meaningful part of their world. In other words, what is learning from an outside observer's perspective is *infrastructuring*, as we have defined it, from the novice's own person-centered view. Therefore, a novice's own account of the process of becoming competent in a profession will provide an account of infrastructuring their world from their inhabited point of view.

2. *Novices have a view of the setting that makes them good reporters.* Novices are potentially ideal reporters of events of an established practice because they view it from a 'sweet spot' between two disadvantageous positions (Reimers et al., 2013); that of 'old hands' at the practice and that of disinterested observers. Old hands are in many ways *blind* to what they do. Their knowledge has become embodied, and they often cannot give an explicit account of it, or they do not even 'see' the most familiar occurrences because their tool use has withdrawn from attention. At the other extreme, a person who has no practical expertise may see everything that happens, but its meaning is quite *opaque* because they have no access to the meanings reproduced in the performances they observe. Consequently, they will not know what is relevant to report.

3. *The frequency of reportable events fits the research timescale.* The pace of events that occur for a novice, especially challenging disruptions, is appropriate for maintaining interest in recording events. According to Lave and Wenger (1991), enrolment of any person in a practice is an on-going apprenticeship to others, so it is likely that experiences of novices and more competent practitioners differ in *degree* of novelty and frequency, rather than in *kind*. Both greater frequency and novelty work positively for obtaining empirical data in a reasonable research duration.

## 4.2. Research design

To capture a person-centered view of infrastructuring, we asked apprentice-novices to maintain a reflective learning diary (Steiner van der Kruk & Schellhammer, 2014), a technique widely used in academic higher education (Moon, 2006). Our research site was a community pharmacy in Germany and as such offered a full range of activities of the profession for our study. We recruited three pharmacy students – so-called 'PhiPs' ('pharmacists in practical training' in German) – who agreed to write a learning diary for one to three months. PhiPs have concluded the academic part of their studies and while most have done an internship in a community pharmacy during their studies, it is only when they work as PhiPs that they assume actual responsibility for treatments and dispensing drugs.

Prior to their start in the pharmacy, they attended a workshop on techniques of reflective diary writing, using material provided by Moon (2006), and after the first week, received feedback on their writing so far. Completed diaries ranged from 8,700 to 16,600 words. For this they were compensated with 200 Euros per month. Two PhiPs structured their diaries strictly chronologically while one switched after 8 days to chronological ordering within themes. They all used color codes to indicate comments added later.

Our research design exploits the unique position of novices discussed above. PhiPs are legitimate peripheral participants in the profession (Lave & Wenger, 1991). They are legitimated as would-be pharmacists through their academic training and participate in the practice as pharmacists. However, they also have the peripheral position as apprentices with special possibilities of observing and querying normally denied to practitioners. We asked them to diarize their own discoveries of how things are done properly in a pharmacy. Since learning is a social phenomenon, we asked them to pay attention to cues such as misunderstandings, advice, critique, praise, and reprimanding. In the second and third month they could also annotate their earlier entries on the basis of their developing expertise.

## 4.3. Data analysis

Of the three participants, diarist 3 (pseudonym 'Phil') provided a detailed first-person account of his own practical problem solving and independent learning. He also diarized and dated his own reflections, both on his on-going experiences and on his earlier comments and misconceptions. As a result, it was clear that his diary entries provided a suitable person-centered account of infrastructuring. The other two diarists produced accounts that were not suited to such an interpretation. Although they described *what* they learned, they did not provide adequate detail of confronting problems with equipment or struggles with their own identity. In fact, their reports were matter of fact as if they were reporting as outsiders to their own learning experience.

We therefore proceeded to reconstruct Phil's infrastructuring experiences only. To capture both the holistic experience and the contextual richness that characterize infrastructuring we reconstructed Phil's progress in the spirit of a narrative inquiry (Chase, 2013). We scrutinized Phil's account for descriptions of ways of doing, understanding and feeling that reflected both an individual style (projection of self) and a need for social accountability (thrownness into a public world). Proponents of narrative inquiry characterize narratives as "... a

specific telling of events, with a focal actor and theme, embodying the values of the social context in which it is told” (Pentland, 1999, p. 4). Such a story-like presentation can keep intact the legitimacy and accountability of individual actions as experienced by a participant (Czarniawska, 1997; Pentland, 1999). Moreover, going through various iterations of the narrative allowed us to develop and refine our theoretical understanding of the empirical material, thus making use of the analytical potential of narrative inquiries (Czarniawska, 2004).

## 5. Case Narrative

In this section, we use Phil’s diary to reconstruct his dealings with the unfamiliar technologies and practices of the community pharmacy practice in the form of a narrative inquiry. We begin with a short description of Phil’s first day in the host pharmacy which foreshadows the main themes of his diary writing. We then reconstruct a narrative of Phil’s journey toward competence into four distinct streams of activity: sorting-in drugs; reordering drugs; updating expiry dates; and recalculating prices.

### 5.1. Phil's first day in the pharmacy (May 2nd)

Phil’s very first assignment, for some time to come, is to concern himself with processing incoming drugs. After having spent just one hour in the pharmacy he is instructed how to sort newly arrived drugs into drug storage drawers. Initially, it takes him some time to find the right compartment in the drawers, which are organized alphabetically. He is told that the pharmacy works with a ‘card system’ but initially he has no idea what that means. But as he begins to sort drugs into drawers, he discovers that there are white and yellow cards sitting in a cardholder attached to each compartment in a drawer; each compartment holds one particular drug. He discovers that every time a drug is sold the white card is removed and placed into a special box. Removing the white card reveals a yellow card underneath, so that the yellow card shows visually the compartment where a drug is missing.

When new drugs arrive, he checks on the computer whether the drug was actually ordered and then places it into its assigned compartment. He also takes the white card that was placed into the box when the drug was ordered and puts it back into the card holder so that it covers the yellow card again. He wonders when the white card has to be taken out; only when the compartment is empty or when one package is removed? When sorting in drugs, he is sometimes instructed by the computer to update the expiration date. He wonders how the computer “decides” when this should be done. He also notices that sometimes the computer wants him to recalculate prices but seemingly no one can explain to him how to do this; instead, colleagues reply that this is “a bit complicated” and they will do it quickly for him.

### 5.2. Sorting-in drugs

On his first day (May 2nd), Phil realizes how to quickly sort the drugs into drawers; open the drawer where you think the drug should be placed and look for a yellow card. This indicates that a drug has been ordered and now needs to be placed into the corresponding compartment (diary entry, May 2nd, evening). While Phil had realized earlier (at lunchtime when he made his first entry) that the card system affords quickly spotting which compartment a drug needs to be placed in, he had not yet ‘built’ that knowledge into his actions; instead, he had used the alphabetical ordering of compartments to locate the correct compartment. In the evening of the first day he reports that his newly acquired knowledge had become performative:

*“When sorting drugs into their compartment, I now open the drawer which I assume contains the correct compartment, look at its inner side whether a [white] card is missing (in that case, the yellow card is easily recognizable) and do not have to tediously go through the alphabetical ordering of all drugs in that drawer. After I had realized this principle, sorting drugs into drawers is much faster.”*

On his first day, Phil made a mistake when sorting a newly arrived drug into the drawer. He put it into the wrong compartment and placed the white card which belongs to that drug over the yellow card that belongs to a different drug. This caused quite a problem since the compartment of the drug that properly belongs there had ‘disappeared’. It took Phil and the pharmacist some time to figure out what had happened, and they were on the brink of setting up a new compartment for that drug. After this experience, Phil decides that every time he places a drug into a compartment he will compare the standard product code (PZN)<sup>1</sup> printed on the white card with that printed on the yellow card to avoid repeating the same mistake. In this manner, mistakes can be “100% ruled out” (May 2nd, evening). This is also the first time that Phil mentions the PZN.

Commenting on that episode later (May 15th), Phil notes that when he makes a card he now verifies the PZN code by placing the card in a card reader (which reads the code punched into the card) to ensure that the PZN is correct. The reason is that Phil later realizes a possible problem with the method that he had discovered on the

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<sup>1</sup> The PZN code (Pharmazentralnummer) uniquely identifies every registered medicine in Germany as a combination of a specific drug and package size. In Phil’s diary this is sometimes referred to as a ‘FAM’.

first day of comparing the PZN codes printed on the white and the yellow cards; the codes on the cards themselves might be wrong. To avoid this possibility, a further routine of verifying the code is necessary.

On his 18th day (May 24th) Phil writes that he had to process some ‘novel [G: Novitäten] drugs’ for which he had to create new cards. Reflecting on that entry almost a month later (on June 20th) he writes that upon sorting-in the ‘Novitäten’ he again noticed how convenient the card system is since it “reserves” one particular compartment for each drug. He compares this with the situation in another pharmacy where he had done an internship previously and which did not use the card system. The card system not only indicates where drugs are to be found but also where drugs temporarily not kept on stock have “their place”, as indicated by a yellow card in the card holder. Hence, it is easy to sort-in that drug should it be re-ordered again in which case it would be treated as a ‘Novität’.

### 5.3. Reordering drugs

On his first day (May 2nd), Phil wonders when the white card has to be “pulled”; “always” (every time a package is taken out) or only when the last package is removed and the compartment is empty? Two weeks later (May 15th) he comments on this passage: “The punch card must be pulled every time when a FAM [particular drug] is ordered irrespective of how many FAMs are still in storage.”

However, a couple of days later (May 23rd) Phil writes that he had asked the pharmaceutical assistant to explain to him when exactly he has to “pull” the white card. “Obviously” this is the case when the compartment is empty, when the last unit has been dispensed. In contrast to his earlier comment, he now writes that the white card must be pulled also when there are only a few units left and the drug is sold relatively frequently. To assess this matter, he looks at the back of the white card to learn how often this drug has been ordered over the past few months since every reordering is indicated by a stroke on the back of the white card. If still in doubt, he can also check the number of sales over the last few months on the computer. He notes that it seems there are other methods to decide whether the white card has to be pulled. But he prefers to use this method because it was the first method he learned and this one appeared most logical to him. In the evening of that day he adds an explanatory note; the back of the white card can indicate only the frequency of orders, not sales. Hence, to really know how often the drug has been sold he needs to consult the computer. It thus turns out that the matter is more complicated than Phil had thought earlier when he wrote that the white card has to be pulled “always” meaning when no package is left or when a unit is sold.

On his 22nd day (May 29th) Phil writes about a conversation with the pharmacist regarding the factors that create customer loyalty. He had believed earlier that the quality of consultation was the primary consideration for both customers and pharmacy personnel, but the pharmacist now explained to him that the main factor is the service level enabled by the inventory. In other words, customers are likely to buy from another pharmacy when the drugs they need are not available from stock. Phil was quite disappointed about this, and notes that the pharmacist was a bit amused about his rather idealistic views. Nevertheless, this episode shows how Phil has broadened his understanding of the ordering activity beyond the technicalities of ordering and the routines required for ordering the correct amount. He now understands the centrality of these processes for the wellbeing of a pharmacy.

### 5.4. Updating expiry dates

On his first day, Phil wondered how “the computer knows” whether or not the expiry date has to be entered when receiving drugs. This question occurs to him when he reflects in the evening on his first diary entry (May 2nd). That entry described how the computer greatly facilitates the work of sorting-in drugs since it prompts him to enter the expiry date only for those drugs which are reordered (replenished) but not for those which are specifically ordered for a customer. These latter drugs are not sorted into the drawers but are laid aside since customers are likely to pick them up on the same day. This contrasts with the practice in another pharmacy where he had previously worked for a short-term internship. There, all newly arrived drugs were sorted into drawers whether or not they were specifically ordered for a particular patient. He is “greatly enthused” by the present practice because it saves so much unnecessary labour. However, it is in this context that he wonders how the computer “knows” whether the expiry date has to be updated and thus, by implication, whether the drug needs to be sorted into the drawers or not. He is especially puzzled by the observation that the computer does not prompt him to enter the expiry date when a drug is “completely unknown” (to the computer). This is puzzling because the need to enter an expiry date in this case seems quite obvious: “... after all, I needed to set up a new compartment and a new card [for these drugs]” (May 2nd, evening).

On his second day (May 3rd), Phil encounters another puzzle regarding the task of entering expiry dates. Now he wonders how, when prompted by the computer, he can decide whether the expiry date proposed by the computer is correct or needs to be updated. The problem is that it is crucial to enter the nearest expiry date. When there is no package left in the compartment the expiry date is that of the newly arrived drug, otherwise he must check all expiry dates of the packages in the drawer. The problem boils down to how to know whether there are packages left in the drawers. In principle, he would have to check every drug’s compartment to see whether there are

packages left to decide this, but that creates much unnecessary work and “running around”, especially given that in most cases the pharmacy keeps only one package in stock. It seems that the pharmaceutical assistant can avoid this but is unable to tell him how she does it, indicating that he will get a feeling for this over time. As a result, Phil feels very “insecure” when he has to update an expiry date.

This issue continues to trouble Phil. He writes (May 7th) that he has been quite “annoyed” because he had to frequently go to the drawers to check whether there are still packages left in order to decide whether to overwrite the expiry date suggested by the computer. He also wonders why he cannot directly check the inventory on the computer since every sale and arrival of a drug is recorded on the computer. He again writes (May 8th) how annoying the issue is. On that evening he adds:

*“Up to now I never had the feeling of knowing at first glance: ah, of this drug we only store one package, so I can overwrite the expiry date. I just always sit around [thinking], hum, I know [this drug], it is not replenished soooooo frequently, it is not prescribed soooooo frequently, do we still have a package on stock? Hum, no idea! Get up, walk up to the drawer! I wonder when a feeling will become manifest [regarding] how many packages are stored [of a particular drug].”*

He inserts comments (May 8th) to his earlier entries (May 3rd, 7th, and 8th) on this issue that indicate he has now solved this problem; the reason the assistants know when to update the expiry date is that they have also placed the order in question. Upon placing that order, they will have checked how many drugs still remained in the compartment, whether it was worth ordering more, or whether to discontinue replenishing that drug. That is, when reordering a drug, one questions how many packages are still left in the compartment; similarly, when dispensing a drug one pulls the white card, places it into the box, and also notices how many drugs are still left in the compartment; thus one “naturally” knows that fact when the ordered drug arrives. Alternatively, Phil lastly notes, he could consult the back of the white card which indicates how often the drug in question has been ordered in the past. If the drug has been ordered only once every second month, it is “very very likely” the pharmacy will keep only one unit of it in stock, and since it now has been reordered, there will be no package left in the drawer. By contrast, if the drug had been reordered three times per month, then it is quite likely that there still is a package in the compartment.

## 5.5. Recalculating prices

On his first day, Phil also wonders how to recalculate prices because occasionally the computer “grumps” that this needs to be done but no one could explain to him how to actually do it. Instead, either the pharmaceutical assistant or the pharmacist would do it “quickly by themselves” should such a prompt occur. They explain that this is “a bit complicated and everyone does it slightly differently”. In the evening of that day (May 2nd) he adds that he has observed that the assistant and the pharmacist use different computer commands for recalculating prices. However, his puzzlement does not result from ignorance of the computer program, but from ignorance of the “theory behind” the need for such recalculation:

*“I have indeed noticed that the pharmaceutical assistant and the pharmacist use different [computer] commands. However, to me the theory behind this is not quite clear because the price is already fixed when ordering the drug; so does the [re-]calculation of the price only concern the selling price??? I have been quite confused but did not have the heart to ask because this issue did not seem so terribly important to me after all.”*

The issue is troubling because it gets in the way of smoothly processing incoming drugs: “If only I knew how to recalculate prices I could process incoming orders on my own without having to ask a single question” (May 3rd).

Two weeks later (May 15th) Phil appears to have worked out the issue; purchasing prices and selling prices of prescription drugs are fixed but selling prices of OTC (Over the Counter) products are determined by the pharmacy. While selling prices for OTC products are usually shown during the ordering process, they may be out of date and need recalculating, usually by lowering them. Thus, Phil had to work out the differences in institutional regimes applying to OTC and prescription drugs, the “theory behind” the recalculation puzzle.

On his 18th day (May 24th) he writes that since the pharmacist had shown him how to recalculate prices he can now do so for the majority of incoming orders, but still does not feel very confident about this:

*“Since I presently still feel a bit insecure when calculating prices, I tell the pharmacist or the pharmaceutical assistant how I have calculated a price in each case in order to be safe, but up to now I have always done this correctly.”*

Almost two months later (July 21st) he adds a comment to this entry which suggests that he does not really recalculate prices himself. However, he can now tell if a recalculation is necessary; it is needed if the purchasing price has changed, or if the pharmacy has not yet sold that particular product, but not when a price has already been communicated to the customer.

## 6. Case Analysis

In the narrative (previous section) we find two distinct threads to Phil’s activity that display distinctly different characteristics. The first thread, which we will call *base-line coping*, runs through the whole diary (although it is mainly narrated in the sections on ‘sorting-in drugs’ and ‘reordering drugs’). It is characterized by the following 4 attributes:

- Problems encountered are repaired promptly;
- Repair uses additional equipment near-by, or help from others;
- Overall familiarity with equipment remains intact;
- Emotional reaction is minimal.

The second kind, of which there are two instances (narrated in ‘updating expiry dates’ and ‘recalculating prices’) we will call *anxiety-imbued coping*, and they contrast strongly on all attributes:

- Certain problems resist solution for an extended period;
- Equipment near-by and help from others offer no immediate solution;
- Equipment loses its familiarity and becomes ‘uncanny’;
- Anxiety grows about his competence.

In the following two sub-sections we will show how these two types of coping can be understood in terms of the theory we presented earlier. We will then show that the outcome of each kind of coping is a particular form of infrastructuring.

### 6.1. Base-line coping

We will interpret base-line coping as enacting the hermeneutic circle of normal everyday being. We then show that in this kind of coping Phil’s being-in-his-world remains within the circle by exploiting the interpretative leeway it offers. Finally, we will show that the outcome of base-line coping is already a particular kind of infrastructuring. For reference, we present the hermeneutic circle again in Figure 3.

Phil is told that the pharmacy uses a ‘card system’. Initially he has no idea what this means, but when he begins to sort drugs into compartments, he encounters white and yellow cards. The earlier talk of a ‘card system’ has prepared him to attend to these cards as possible equipment. We interpret this as an initial projection of an understanding of his equipment [1], where something like a card will play an important role. Soon Phil discovers how to use yellow cards to quickly find the right place for a drug in a drawer. Thus, based on this prior understanding, he discovers yellow cards as equipment [2]. However, initially he does not put the yellow cards to use for this but instead relies on the alphabetical ordering of drugs. Thus, discovering equipment is distinct from putting it to regular use. When he does take up using the yellow cards [3] he expresses satisfaction with the convenience they afford [4], indicating they are now becoming part of his world.

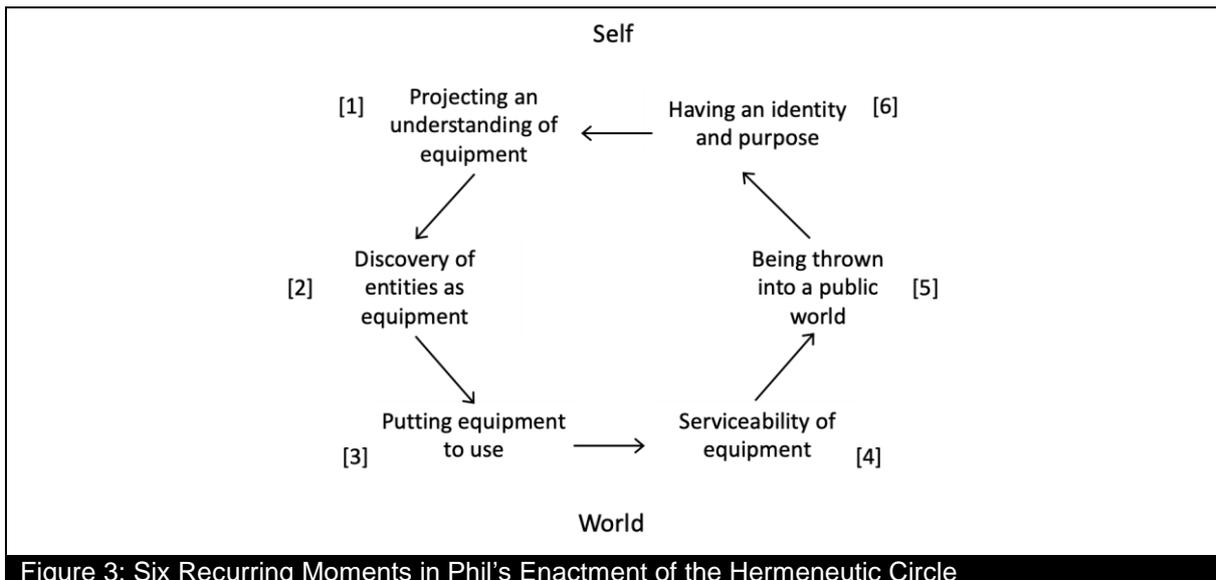


Figure 3: Six Recurring Moments in Phil’s Enactment of the Hermeneutic Circle

However, Phil later encounters a situation where this equipment apparently fails: the compartment for a drug package Phil is holding has ‘disappeared’. It takes a little time for Phil and the pharmacist to resolve this issue; a yellow card had been covered by the wrong white card. This is a case where the serviceability of equipment [4] is negated (for a while). That the pharmacist gives time to help him, makes the importance of the matter clear to

Phil. The result is that Phil discovers white cards as distinct equipment for marking that a given drug (identified by the yellow card) is in stock. Thus, proper use of equipment needs to be ratified and possibly corrected by the others as part of being in a public world [5]. In a later conversation with the pharmacist, Phil learns that in some respects it is more important for a pharmacist to be a good inventory manager than to give good pharmaceutical advice to patients. Phil expressed disappointment, but this modification of his identity and purpose [6] is necessary for an appropriate re-projection of his understanding of equipment [1] in the service of this identity.

The issue of the ‘disappeared’ compartment provides further insights into the nature of coping in this mode. First, solving this problem leads Phil to discover white cards as equipment distinct from the yellow cards. Soon PZN codes printed on the cards are discovered as further equipment for checking whether the correct white card is placed over a given yellow card. Two weeks later, Phil discovers a possible problem (the wrong PZNs might be printed on white or yellow cards) along with equipment that will remedy it (the PZN code on a newly made card may be checked using the card reader). Similarly, successive discoveries are made about the marks made on the reverse side of white cards. Thus, problems with current equipment use [4] lead to the discovery of chains of further equipment [3]. This means that new equipment discovered is always ‘near-by’ in the sense that it has a practical connection to equipment previously discovered. In this way further discovery can occur within the normal everyday mode of being. Although the evidence is incomplete, these successive discoveries of equipment and failures of serviceability appear to result from successive enactments of the hermeneutic circle. At the start Phil encounters the ‘card system’ just as a meaningless term; by the end he understands it as a structured whole of multiple equipment that does something quite unique: it reserves a place for a drug even when the drug is temporarily out of stock.

Second, while this event conforms with the traditional notion of a ‘breakdown’, the matter-of-fact way it is reported in Phil’s diary suggests that encountering such situations and working out solutions is considered a *normal part* of work. Furthermore, the way that solutions are found ‘near-by’ argues against any notion that the ‘card system’ as a whole becomes available for explicit analysis in such an event.

#### *Exploratory infrastructuring*

When problems occur, they are repaired with equipment near-by in the normal everyday mode of being, indicating that Phil is at home in his world *despite* interruptions. On the other hand, *because* interruptions occur, Phil comes to discover more equipment and understand his identity with more nuance. This is possible because the hermeneutic circle offers a certain ‘leeway’ in how it is enacted on different occasions. Thus, as Phil discovers more equipment and updates his identity he explores and maps his world *outward* from his current understandings. In doing so, he also brings *into* his world the prescribed technologies and practices of the pharmacy profession. This means that the most basic absorbed way of being-in-the-world *already results in a form of infrastructuring*. We term this *exploratory infrastructuring* to denote how everyday being-in-the-world has the unintended consequence of exploring and mapping the limits of equipment-use and identity *outward*, and therefore, has the effect of bringing specified technologies and practices on the horizon *into* one’s infrastructure world.

## **6.2. Anxiety-imbued coping**

The stand-out feature of anxiety-imbued coping is the role that ‘uncanniness’ of the world and anxiety on Phil’s part play in the events, including their resolution. This indicates that ‘world’ and ‘self’ must be a part of any explanation of this kind of coping and, therefore, it cannot be a straight-forward case of enacting the hermeneutic circle. We will interpret these episodes as cases of anxiety-induced breaks of the hermeneutic circle, as described in the theory section. We recap the first episode and then offer such an interpretation of it.

The first episode relates to whether an expiry date must be updated on the pharmacy computer system when drugs are received. Phil initially cannot rely on any equipment already discovered to ascertain whether a package is in the drug compartment when prompted to update its expiry date. Therefore, when drugs arrive that may need their expiry date updated, Phil has to physically check whether the compartment already holds some of the drug packages. He can go on with the task at hand in this way, but he feels “insecure” and “annoyed” because his colleagues seem to “somehow” know whether there is a package left in the compartment but cannot tell him how. Thus, his equipment refuses to provide the support that he has come to expect of it to feel confident and competent. This situation also calls into question his own identity as a pharmacist because, unlike his colleagues, he has no clue how to acquire this knowledge. The issue lingers on. It appears early on (his second day) but Phil writes about it in detail twice more before he eventually works out the solution one week later. Phil realizes that those who do not find this issue a problem actually come from a different perspective on it; they have generally become aware of the stock in the compartment ahead of time, in the course of dispensing or ordering the drug. Consequently, they will generally know the contents of the compartment afterward, when receiving the drug. Upon this insight, Phil now incorporates this perspective into his own understanding when receiving drugs. On the basis of this new understanding Phil now also discovers previously unseen strokes on the back of white cards, indicating the frequency of past drug ordering, as further equipment for updating expiry dates.

The events above display a pattern which is also repeated in the second instance of anxiety-imbued coping ('recalculating prices' in the narrative). A situation is not repaired with equipment that can be discovered at near-by range (as it is in base-line coping). The world takes on a certain uncanniness because although the task can be completed, equipment does not offer expected support. Phil becomes anxious about his identity because it derives from his competence. Phil grapples with the problem resolutely. Incorporating another's perspective resolves the problem (completely in the first instance and in principle in the second). It is helpful to note the following points about this pattern.

First, equipment does not fail Phil completely – he has a workaround that uses equipment already discovered. This is why equipment feels 'uncanny' rather than completely unavailable. Secondly, the mood that Phil enters is not fear (of a threat from the environment) but anxiety (fear of the lack of solid ground to his self-understanding as a pharmacist). Thirdly, he could 'flee' from the building anxiety but instead resolves to confront it. Finally, it appears that the growing resolve to face the problem is what makes Phil open (Gadamer, 1989, p. 269) to *taking in* some other perspective and *owning* it. These observations justify the following interpretation of the two episodes.

#### *Emancipatory infrastructuring*

In the theory section, we mentioned the role that the mood of anxiety (Heidegger, 1962, p. 393) can play in derailing the hermeneutic circle of projection and thrownness. As a conclusion to the building sense of groundlessness of world (uncanniness) and self (anxiety), a discontinuous break in the self-reinforcing cycle of projection and thrownness can occur. A moment of authentic self-insight is thus made possible, which rewards the work of resoluteness in the face of rising anxiety. In our case, we interpret Phil's *taking in* an alternate perspective as such a moment of in-sight, which solves the problem (updating expiry date) by re-projecting how equipment discovered in apparently unconnected contexts (dispensing and reordering) hangs together as a larger whole (including strokes on white cards), and at the same time adds nuance to his perspective and identity (for-the-sake-of-receiving-*and*-dispensing-*and*-reordering of drugs).

As such, anxiety-imbued coping also has an unintended outcome of infrastructuring Phil's world. It provides another way that the horizon of Phil's world is expanded, this time by the fusion of the horizons (Gadamer, 1989, p. 370) of the new perspectives with his own. We term this *emancipatory infrastructuring* because Phil is able to transcend the myopia of his initial perspective and make connections between his perspective and those of others. Again, this brings the prescribed technologies and practices of the pharmacy profession into his infrastructure world, this time by remapping how technology hangs together in the service of a more multifaceted identity and purpose. Anxiety-imbued coping is compatible with base-line coping as shown by the availability of workarounds that employ equipment already discovered. As a result, we view emancipatory infrastructuring as complementary to and building upon exploratory infrastructuring.

### **6.3. Summary**

In sum, each of the two contrasting types of coping found in the case can be interpreted on the basis of our theory as producing distinct forms of infrastructuring. Base-line coping is a person's normal everyday way of being-in-the-world, which is to be actively absorbed with their immediate projects and goals. It is not emotionally challenging because it operates within the range of already discovered equipment and a received understanding of identity and purpose. But it is not static either, because routine repair of disruptions results in the discovery of further equipment near-by, which allows the person's horizon of understanding to be incrementally enlarged. The result is that technologies and practices that were initially only on the horizon of their world are *brought in* and made a part of this person's infrastructure. Consequently, every person is engaged in *exploratory infrastructuring* as a result of simply going about normal business in an attentive and responsive way.

By contrast, episodes of anxiety-imbued coping are instances of a more resolute and authentic mode of being-in-the-world. Here certain recurring, emotionally disturbing situations – rather than discrete disruptions – over some extended period create a mood where the person becomes open to a change of understanding of 'self' and 'world'. These episodes have a long build-up, resolved (if they are resolved at all) by the sudden in-sight that their own inhabited view of their world can be broader. The result is an expansion of the person's horizon, this time by fusing it with the horizon of some other's understanding. Thus, anxiety-imbued coping results in a distinct kind of *emancipatory infrastructuring* where the person is freed from a prior limited and short-sighted perspective on their own existence and equipment, meaning their infrastructure undergoes a discrete change. Exploratory and emancipatory infrastructuring are both ways of being-in-the-world, and as effortful (and complementary) ways of bringing technologies and practices into a person's world (their infrastructure) they conform to our interpretation of infrastructuring.

## 7. Discussion

In previous sections, we have presented an alternative perspective of infrastructure as a home for a person. In this section, we discuss the implications of this alternate interpretation of relationality for the existing infrastructure and infrastructuring literature which has largely neglected this part of Star and Ruhleder's (1996) original proposal. We discuss in turn two kinds of such implications. First, because our conception of relationality shifts the focus from the relation between exogenous technologies and practices to the relation between a person and their infrastructure, this implies an inversion of the priorities in several of the core debates in the literature. Second, our findings extend certain themes of the literature by clarifying key issues under debate. We conclude by presenting certain implications for practice.

### 7.1. Inverting priorities in core themes of the literature

First, the notion of infrastructure as a home for a person implies that infrastructure cannot be conceptualized as a relation between technologies and practices, as is predominantly done in the literature (Pipek & Syrjänen, 2006; Bossen & Markussen, 2010; Parmiggiani, 2017; Mikalsen et al., 2018). The reason is that a person is always already at home in their world *prior* to any particular technologies and practices becoming part of that world and being discovered as equipment and identity. The holistic understanding of equipment and purpose constituting a person's world, and thus their infrastructure, is the *basis* upon which a technology can be discovered as a person's equipment, or a practice can become a part of a person's identity and purpose. Consequently, being at home with equipment use toward an identity and purpose cannot be construed as relating the exogenous technologies to exogenous practices. The practical implication is that infrastructure cannot be designed if this is taken to mean describing the practice and technology in question and relating them to one another in a purposeful manner (Karasti & Syrjänen, 2004; Pipek & Wulf, 2009; Mikalsen et al., 2018). We present an alternate approach later.

Second, our account of exploratory infrastructuring implies a reversal of the temporal sequence and causal priority of breakdown and infrastructuring. According to our account, a breakdown should not be conceived as a starting point for subsequent infrastructuring but rather as a symptom of ongoing infrastructuring. As new technologies and practices are accommodated into a person's world, the hermeneutic circle will be modified. These modifications may manifest as interruptions to on-going activity because equipment may prove unserviceable, as illustrated in our case. These events would be characterised in the existing literature as 'breakdowns' (Pipek & Wulf, 2009). However, in our framework, overcoming these interruptions occurs within the leeway that exists in the hermeneutic circle because they do not challenge the person's overall understanding of their equipment whole. Exploratory infrastructuring must therefore be understood as an ongoing process which continually *adjusts* a person's world to disruptions and variations, some of which may be triggered by the appearance of new technologies and practices on their horizon. Therefore, a so-called breakdown is not a moment when an infrastructure becomes visible and available for purposeful design activity, as portrayed in the literature (Pipek & Syrjänen, 2006; Pipek & Wulf, 2009; Bossen & Markussen, 2010; Jackson, 2014; Karasti et al., 2018), but instead is a benign symptom of ongoing infrastructuring.

Third, the notion that infrastructure is a home for a person suggests an alternative locus of action to uncover and overcome power structures and asymmetries inscribed in infrastructure, namely, the person who dwells in their infrastructure. If emancipation is understood as a person freeing themselves from the meaning structures reproduced in their own infrastructure, then, as shown in our case, this can occur spontaneously as a response to recurring situations where their infrastructure becomes 'uncanny', provided the person makes use of such experiences to become open to the perspectives of others. On the other hand, the literature has largely focussed on techniques to 'invert' an infrastructure in order to make visible such power structures (Bowker, 1994; Bowker & Star, 1999; Karasti & Blomberg, 2018). These include historical reconstruction, enforced breakdown, and the critical analysis of technical artefacts (Bossen & Markussen, 2010; Young & Lutters, 2017; Karasti & Blomberg, 2018; Simonsen et al., 2020). These techniques emphasise the possible role that some actor, *other* than the person who is the victim of inscriptions in infrastructure, can play in emancipating that person. Our account of emancipatory infrastructuring highlights the role that a person can play in emancipating themselves. Such a person-centred account is both consistent with Star and Ruhleder's relational view, and avoids any implication that infrastructure is an entity that is understood in the same way by diverse actors. Such self-emancipation can be assisted by others (a point we take up under implication for practice), and it is not limited just to the person's own infrastructure (a point we take up in the next sub-section).

Fourth, our account of infrastructuring implies that the reach of an infrastructure should be understood as the extent of a person's world rather than the 'size' or 'scale' of some technical network or system, as it is predominantly in the literature (Pollock & Williams, 2010; Parmiggiani, 2017; Mikalsen et al., 2018; Karasti & Blomberg, 2018; Karasti et al., 2018). According to our account, the reach of an infrastructure is all that is within the horizon of a person's world – the extent to which the world is understood by a person. Therefore, extending the reach of an infrastructure from our person-centred perspective means that the horizon of a person's

understanding is extended. According to our case observations, this can occur either by exploring equipment relations outward from a focal task through exploratory infrastructuring, or by a fusion of a person's horizon with those of others through emancipatory infrastructuring. In either process, technologies and practices encountered on the person's horizon will be discovered and made public in their world. This implies that the reach of their infrastructure can be continually extended by hermeneutic processes, rather than extending a sociotechnical system by connecting new technologies and practices to it, as often proposed (Bossen & Markussen, 2010; Young & Lutters, 2017; Mikalsen et al., 2018).

## 7.2. Extensions of existing literature themes

First, our research extends current understandings of the role of mood in infrastructure development and IS development more generally. We have shown, both through observations in the case and our interpretation of these using our theory, that a mood of anxiety can lead a person to embrace new perspectives on their world so that new ways of extending their infrastructure become accessible. By contrast, such world disclosing moments have, so far, been attributed to breakdowns when an infrastructure supposedly becomes visible. As such, world disclosure itself has been viewed as a cognitive rather than an emotional phenomenon (Pipek & Syrjänen, 2006; Pipek & Wulf, 2009; Bossen & Markussen, 2010; Jackson, 2014; Karasti et al., 2018). Furthermore, to the extent that they have been considered in the literature, moods have been predominantly understood to hinder infrastructure or IS development. In the infrastructure literature, the boring nature of infrastructure has been seen to contribute to a lack of interest in infrastructure and its development among users (Star, 1999; Clement et al., 2012; Karasti, 2014). Thus, overcoming boredom is seen as a motivational issue *prior* to infrastructuring efforts. In the general IS literature, the role of mood has received increasing attention (Wastell, 1999; McGrath, 2006; Ciborra, 2006; Kelly & Noonan, 2008; Zhang, 2013; Yin et al., 2014) and anxiety particularly (Wastell, 1999; Brown et al., 2004; Beaudry & Pinsonneault, 2010). However, anxiety has been viewed negatively as hampering our ability to respond appropriately to a given situation by closing off possibilities (Beaudry & Pinsonneault, 2010), a role which would be associated with fear in Heidegger's phenomenology. By paying attention to moods in *ongoing* infrastructure development processes we have contributed a positive role for anxiety in infrastructure development.

Second, we bring to the literature a much-needed clarification of the ontological status of infrastructure and infrastructuring based on a philosophical ontology suited to the problem, and which opposes the Cartesian substantivist stance (Cecez-Kecmanovic, 2016; Riemer and Johnston, 2017) that underpins the traditional notion that infrastructure is an extant thing (e.g. Bygstad, 2010; Edwards, 2010; Eriksson & Agerfalk, 2010). The literature adopting the standard relational view has either avoided the issue of clarifying the ontological status of infrastructure by theorizing infrastructuring rather than infrastructure (Pipek & Wulf, 2009; Bossen & Markussen, 2010; Karasti et al., 2018), or it has opted for a strategy of embracing ambiguity by assigning infrastructure the status of 'existing only partially' (Karasti & Blomberg, 2018). This indicates that researchers have acknowledged the difficult problems associated with the ontological status of infrastructure in the relational view, while also wishing to distance themselves from the traditional view of infrastructure as a thing (Parmiggiani, 2017; Karasti et al., 2018).

Our approach to the relational view implies that infrastructure can only be defined in relation to a particular person. This means that infrastructure cannot be conceptualized as an extant thing, as was already made explicit by Star and Ruhleder (1996). However, that does not mean that infrastructure is purely subjective because each person's infrastructure is also a public world of discursive and material interactions. In other words, infrastructure is neither an objective nor a subjective entity, but a world (in Heidegger's holistic sense of a totality of meanings) inhabited by a person who is both an individual self but also answerable to others<sup>2</sup>. Therefore, a world, and by implication an infrastructure on our view, is both a personal place where the person is at home, but also public in the sense that it is open to, and partly constructed by, the discourse and validation of others.

This personal / public duality of infrastructure is the reason why, on the relational view, it is always necessary when describing infrastructure to be clear about the perspective adopted. The literature has called for infrastructure to be seen as perspectival (Parmiggiani, 2017; Karasti et al., 2018; Plantin & Punathambekar, 2019). However, we should avoid taking this to mean that there is a common extant thing that is looked at from different vantage points. The idea that infrastructure is a person's world is more radically perspectival than this, because every person 'owns', and has their own world, both personal and public in the above sense. For every person, infrastructuring always 'begins at home' from their own infrastructure and extends outward as technologies and practices on its horizon are brought into their infrastructure. The worlds of different people inter-penetrate and expand contributing to the public side of each person's personal world. This means that every

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<sup>2</sup> These dual dimensions of the person's existence are balanced in the hermeneutic circle by the successive moments of projecting one's self and being thrown into one's world.

person's perspective on infrastructure is different because their perspective is of their own world: there is no common singular infrastructure of which different perspectives can be had.

Moreover, our approach gives a theoretically grounded meaning to the notion of infrastructuring: it is the process of bringing technologies and practices into one's world. By contrast, the literature has defined this term only loosely, as shown in the literature review. In addition, our approach clearly specifies the relationship between infrastructure (a person's world) and infrastructuring (a person's being-in-their-world). When this relation is specified at all in the literature, infrastructure is viewed as the eventual result of infrastructuring, although it is never reached (Karasti et al., 2018).

### 7.3. Implications for practice

Our new interpretation of the relational view of infrastructure suggests a novel approach to infrastructure development, which is particularly geared to supporting emancipatory infrastructuring. According to our theory, exploratory infrastructuring is not an activity that needs to be especially encouraged or supported since it is ongoing and must be happening for infrastructure to occur. By contrast, emancipatory infrastructuring does not happen with similar regularity and reliability. Rather, it is likely that moments of anxiety are rare, not least because it is possible to avoid them by turning anxiety into fear. Even when anxiety is allowed to arise, it is possible to let such moments pass by without using the opportunities that they offer. The possibility of using anxiety as a means of developing infrastructure has not been considered in the literature to date.

Our proposal is to support people in some domain to 'hold on to' moments of anxiety and to use them productively to expand the reach of their infrastructure through a fusion of horizons. The idea is to cultivate a 'safe public space' around some common concern which brings together people with different perspectives in a domain where the role of infrastructure support is a contested issue. They would *not* come together to define requirements for some technical infrastructure, as they would in many IT projects or in participatory design. Rather, they would be encouraged to meet regularly to form personal and professional ties as a real community that 'owns' these concerns themselves. The aim would be for them to make productive use of their individual anxiety about the common concern, toward the collective work of reconciling their diverse perspectives, and potentially fusing the diverse horizons of their ways of understanding the focal issue. The proximity of diverse views is expected to increase the frequency of what we have called anxiety-imbued coping in relation to the common concern.

In anxiety-imbued coping, a normally familiar world is experienced as 'uncanny' and the resulting anxiety is harnessed to promote an increased resolve to solve a problem. When successful, the outcome is the emancipatory form of infrastructuring, as shown by our case. According to our theory, the proposed approach would represent the bottom-up development of a shared infrastructure home. However, our notions of 'understanding', 'world' and 'infrastructuring' are inherently active, so as well as creating a safe environment for debate, it is envisioned that engagement between participants would also become practical by developing material artefacts that would facilitate the sharing of a world, which might become prototypes for the materiality of the shared infrastructure.

We have previously suggested such an approach from a different orientation under the name of a Leaning Community (Reimers et al., 2013) in the area of medication management. It has proved feasible and strongly supported by participants from patients, general practitioners, pharmacists, health insurers and nursing organisations, among others. Although not originally conceived this way, the outcomes can be viewed as instances of anxiety-enabled emancipatory infrastructuring, as set out above.

## 8. Conclusion

As shown in our review of the literature, Star and Ruhleder's (1996) influential 'relational view' of infrastructure is usually understood to mean that infrastructure is a relation between technologies and organizational practices. In this paper, we give an alternate interpretation of the relational view by focussing on the relation between a person and their infrastructure, rather than on the relation between technologies and practices.

The work embodies important innovations. We propose a new vantage point from which to study the nature of infrastructure, that of the person who is at home in infrastructure, and we show that infrastructure presents a different phenomenon from this perspective than it does to a researcher or designer for whom it is an object of study. We thus highlight the importance of perspective in studying infrastructure. Studying infrastructure from this perspective requires a phenomenological approach to both theory and empirical data collection. As a theoretical framework, we introduce important hermeneutic elements from Heidegger's (1962) philosophical work to the infrastructure literature where previously only ontological elements had been used, and then only in passing. For empirical work, we make a new argument that the hands-on learning experiences of novices to a profession reported from their perspective provide vicarious access to infrastructuring consistent with our phenomenological approach.

Based on this new interpretation of the relational view, we give new theoretically grounded interpretations of infrastructure and infrastructuring. Empirically, we identify two modes of infrastructuring not previously distinguished. Furthermore, the perspective sheds new light on a number of key themes and debates in the literature.

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**Robert B. Johnston** BSc, DipEd, MSc, PhD is Professor of Business Information Systems at the University of Sydney Business School and Professor Emeritus at University College Dublin. His main research areas are electronic commerce, supply chain management, information infrastructures and philosophical foundations of Information Systems. He has over 150 refereed publications, many in leading international journals, including *MIS Quarterly*, *Information Systems Research*, *Management Science*, *Journal of Information Technology*, *Information Systems Journal*, *European Journal of Information Systems*, *Journal of Strategic Information Systems*, *Communications of the ACM*, *International Journal of Electronic Commerce*, *Electronic Markets*, *OMEGA*, *Journal of the Operational Research Society*, *International Journal of Production Economics*, and *Supply Chain Management*. Prior to becoming an academic he spent 13 years as an IT practitioner in Australia.