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The Role of Users in Prototypical and Infrastructural Systems Design

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THE ROLE OF USERS IN PROTOTYPICAL AND INFRASTRUCTURAL SYSTEMS DESIGN

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Abstract

This theoretical study examines the role of users in an infrastructural systems design. We analyzed different perspectives and used theories on infrastructure, long-term factors in infrastructure, and the role of users in infrastructural systems design. By doing this we demonstrated how prototypical design has been used in infrastructural systems design and how the users' role has been taken into account. This study summarizes infrastructuring modes, purposes, activities, and methods and also offers both theoretical and practical contributions. First, we offer a new view on prototypical design as it is conceptualized for infrastructural systems design. Second, as a practical contribution, this study provides valuable knowledge to end users and domain and information systems practitioners, especially regarding how information systems artefacts can contribute to infrastructural design and vice versa.

Keywords: Infrastructuring, Prototypical Design, Participative Systems Design, Information System

1 INTRODUCTION

During the past 20 years, there has been a growing interest to study issues related to information infrastructure (II) and infrastructuring (Star & Ruhleder 1996; Ciborra et al. 2000; Pipek & Wulf 2009; Boulus-Rødje 2014; Lecluijze et al. 2014). Existing research on II has emphasized that we should study and develop information systems (IS) as IIs and pay critical attention to evolving work practices. Thus, end users and other domain practitioners play a critical role in design through cyclic data catering, ideation, iteration, evaluation, and adaption of designed systems as the design essentially affects users' everyday lives and work practices (Karasti & Baker 2008; Boter & Saad-Sulonen 2010). In addition, Star (2002, p. 116) has stressed that we should pay attention to "the situation of those who are *not* served by a particular infrastructure."

There is some agreement in the literature that it is hard to define infrastructure boundaries, overlapped use, design, building, and management cycles (e.g., Star & Bowker 2002). Thus, many researchers have suggested using cultural–historical sources and conducting longer term studies in situ. One of the current interests has been to find solutions, for example, how social, material, and technical systems cooperate and are used at the same time (Baker & Bowker 2007; Karasti & Baker 2008). Although, there has also been a growing interest to study how prototypical design could be used to demonstrate the long-term developmental objectives of IS use and work practices, few studies focus on long-term phenomena and use prototypical design from the viewpoint of evolving practices, such as infrastructuring systems design and use (Star & Bowker 2002; Karasti & Baker 2004; Bolmsten & Dittrich 2011; Botero & Hyysalo 2013).

Based on guidelines of Hevner et al. (2004), such methods as case studies and field studies and research knowledge fit evaluation of a designed artefact. According to Orlikowski and Iacono (2001) we also have to take into account the increasingly problematic interdependence of information technology (IT) and socio-economic contexts and practices. In addition, Gregor and Jones (2007) argue that we need to consciously focus on the issues of IS artefact's mutability, which is the special nature of the IS artifact and refers to its potential to respond to evolving user needs. We consider these as arguments for enhancing infrastructure thinking in the IS and design science (DS) fields.

This theoretical study focuses on two main research questions: 1) How has prototypical design been used in infrastructural systems design? 2) How have researchers taken into account the users' role in infrastructural systems design? The contribution of our study is twofold. First, once prototypical design is conceptualized for infrastructural systems design, this will contribute to the issues with IS artefact evolution within evolving work practices and their adoption as infrastructural systems. Second, as a practical contribution, this study offers valuable knowledge to end users and domain and IS practitioners, especially regarding the contribution of IS artefacts to infrastructural design and vice versa. For DS research and management experts, use of the infrastructuring modes can provide longer term constructive and reflective measures when the aim is to develop systems within II settings.

The remainder of the study is structured as follows: We first reflect on related research on infrastructure and design for our theoretical frame. Next, we describe our research methodology and analysis of empirical studies. Finally, we discuss the users' point of view in prototypical infrastructural design and examine alternative paths for IS and DS research by the infrastructuring approach.

2 THEORETICAL FRAMEWORK

Our literature review contains the three streams of related research on infrastructure and infrastructuring that are considered relevant here: different perspectives on infrastructure for research and design, an approach to prototypical design and long-term factors in infrastructuring, and the users' role in infrastructural design.

2.1 Different Perspectives on Infrastructure

Infrastructure is most often referenced using classical socio-technical perspectives, such as large technological systems, social construction of technological systems, actor network theory, and cultural–historical activity theory. On one hand, the use of these theories has broadened the research and design focus from single systems and user-centered thinking to multiple intertwined systems, communities, and ISs, which must be integrated and be functional within limits of everyday realities. On the other hand, several alternatives to too-privileged and specialized technology and device-driven design practice have been suggested when using these theories, and these have led to an increased understanding of the importance of temporally and culturally grounded social aspects in II.

Beyond the traditional notion of infrastructure as a systems substrate or just a network of connected technological entities, there is a perspective of infrastructure that relates to its meaning for users: "It means different things to different groups" (Star 1999, p. 377). Therefore, rather than contrasting the different meanings, the elaboration focus should be on relations of people, their roles, competencies, perspectives of infrastructure, and changing interest in and dedication to infrastructural design. Consequently, the context considered in II constructions is seen as requiring several analytical viewpoints to enable more comprehensive infrastructural design for the multidisciplinary design objectives, which have been informed by many II definitions.

Technologically, an infrastructure can be thought of as a generative, artefact-based, endlessly scalable, and fixable (Star & Ruhleder 1996; Johannessen et al. 2012; Monteiro et al. 2012) assembly that normally stays unnoticed in the background and becomes visible upon breaking down. The research on infrastructure is consequently challenging because it tends to grow into "ecologies" (Star & Ruhleder 1996) that constantly gain new ground, fringes, and spaces (Star 2002) by and in social, political, material, or economic systems of society. Hence, interrelated dynamics in II systems continually transform each another and their existing infrastructural bases (Johannessen et al. 2012).

As a social structure, an infrastructure unfolds in practices when connected to activities and organizing structures; thus, both standards and customizable components are equally needed (Star & Ruhleder 1996) in infrastructural development activities. When devoted to working for human activities, development and growing of an II usually entails actors' longer term relationships, shared interests, and networked systems. Tilson et al. (2010) address this using digital convergence referring to how new social realities have been constructed upon digital communication systems, which as part of a modern II have proven to have wide ranging effects on people's everyday lives. Another example, provided by Hanseth et al. (2010) and relating to complex adaptive systems, shows how an II system can be bootstrapped; building starts as some nascent user needs are identified, a system is designed to meet the needs of target users, and the user group is then expanded by designing persuasive tactics while the initial design is scaled from the local users' level to the global one.

As a result, social organizations shape systems in II but they are also shaped by it. The crucial issue in II making is the "changes in infrastructural relations" (Star & Ruhleder 1996, p. 113), while the user-oriented design choices will be made relative to the context, people, and their dedications to design, the process of problem identification, objectives, design, development, demonstration, evaluation, and communication (Peffers et al. 2007). Once an IS artefact has gone through such a process, only after a relatively long period can we address the results of its function for end users and part of the focused II.

2.2 Prototypical Design and Long-term Factors in Infrastructuring

Infrastructural design is related to social and material issues and choices made within a particular culture and society that maintain infrastructure (Bowker 1994; Star 2002; Pipek & Wulf 2009; Hillgren et al. 2011). As long-term constructions, infrastructure is not designed as such but built up step-by-step by linking together local and global practices, which in certain significant ways relate to each other. On one hand, infrastructural design is motivated by practical work problems, which impinge upon the expected system's use; on the other hand, the objective is to solve the problems,

which relate to the technology's inflexibility to conform to emergent social needs. Thus a significant part of infrastructural design takes place in field conditions, which along with a target group, special scales, rhythm, and timing (Bowker 1994) of the activities, is enacted as *infrastructuring* the activities with use and design (Star & Bowker 2002):

- The infrastructure designer must always be aware of the multiple sets of contexts her/his work impinges on.
- The infrastructure designer must pay close attention to issues of communication (e.g., by providing reliable metadata).
- Standards are necessary—from social protocols to wiring size—and create the infrastructure but also involve complex ethical and philosophical issues.
- The built environment and information technology are increasingly integrated and information convergent.
- Access and usability issues in infrastructure shape barriers to and divide society by given information.

Star and Bowker (2002) view the long-term factors as especially important: A successful infrastructure grows steadily enough for persisting information, while it remains modifiable by end users and capable of responding to emergent social needs. For these reasons, the basic infrastructural design mode is a prototypical design: "Infrastructures subtend complex ecologies: their design process should always be tentative, flexible and open" (ibid p. 160). However, a significant range of infrastructural design objectives deals with longer term social, technical, or material constructions, which rather are closed, difficult to reach, and analyze and conceptualize from outside. These are, for instance, organizing of education, work, healthcare, services and industries, or the use and maintenance of common properties, environment, and nature (Bossen & Markussen 2010; Botero & Saad-Sulonen 2010; Johannessen et al. 2012; LeDantec & DiSalvo 2013; Ekelin & Eriksén 2015).

Based on these studies, there is a growing understanding of the importance of participatory design (PD) as engaging people in professional design (Bødker & Iversen 2002), but infrastructuring aims at setting apart from any privileged form of design. In addition, the shared view is that what finally "makes" the infrastructure is the entire use activity, not only the external functionality of IS artefacts but also their initiations into the end users or practitioners' communities of practice. This embodies the users' critical role and interest in infrastructuring. There are such objects of design that only are available to users, which on the other hand enable their relevant contributions to professional design.

2.3 The Users' Role in Infrastructural Design

The success of user participation is often related to the user–designer relationship, their possibilities for learning the context and practice of design, and mediation between use and design (Björgvinsson 2008; Hagen & Robertson 2009; Iivari et al. 2009). This involves considering how to find, select, and visualize relevant design possibilities and system components for infrastructural design and how the different viewpoints can be enhanced cooperatively. This in turn may require giving up a priori systems views, processes, design roles, tasks, methods, and objects of design, which may increase use-design mediation and between researchers, users, and designers.

Hence, infrastructural design underlines the users' critical role by two overlapping factors, which influence design construction. The first is how "to become aware of social and political work the infrastructure is doing and then seek to modify it (locally or globally) as needed" (Star & Bowker 2002, p. 160). The second is "the capacity of integrating unique ideas and practical design solutions at the end-user's level" (Ciborra 1992, p. 299). The first lays more stress on the socially sustainable design (e.g., decision making), and the latter stresses the practically sustainable design (in situ). They both epitomize the users' interest to contribute to design that is intended to have a longer lasting effect as evolving form their practice or ISs. For designers or researchers, grasping the users' critical role enables a unique opportunity to learn how practical knowledge is used and developed in the context of its application (Gibbons et al. 1994).

Generally, there is a growing agreement in the literature that social or work-based issues are of user interest to contribute to infrastructural design, especially as enhancing means of communication in a specific community, organization, group, area, or activity (Karasti & Baker 2008; Johannessen et al. 2012; Parra et al. 2012; Botero & Hyysalo 2013; Ortbach et al. 2014). On the other hand, this sustains end-users' cooperation in situations where professional help is not available.

2.4 Summary

Using the theories beyond infrastructure, II appears as a multidisciplinary research and design target that is partly redesignable and partly taken as granted, and its fundamental character is that it is shared by and shaped for human organization. II has a sustainable structure by established and standard properties and emergent changing properties, which provide targets for infrastructural design, knowledge production, and participative systems design. Although the use of theories has enacted approaches to infrastructure differently, empirical studies have united in seeing II as a user-oriented systems design area. The users' role and interest in infrastructural design underlines socially and practically sustainable II artefacts.

3 METHODOLOGY

Using IS and systems design literature, our intention is to review the purposes for which prototypical design has been used in infrastructural systems design and how the activities have manifested the users' role in research and design processes. Specifically, the studies in which prototypical design has played a constructive role in infrastructural design have been included. However, instead of striving for a comprehensive explanation (Hammersley 2001), our analytical interest is in highlighting the studies where infrastructuring modes and user-oriented design objectives have been reported. Therefore, we adopt a narrative line as reviewing the users' input from II background work, seeking alternatives, and showing design thinking to design interaction situations where both design choices and artefacts reinforce and move on as enacted II innovations. The narrative review usually identifies what has been written on a topic, and "there is no attempt to seek generalization or cumulative knowledge from what is reviewed" (Paré et al. 2015, p. 3).

4 ANALYSIS OF SYSTEMS DESIGN STUDIES

Using the perspectives on infrastructure, prototypical design, and long-term factors in infrastructuring and the users' role in infrastructural design, four different design modes can be outlined: 1) background infrastructuring, 2) alternative infrastructuring, 3) design-thinking infrastructuring, and 4) design-interaction infrastructuring. These will be discussed in the following sections.

4.1 Background Infrastructuring

In infrastructure development, IS artefacts have been considered with socio-technical views, such as large technological systems and social construction of technological systems. Some theories, such as actor network theory and cultural–historical activity theory, have been utilized in order to understand the role of invisible work that reaches beyond the immediate systems use, users, and tasks at present.

Based on the reviewed work, the situated nature of background activities is substantiated and linked to the resourcing, preparing, and versioning of work, which are bounded to certain places, timing, people, and cultures. Bowker (1994) has addressed this as *infrastructural inversion*, which refers to the ambiguity and complex paths of social production through which infrastructural systems develop and which tend to be absent from their examination. As dealing with changes in society or collectives, this factor has been integrated with the political or strategic design perspective, which the user should be aware of. Botero and Saad-Sulonen (2010) enact such activity as being "in-between" infrastructure making with the role of mediation. Karasti and Baker (2008) view it as the end-users or domain practitioners' infrastructure making, where design in situ takes place within an ongoing activity.

However, because the intention of usage for a certain IS artefact is invisible in these activities, their sense making in relation to use or work is difficult to articulate and often remains unreported (Baker & Bowker 2007) and unrecognized as a constructive prototypical design for II.

On the other hand, such background infrastructuring is linked to higher levels of society and IS management taking place in global, national, and organizational settings involving local/remote users. Star (1999) in the Worm Community Project notes that despite defining, prototyping, and testing a new IS with users, few adopted it as researchers were not aware of the users' local infrastructure (the existing installed base) and the values adopted by "backstage" communities. LeDantec and DiSalvo (2013) point out a similar type of infrastructuring beyond national decision making that refers to actors' "attachments." In addition, Ciborra et al.'s (2000) "drifting" (deviation from planned purposes), Hanseth and Lyytinen's (2010) "enrolling new communities," and Johnson et al.'s (2014) "prosumer" (users as co-producer–consumers) join infrastructuring by community relations.

Hence, the studies have provided several prototypical design aspects that can exemplify the users' focus of interest in infrastructuring (e.g., sense making of design values, conditions, and paths of decision making or resourcing of socio-economic production) and their role in strategic, timing, in-between, and in situ designs. Also, in-versioning as a form of social production and use-design mediation reveal participation in infrastructuring and user-oriented design objectives. To what extent these demonstrate an increase in users' influence on design remains open, but the studies clearly show the importance of "being there" where design decisions for II making are made. For researchers, this offers better possibilities to understand uncertain empirical factors beyond II (Boulus-Rødje 2014). From the viewpoint of users, understanding background infrastructuring offers potential to go about issues with the installed base of II that is the sine qua non of alternative infrastructure making.

4.2 Alternative Infrastructuring

Decision making and participation in design relate to the users' abilities to reflect on a technological solution, especially to reject, define, select, or find a different one. Robertson (1996) has termed these actions indirect participation, which on a concrete level manifests the means by which people can influence IT production; however, this requires certain skills and knowledge of IT production.

Efforts to alter mainstream design have shifted researchers' focus onto those people who are not using IT-based systems or services and who may not have the skills or potential needed to participate in societal decision making (Hillgren et al. 2011; Botero & Hyysalo 2013). In these II projects, user-oriented objectives strive for social values, democracy, design for all, societal welfare, and learning. Increasing participation in design has involved diverse means that are typical of inclusive design (e.g., prototyping, use of cultural probes, activities of interest, art, music, and Living Lab setups). This has resulted in social innovations, such as new activity systems with design, coordination, and business competences. That is, the objective is in empowering people to act on their own initiatives and learn how to design for their own interest and everyday problem solving.

Do it yourself (DIY) projects (Lukens 2013) in turn have highlighted alternative infrastructuring that is carried out by people with certain IT and organizing skills and who are volunteering for the sake of designing better technology as needed in their everyday lives. In these projects, the self-directed activities of non-experts have been a key to questioning given technology and the use of existing, available recourses, IT, and social networks. Lukens shows that this kind of activism could initiate long-term changes on higher societal levels and in areas considered to be the job of paid experts.

Similarly, Karasti and Baker (2008) show alternative infrastructuring related to end users or domain practitioners' activities in their community design. This could maintain social, knowledge, and technological practices. It provided members with chances to reflect on the ongoing changes in their field, involve the data collected from and valued in their field, and include visualizing the impacts of the chosen development directions. In these communities, ISs were developed in situ and "fully" open for members' programming (from source code to interfaces), while the success of this design was

measured via long-term changes in the communities' raison d'être activities. This affected the evolution of the communities' infrastructural design and redirecting the communities' practices by II.

As a result, prototypical design appears as applying user-driven objectives, which gives reasons to reject designs or select other solutions and redirect people as needed to pay attention to the consequences of using certain designed systems. The role of users in design for all, design for interest, do-it-yourself design, and community design refers to the responsibility of local actors to follow and react to the system's design consequences. Advocates of alternative infrastructuring thus need to develop measurements for the evolution of IS and other artefacts as part of II. However, the studies leave open how to cope with conflicting viewpoints (Lecluijze et al. 2014), which influence the generative role of II, and to the users' role in design work (Johannessen et al. 2012). The critical aspect is how to show the users the systems design that manifests a certain kind of design thinking.

4.3 Design Thinking Infrastructuring

When design involves changes in collectives, the user-designer relationship has been a common way in considering how to enhance mutual understanding of everyday and professional design thinking. Typically, design thinking is mediated by user-designer cooperation and design practice, involving the selection of methods, materials, and user-data analysis, and constructing and testing design ideas to the abstractions that finally will be implemented as an infrastructural system or artefact.

According to Björgvinsson et al. (2012), design ideas must be "envisioned" or "prototyped," but the selection of a suitable method is a complex matter depending on the context of interaction, domain, design organization, and objectives. Generally, a great range of prototyping strategies is available (e.g., constructive, alternative, critical, or inclusive) and objectives for using them (e.g., problem solving, emancipatory, developmental, or creative designs). Design thinking (Björgvinsson et al. 2012) infrastructuring in turn strives for binding people together as designing for evolving practices while visualising both the "use before actual use" (artefact to be used) and "design after design" (ibid., p. 102), (e.g., modifiability, tailorability, or mutability). This extends prototyping objectives from mirroring the current understanding of the design problem at hand toward "adaptation to changing conditions" of use "after a specific project is finished" (ibid., p. 104-5).

A common way of demonstrating design thinking with IS artefacts has related to the user interface, but prototyping using various techniques of design by doing, with situated or located design, has dealt with a variety of issues derived from participants' practices (Neumann & Star 1996; Stevens et al. 2009; Johannessen et al. 2012; Parra et al. 2012; Botero & Hyysalo 2013). This has made possible giving or modifying given design ideas as well as reflecting different viewpoints, concerns, and interests (Björgvinsson et al. 2012) of participants while involving analysis on people's everyday activities. For designers or researchers, these thinking tools mediate what users expect from IT support and how to practice professional design during user cooperation (Bødker & Iversen 2002; Bødker & Christiansen 2004). The key concern in design thinking infrastructuring is how to grasp the socio-economic setting (Björgvinsson et al. 2012; Lukens 2013) in the making while directing design choices by prototyping and generating solutions in relation to the installed base of II.

The studies thus maintain design thinking infrastructuring as important for striving user-oriented design objectives so that infrastructural prototypical design should be understood as directional, selective, and generative in relation to II. This involves situated or located design by which users can be aware of their role and participation in infrastructural design (Star 2002). "Design after design" thinking refers to infrastructuring on a longer term basis, which may come into question only for a few users. Hence, it is incumbent on designers or researchers to show the infrastructural design issues in design interaction when conscious design influencing (Brown et al. 1994) is still possible.

4.4 Design Interaction Infrastructuring

For users and designers, the borderline between use and design may not be defined per se, but in infrastructure analysis it has played a central role in understanding how different parties can advance from design interaction, especially when they are delegated to interact for the sake of others.

For instance, Botero and Saad-Sulonen (2010) view the roles of designer and user not only as given in a social organization but also as practiced in interaction. Making a practice visible therefore requires the means by which the roles taken on can also be articulated. In their study of citizens and officials involved in service design, imaginative scenarios and prototyping helped individuals to visualize their attitudes with the activities of others and contributed to grasping the dynamic relationships between citizens and officials who shaped new service models together.

Quite similarly, Björgvinsson (2008) defines shaping of a prototypical practice as a synthesis of different attributes of work that a collective possesses. This is especially characteristic of work collectives that practice professions. Designing a practice thus means embedding relevant sustained attributes into the activity when a new form is still in the making (Star & Ruhleder 1996; Stevens et al. 2009; Johannessen et al. 2012) and driving for incremental rather than disruptive change (Ekelin & Eriksén 2015). In patient-care work studies (Björgvinsson 2008), this involved explorations in situ, metaphor games, future workshops, and prototyping, which resulted in a new technology via designer, nurse, and aide interaction, along with a new use practice that was designed for future purposes and was redesignable by the work community when needed. This can be seen as infrastructuring systems design and evolving work practice so that set user-oriented objectives can be achieved in practice.

Other reviewed studies have shown that such objectives can also be achieved in loosely bound or heterogeneous collectives, for instance, people engaged in worldwide activism (Brabham 2008) and in nonprofit (Karasti & Baker 2008) or DIY (Lukens 2013) communities capable of organizing productive design interaction in the long term. Such an outcome has involved visualizing the meaning of infrastructuring for users, maintaining continuous input of end users or practitioners in their field of practice, while taking a conscious stand (Lecluijze et al. 2014) on issues people really care about.

Hence, this infrastructuring mode involves designing a design interaction so that it can reify prototypical design through data catering, ideation, iteration, evaluation, and adaption of designed IS and other artefacts. In this way the design practice evolves while it maintains the role of users in relation to social, material, and technical systems that the users use within their ongoing activity.

4.5 Summary of Infrastructuring Modes

Based on the reviewed IS and design literature, four infrastructuring modes could be identified, which define the role of users, activities, and methods used in prototypical and infrastructural systems design (Table 1). The results are discussed in detail in the next section.

Mode/purpose	Activity	Design method
Background infrastructuring	Locating, exchanging, resourcing	Strategic design, timing design, in situ design
Alternative infrastructuring	Rejecting, selecting, redirecting	Design for interest, do-it-yourself design, community design
Design thinking infrastructuring	Mediating, reflecting, modifying	Design by doing, situated design, located design
Design interaction infrastructuring	Visualizing, embedding, maintaining	Design of practice, design of use, design of design

Table 1. Summary of infrastructuring modes/ purposes, activities, and methods

5 DISCUSSION AND CONCLUSIONS

This study was guided by two main research questions: 1) How has prototypical design been used in infrastructural systems design? and 2) How have researchers taken into account the users' role in infrastructural system design? In this study, we reviewed studies that have presented various perspectives on prototypical design, long-term factors in infrastructuring, and the users' role in infrastructural design. Based on the earlier literature, we were able to conceptualize four different infrastructuring modes and the activities and methods used in infrastructural systems design.

5.1 A View on Prototypical Design and the Role of Users

As conceptualized for infrastructural systems design, prototypical design can be seen as enacted by infrastructuring modes, which reify the nature of tentative, flexible, and open design while applying varied participative systems design methods. Based on infrastructuring purposes, four infrastructuring modes were identified: 1) background, 2) alternative, 3) design thinking, and 4) design interaction infrastructuring. In each of these modes, the users play a critical role.

Background infrastructuring is used for locating people, materials and timing, exchanging assets, and resourcing II making. These activities apply to the objectives of strategic design, timing design, and in situ design used for systems that strive for longer term changes in society or the collective in question. For instance, while performed by "being there" when design decisions for II making are made, the intention of usage beyond background infrastructuring can be realized. Regarding the users' role in infrastructural systems design, this enables users or designers to pay attention to issues with the installed base of II that is the critical long-term factor for concerning alternative infrastructuring.

Alternative infrastructuring emphasizes the role of users in relation to such user-oriented objectives that relate to rejecting designs or selecting other solutions and as redirecting people to consider the long-term outcomes of maintaining certain kinds of designs for II. Related methods for achieving these objectives are those such as design for one's own interest, do-it-yourself design, and community design. These by themselves are long-term measures for infrastructuring of use and design and require the means by which an evolution of IS and other designed artefacts as part of II can be measured and by which users or designers become aware of design thinking beyond infrastructural systems design.

Design thinking infrastructuring is used in mediating, reflecting, and modifying the ways by which the user-oriented design objectives and design directions are carried out in infrastructural systems design. These refer to prototyping the IS artefact to be used and modifications of the built artefact taking place in use. This requires the artefact's transformation by cyclic data catering, ideation, iteration, evaluation, and its adaption within evolving practices, using methods, such as design by doing, situated design, or located design referring to people's everyday conditions. From the users' point of view, this also involves the interaction means by which participants of design situations can influence designs.

Design interaction infrastructuring has a significant role in reifying abstract design activities by visualizing, embedding, and maintaining the users' work with technologies and designing in use. This involves the methods for design of practice, design of use, and design of design for evolving work practices. From the users' point of view, these maintain their activities in their field of practice.

The infrastructuring modes and purposes overlap in terms of activities and methods, but each of them is identifiable in relation to prototypical design, long-term factors in infrastructuring, and the users' role in infrastructural systems design. Each of the activities and methods typical in participative design offer a number of further research possibilities. The different modes highlight driving of user-oriented design objectives, which strive for evolving everyday practices where social, material, and technical systems need to cooperate. The purposes of using different infrastructural design modes emphasize the complex paths through which the systems develop and design ideas and outcomes accumulate in a generative and cumulative way. This makes their analysis challenging and requires paying critical

attention to the users' role in infrastructural systems design settings and in the knowledge production that takes place in the context of application (Gibbons et al. 1994).

As a result, we believe that the conceptualized infrastructuring modes contribute to IS and DC research and are valuable knowledge to end users and domain and IS practitioners. This is particularly the case with respect to how IS artefacts may contribute to infrastructural systems design and vice versa. We next highlight this by the relationship of IS artefacts and the II context.

5.2 The Relationship of IS Artefacts and the II Context

With what we have addressed in this paper, the relationship of IS artefacts and the II context can be seen as regenerative in relation to both. It unfolds via prototypical infrastructural design conceptualized into four different infrastructuring modes. Using the infrastructuring modes, II making can be seen as revolving by the long-term change objectives, the outcomes of using instantiations of IS artefacts, the resultant sifts in design thinking, and the turns taken in use-design interaction. This causes an IS to develop as a robust setup capable of persisting information, while its evolution continues as responding to emergent needs and as remaining modifiable by the end users. On the other hand, the evolving IS contributes to the growth of the infrastructure, which constantly gains new ground, fringes, and spaces (Star 1999).

Regarding the evolution of the IS artefact as an infrastructural system, Gregor and Jones's (2007), referring to the concept of mutability, have addressed the special evolving nature of IS artefacts, which aligns with our view on prototypical infrastructural systems design, reifying the nature of tentative, flexible, and open design (Star & Bowker 2002) for ISs within II settings. We thus see the conceptual deepening of these aspects as an interesting possibility for further research, especially as focusing on the regenerative phenomenon. However, we also want to recall that not all ISs in IIs need to be mutable, but based on Gregor and Jones (2007) and Gibbons et al. (1994), it can be seen as the long-term IS feature that essentially affects supply and demand factors in IS industry and knowledge production in IS and DS contexts. Conversely, Orlikowski and Iacono (2001) argue that there is the problematic interdependence of IT artefacts with socio-economic contexts and practices, which increasingly challenges IS theorizing and design. We thus suggest that as focusing on the evolution of IS artefacts in II, prototypical infrastructural systems design can offer practitioners, designers, and researchers a number of means by which long-term socio-economic factors can be taken into account.

Considering ISs as evolving technological systems, we see the Germonprez et al.'s (2007) perspective on tailorable technology design as responding to objectives of developing IS artefacts for II. They have defined it from the viewpoint of designing end users; it specifies the designer and user environments and design principles for tailoring and supports the "users of technology as designers of action" (p. 352) position and the use of methods, such as learning by designing (Romme 2003). However, although the systems developed by the empirical setup have been a successful implementation of the user-driven objectives beyond tailorable technology design, Germonprez et al. (2007) still emphasize that the theory needs to "include the contexts and reasons why users tailor technology" (p. 364). In terms of infrastructural systems design thinking, this means infrastructuring the use and design for purposes of designing end users. Hence, we see our view on infrastructural systems design supportive for the authors' view and contributive to the need of developing both conceptual and practical means for the IS context. In addition, the information service view by Germonprez and Hovorka (2008) offers a potential direction for extending research on prototypical infrastructural systems design, for instance, in information-intensive service contexts.

Evolving work practices by prototypical design has points of resemblance to the view on "live routines" by Pentland and Feldman (2008). Using the example of failed software implementation, authors were able to address the relationship of patterns of action and live routines. These were enacted as generative systems (cf. installed base), which embed into work while being modifiable by it. They especially highlight the importance of paying attention to the emergence of patterns of action as well as to their consequence and how people can appropriate their routines in everyday settings. This fits

our view on prototypical design, but the aspects of infrastructural systems design and the role of users in integrating use and design (Pipek & Wulf 2009) have not been the central focus of interest in the Pentland and Feldman's article. However, their framework offers some possibilities to be put forward with our work, for instance, regarding the regenerative nature of routines and patterns of action. This may also help to understand why different infrastructuring modes are important in prototypical infrastructural systems design, which strives for a longer lasting effect on development of systems within II contexts.

5.3 Concluding Remarks

Hevner et al. (2004) note that there is a gap between academic IS and DS research and their adoption in industry. They suggest improving communication between research and industry by clarifying the knowledge produced by research efforts. Existing research on II in turn has emphasized that we should study and develop information systems as IIs and pay critical attention to evolving work practices. Although there is some agreement in the literature that it is hard to define infrastructure boundaries, overlapped use, design, building, and management cycles, researchers have been able to overcome the problem by using cultural–historical sources and as conducting longer term studies in situ. This has helped the researchers to realize how social, material, and technical systems cooperate and how prototypical design can be used to demonstrate such long-term phenomena as IS and evolving practice.

This theoretical study has examined the role of users in an infrastructural systems design by analyzing different perspectives and has used theories on infrastructure, long-term factors in infrastructure, and the role of users in infrastructural systems design. By conducting the analysis, we were able to demonstrate how prototypical design has been used in infrastructural systems design and how the users' role has been taken into account in infrastructural system design.

In conclusion, in infrastructural systems design, prototypical design has been used as infrastructuring, which refers to tentative, flexible, and open design. We were able to conceptualize four different infrastructuring modes: background, alternative, design thinking, and design interaction infrastructuring. In addition, we summarized the modes with purposes, activities, and methods. In each of the infrastructuring modes, the users play a critical role in infrastructuring use with design in the course of cyclic data catering, ideation, iteration, evaluation, and adaption of designed systems into their everyday lives and work practices. Infrastructural and prototypical design shapes the regenerative phenomenon of IS and II, which is beneficial for both IS artefacts and systems designed for II context. Our future research will focus on the regenerative phenomenon.

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