Design Archaeology: Generating Design Knowledge from Real-World Artifact Design

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Abstract. When formulating prescriptive design knowledge in design science research (DSR), we usually reflect on our vision of created artifacts, relevant design decisions, and what we have learned throughout the design process. Seldom do we attempt to extract prescriptive knowledge from existing and widely acknowledged artifacts in the manner of *ex-post facto* or *in situ*. But what *can* we learn from decades of designing digital artifacts that have fundamentally revamped work processes across industries, allowed for the emergence of new business models, and even spurred entirely new industries? This essay is inspired by the way archaeologists make sense of the past and represent the resulting knowledge. We propose a novel approach to the analysis of digital artifacts based on the archaeological approaches to context reconstruction and artifact analysis. We explain how a design archaeologist can shift among the perspectives of designers, users, and the generated artifact to make inferences about the artifact (i.e., design artifact), how it has been designed (i.e., design process), the context in which it has been designed (i.e., the design context), and the situations in which it has been used (i.e., the use contexts).

Keywords: Design theorizing · Design knowledge · Design science research · Artifact analysis · Archaeology · Information systems

1 Introduction

Compare the two main characters in the following narrative. Primo and Secondo were the sons of a mighty ruler who was determined to teach those without a profession to make good wine. She expressed her wish to both sons and, at the end of their conversation, it became clear that they must go on separate ways. Pluralism of truths was a principle held dearly in their family.

Primo left for Bourgogne and Bordeaux to observe the best winemakers in action. He would also ask them about the past and how their craft of making wine had evolved. Not seldom did he find himself running out of parchment and ink in a lively discussion. Secondo stayed home and established several vineyards that stretched from coast to hill. He enjoyed experimenting with various techniques and different grape varieties. He never failed to keep a daily record of his progress. Time flew since both enjoyed themselves. The mighty ruler found herself scanning through the work of her sons, overwhelmed with multiple visions of possible brighter futures.

B. Tulu et al. (Eds.): DESRIST 2019, LNCS 11491, pp. 32–45, 2019.
https://doi.org/10.1007/978-3-030-19504-5_3

We notice that Primo and Secondo followed two different approaches to acquire the "how to" knowledge (design knowledge) on making exceptional wine. Secondo made wine and tried to make the best his soil would allow him. Primo tasted the most prestigious wines and got his knowledge from the winemakers. He also tasted old wines and learned about the crafts of the past. While the narrative does not tell us how their design knowledge compared with each other, it shows us that design knowledge can indeed be acquired through first-hand experience as well as second-hand experience.

In this essay, we suggest that design science research (DSR) in information systems (IS) should follow the paths of *both* Primo and Secondo. First, it should actively engage in design and evaluation processes in order to generate design knowledge. Second, it should study the artifacts of our past and present to reconstruct the meaning and consequences of their material properties in the various contexts in which they have been used. This will give the DSR field access to a world full of past and present artifacts—a world full of design knowledge. Instead of only including the design of artifacts in the research processes themselves, we suggest to also observe and learn from the design processes taking place in our economy and society and the resulting artifacts that are often exposed to millions of users. This lens is aimed at deriving design knowledge from "naturally occurring" design and evaluation.

Archaeology is the study of (past) human activity through recovering and analyzing artifacts and other physical remains. In analogy, a *design archaeology* in the realm of IS is *the study of design activity by recovering and analyzing digital artifacts;* this, we contend, can provide important insight into key design decisions that were involved in creating these artifacts.

We argue that such view complements the prevailing practice scripts in the DSR field [1] and can help derive design knowledge. The primary purpose of DSR is to formulate prescriptive knowledge about the design of IS artifacts, such as software systems or development methods. The dominant DSR practice script is one where the researcher is at the same time also the designer who develops and experiments with an artifact. Typical stages involve problem identification, objective definition, artifact design, demonstration, and evaluation, followed by the communication of results [2]. Through this process, the researcher makes contributions at different levels of abstraction, ranging from specific instantiations to more abstract knowledge about artifacts that belong to the same class—typically expressed in terms of design principles [3–5] or design theory [3, 6–8]. An archaeological approach to design science holds a number of promises:

- There is a wide range of problem and solution spaces that can be explored to identify underlying principles. Once the design process has been completed, these are *problem spaces of the past.* The design science researcher is thus challenged to reconstruct the design context to be able to understand salient design decisions.
- Industry practitioners often possess years of experience in designing artifacts and are thus invaluable sources of information about design.
- The identified abstract principles underlying existing designs can also be applied in other contexts, contributing to solving a broader class of problems.

- Observing real-world designs in their past and present contexts allows for cross-sectional as well as longitudinal studies and can provide insights about specific design decisions that may have eventually led to its success or failure.
- Finally, DSR has been described as difficult and effortful to conduct. Studying real-world design may open the community toward those who wish to contribute to the derivation of design knowledge, capitalizing on their interest and experience in other research traditions. This, in turn, can foster the development of knowledge in order to tackle relevant societal problems.

We proceed as follows. The next section discusses the theoretical background in terms of IT/IS artifacts, artifacts-in-use, and design knowledge. We then highlight some relevant insights from the field of archaeology, which we then draw upon to devise our approach to design archaeology in IS research.

2 Artifacts and Design Knowledge

2.1 On the Notion of *Artifact* in IS and DSR

While design can be considered universal, the product is usually context related—which is why semiotics or the interpretation of meaning are indispensable [9]. Consequently, we need to define the notion of *artifact* in the context of IS and DSR. A classic definition in any discussion about this notion is that of Simon [10]:

> "my dictionary defines "artificial" as, "produced by art rather than by nature; not genuine or natural; affected; not pertaining to the essence of the matter" (p. 4).

Recent discussions called for more clarity in defining IS artifacts, in order to reduce confusion between the terms IT artifact and IS artifact [e.g., 11, 12]. Lee et al. [12] redefined the notion of IS artifact as "a system, in which the whole (the IS artifact) is greater than the sum of its parts (the IT artifact, the social artifact and the information artifact), where the constituents are not separate, but interactive, as are any subsystems that form a larger system" (p. 9).

With specific focus on DSR, several scholars have also elaborated on the notion of artifact in a DSR project [5, 13–15]. This essay, however, will follow the categorization proposed by Gregor and Hevner [16] that highlights the different levels of abstraction DSR studies can produce: design theory (abstract level), nascent design theory (intermediate level), and tangible end products, such as a software or process (specific level). Many, if not most of, the tangible end products produced through a DSR endeavor take a digital form. For the rest of the essay, we refer to this category of DSR artifacts as **"digital artifacts"** (i.e., artifacts at the specific level). When referring to the more abstract category of DSR artifacts, we use the term **"design knowledge"** (i.e., artifacts at the intermediate and abstract level).

2.2 On Artifacts and Artifacts-in-Use

The literature in Information Systems, Interaction Design, and Digital Humanities is rich in describing the notion of digital artifacts. Consider the following definition: "By digital artifact we mean existing as well as potential types of physical product that delivers digital contents through its interactive features" [17, p. 154].

What is interesting about this definition is its distinction between digital contents and their carriers. It also implies that digital artifacts possess some characteristics or attributes that distinguish them from their non-digital counterparts. The following attributes have been suggested in Kallinikos et al. [18]: digital artifacts are (1) editable, (2) interactive, (3) open or reprogrammable, and (4) distributed. While physical artifacts have fixed forms that are difficult to change, digital artifacts can be acted upon and modified continuously by a human agent or even another digital artifact (such as a program).

However, artifacts are first and foremost outcomes of design that communicate designers' intentions and fulfill sets of requirements. They become more meaningful when analyzed *in situ*, as artifact-in-use or technology-in-use. If the context cannot be readily observed, it is necessary for the design researcher to reconstruct this context—only then she can understand the meaning of the digital artifact in terms of its physical and digital materialities. The important question is, however, when should we wear the "designer hat" in analyzing an artifact and when to wear the "user hat." It is important to note that some users are also creators of their own applications (e.g., spreadsheets) and information items, a phenomenon dubbed as secondary design [19]. Nevertheless, considering a more designerly point of view can be fruitful.

We can also decompose the notion of digital artifact into its modular layered components [20] or revisit artifact-related concepts we often use interchangeably and clearly identify which is our object of study. Despite the common use of the term IT/IS artifact in relation to design (for instance, in conceptualizing IS artifact [e.g., 12]), Iivari [21, p. 761] argues that "IS artifact is not necessarily an appropriate unit of design" and suggests the concept of "IS application as the design nexus"—consistent with the notion of artifact-in-use. The implications for the overall idea of this essay are summarized in three points:

- Digital artifacts include digital contents and digital applications that can be analytically separated for the purpose of interpretation.
- Digital artifacts can be treated as standalone products or as artifacts-in-use.
- Digital artifacts need to be studied in their context of development and use.

2.3 On Design Knowledge

Design knowledge is "knowledge that can be used to produce designs" [22, p. 9]. In other words, it is the "knowledge about creating other instances of artifacts that belong to the same class" [5, p. 39]. We can also view design knowledge as a manifestation of the theory for design and action, that "says how to do something […] gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artifact" [23, p. 620]. Knowledge is beyond information, as it incorporates agency and purpose [24]. Consequently, deriving design knowledge is a far more complex activity compared to simply gathering information.

Design knowledge in DSR is the result from processes of reflection and abstraction, where the design researcher applies different types of reasoning to identify mental causes (i.e., the designer's vision), active causes (how the artifact produces an outcome), and passive causes (how the artifact offers affordances that are identified and enacted by users) [25].

Resulting from such processes of abstraction and reflection is design knowledge in different forms and at various levels of abstraction. With regards to the form of representing design knowledge, the notion of design theory [3, 6–8] has gained some prominence in the IS field, and various design theories have been proposed such as for IT support for emergent knowledge processes [26], secure information systems design methods [27], green information systems [28], and sensemaking support systems [4], all of which represent classes of digital artifacts—these theories are abstractions that provide prescriptive statements in relation to a set of boundary conditions. Another, more atomic form of design knowledge is that of a design principle, and typically scholars develop sets of design principles in order to say something about the design of a class of digital artifacts [29]. Design principles are prescriptive statements and are a key element of design theory [6].

3 Insights from Archaeological Approaches

3.1 Discourse on Archaeology and Digitization

What has archaeology got to do with IS and digital artifacts? Recent development in archaeology points out several themes that are similar to the contemporary discourse on digital artifacts in the IS field. The widespread digitization of data and infrastructure has led to the rise of digital archaeology, sometimes also referred to as cyber archaeology and virtual archaeology [30]. This phenomenon has been described as follows: "archaeologists are creating multimedia experiences of the past, directly authored by archaeologists collaborating with stakeholders, and these experiences are available to anyone with a connection to the Internet" [31, p. 521].

Recent discussion in digital archaeology has been moving toward how to do archaeology digitally [e.g., 32–34]. Recording archaeological data digitally, for instance, results in increased transparency because stakeholders can view generated data during the excavation and can participate in post-excavation artifacts analysis. Finally, digital media enrich the representation of artifacts. IS researchers in related fields have contributed significantly in this area, appropriating augmented reality in museums and exhibitions [e.g., 35, 36] and developing interpretive archaeology systems [e.g., 37, 38]. We conclude that digital archaeology views digital technologies as artifacts, exploration and analytical tools, as well as representation media and infrastructures.

3.2 On the Interpretation of Meaning

The classical definition of archaeology still rings true today: "Archaeology is the study of human history and prehistory through the excavation of sites and the analysis of artifacts and other physical remains" (Oxford Dictionary). In other words, the

interpretation of meaning occupies a central role in all archaeological endeavors [40]. In what follows, we highlight four general features of archaeological approaches that are relevant to the purpose of this essay.

First, archaeology is about ***using and investigating meaning of material signs in order to produce knowledge*** [39]. Note that producing knowledge is the purpose of any archaeological endeavor. It its simplest form, knowledge is knowing what a sign (e.g., an object, a word, a gesture) means—that is, through semiotic analysis. Semiotics occupy a central role in present-day interpretive archaeological practice [38, 40]. Among the widely adopted approaches is Peirce's sign-interpretant-object triad [39]. This focus on semiotic analysis of material artifacts is consistent with the focus of the IS field on material artifacts, both in terms of physical and digital components [41, 42].

Second, ***artifact analysis occupies a fundamental role in archaeological endeavors***: "In order to find an answer to the question 'what is this thing?'—a question posed when curious remains or ruins were found—scientists created a new science: archaeology" [43, p. 41]. Some approaches in IS also study artifacts in situ (e.g., works on technology-in-practice and sociomateriality [44]), proposing that digital technologies get their meaning from their context of use.

Third, archaeological endeavors are aimed towards ***reconstruction of the past***. When we interpret objects, we are actually trying to find out how people engaged with those objects in the past [39]. Such reconstruction of contextual factors becomes particularly challenging in the context of emergent information technologies characterized by multilayered architectures providing the basis for the emergence, evolution, and at times disruptive change of digital ecosystems [20]. The context is a different context at potentially every point in time.

Fourth, it is ***not only about looking backward, but also about looking forward*** at how we use objects today and what meaning they possess in the present that can be projected into the future [39]. This feature is in sync with what Peirce once argued: "Whatever is truly general refers to the indefinite future, for the past contains only a certain collection of such cases that have occurred. The past is actual fact. But a general law cannot be fully realized. It is a potentiality; and its mode of being is esse in futuro" [45, p. 414]. This understanding is key for IS and for the sciences of the artificial in general.

4 Towards an Archaeology of Digital Artifacts

4.1 Four Analytical Dimensions

IS researchers tend to describe the roles of artifacts in organizations from the perspective of sociotechnical systems (STS) [46–48] or Neo-STS [49]. This perspective views organizations as consisting of interdependent and interconnected social systems (knowledgeable human actors and social structures) and technical systems (artifacts connected in a functional and meaningful system). Artifacts are viewed as tools if a study focuses on their instrumental aspects, or as ornaments, if the focus is on their symbolic aspects [50]. On this view, the instrumental perspective requires to attend to the digital artifact in its context of use. Although often downplayed, understanding the

aesthetic aspects of artifacts is an integral part of artifact analysis [51, 52]. Integrating these prior works, we adopt four analytical dimensions [51] for design archaeologists:

- **Historical dimension:** When analyzing an artifact we need to consider the context that surrounds its production and conception in the past. This dimension includes organizational context, social context, and other boundary conditions.
- **Instrumental dimension:** This dimension specifies the extent to which the artifact contributes to performance or to promoting goals. Artifacts can be evaluated as to how well they help users accomplish their goals.
- **Aesthetic dimension:** The aesthetics of an artifact refer to the sensory experience (both formal and sensory) when encountering and using it.
- **Symbolic dimension:** The symbolic dimension of an artifact represents the meanings or associations that are elicited when interacting with the artifact. Symbolism is contextual and is based on subjective interpretation made by users.

4.2 Aspects of Design and Usage

In interpreting the meaning of artifacts, archaeologists differentiate among various aspects. The three-step cognitive is a widely recognized approach in archaeological artifact analysis that follows Peircean semiotic. At the level of the artifact analysis (the "physical find analysis" in archaeology, compared to the "excavation site analysis"), it can be described as follows [43, p. 50]:

- Acquisition: perception, description, recording, coding intrinsic information
- Structuration: partition
- Object reconstitution: intrinsic and extrinsic added explanations

Intrinsic knowledge is "information perceived by an archaeologist about an artifact, formalizing a (and not the) representation of this artifact" (p. 43). The resulting knowledge is shaped by the cognitive interaction between the archaeologist and the artifact. Extrinsic information is recorded from the context of the artifact and results from the precision of an excavation. Intrinsic knowledge can be broadly distinguished into the appearance (design) aspects and the usage aspects.

The "appearance aspect" covers size, material, color, texture, and the underlying technology. It captures the materiality of digital artifacts which can be understood as having a certain degree of durability [53], combining physical and digital elements [41]. The usage aspect relates the digital artifact to its context, including the purpose of the artifact. It highlights the need for a perspective of the artifact-in-use.

Certain properties of digital artifacts impact on how users perceive, interpret, and interact with this technology, and thus impact on the social construction of meaning [48]. These are the symbolic expressions of the technology—its communicative possibilities (sic). What specifically the artifact affords its users depends on the context, including the specific action goals pursued in that context.

4.3 Anticipated and Unanticipated Consequences

Designers when conceiving of digital artifacts imbue the artifact with their vision—their idea of how the artifact should solve a problem or class of problems. Digital artifacts are technologies and as such they always have purpose [10, 54].

There is some agreement in IS research that digital artifacts are not deterministic in the sense that they bring about specific results with certainty [55]. Instead, they are seen as deeply embedded in organizational practice. They provide opportunities for change [56], they provide spaces for organizational action, now typically captured through the notion of affordance [48, 55, 57], and they may impact beyond the envisioned effect boundaries [58].

As a consequence, an archaeology of digital artifacts must attend to both the anticipated and unanticipated consequences of IT adoption and use. The relevance of this perspective is highlighted by the understanding that digital artifacts are malleable and are increasingly part of digital ecosystems which are characterized by emergence, change, and combinatorial innovation [20]. It is noteworthy that by "unanticipated" we do not mean "negative." Many of the consequences of Internet based technologies such as in the sphere of social media were unintended, but have indeed spurred the development of entirely new revenue streams and even industries.

While the designer perspective can only provide insight into anticipated consequences, the user perspective may do both. Still, it is always possible that there are differences between designer intentions and what the user sees in an artifact and its use [59], the analysis of which can provide important insight into how artifacts should be designed if the design archaeologist pays attention to those unanticipated uses.

4.4 Specifying the Unit of Analysis

Clearly, the design archaeologist is confronted with a complex situation when reconstructing the design of artifacts in contemporary organizing, calling for a decomposition of this analytical problem. She needs to clearly define the unit and level of her analysis. First, we contend it to be a strength of an archaeological perspective on design to be potentially able to consider different points of view. The design archaeologist thus needs to decide whether she wants to follow the perspective of the creator/designer or the user of the artifact. This consideration also determines whom to collect empirical data from.

Second, basic assumptions about the nature of the artifact need to be clarified—is it viewed as a static product or a dynamic object that changes across use contexts? In any case we can assume a certain durability and relative stability [60] that makes the artifact amenable for analysis. Finally, the design archaeologist may attend to different material aspects of the digital artifact—most notably its content versus its underlying logics such as algorithms or presentation to users. These can be analytically separated for the purpose of interpretation.

5 A Framework for Design Theorizing from Artifacts

Grounded in our understanding of digital artifacts, design knowledge, and insights from archaeology, we now describe a framework for design theorizing from artifacts. An archaeology of digital artifacts must (1) attend to various analytical dimensions (aesthetic, symbolic, historical, instrumental); (2) consider both aspects of appearance and function; (3) explore both intended and unintended consequences; and (4) be clear about the unit and level of analysis, in terms of points of view (designer vs. user), assumptions, and contents. Together, these dimensions allow us to view the artifact in context and reconstruct its meaning—and in turn derive abstract knowledge about the artifact/class of artifacts. Figure 1 summarizes these ideas.

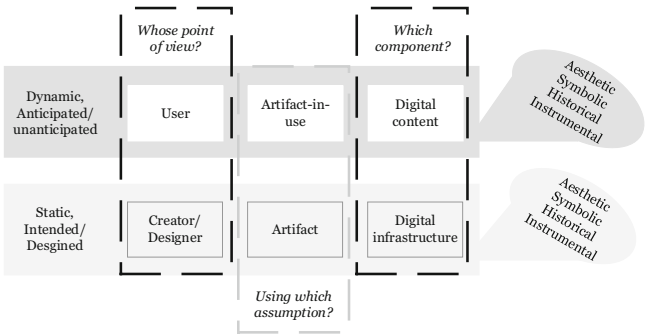

Fig. 1. Towards a design archaeology

We can continue to suggest a set of design principles or guidelines about how to conduct archaeology of digital artifacts:

First, the design archaeologist choses the relevant points of view, assumptions, and components. For instance, she might be interested in how designers and users conceive of an artifact-in-use. From the designer's perspective she may ask what practices the designer envisioned. From a user's perspective she may ask what practices the artifact *actually* allowed for—and why.

Second, the design archaeologist will consider both the appearance of the artifact of interest and its functional aspects. It is necessary to consider simultaneously both dimensions in order to recreate the meaning users assigned to the artifact in context—as well as to consider the designer intentions.

Third, the design archaeologist will consider the digital artifact in focus in terms of instrumental, historical, symbolic, and aesthetic dimensions to construct a holistic understanding that allows her to reconstruct the artifact's meaning in context—including its purpose, performance, and outcomes.

Finally, she will attend to both the intended and unintended consequences and will aim to relate these to the specific design features and underlying design decisions. This approach carries the potential to understand and distinguish "good" design from "bad" design. At the same time, it may reveal unintended positive effects—if the underlying

design decisions are understood this can have important implications for the practice of design. At the same time, this approach may help avoid situations where the archaeology of a design artifact only confirms what practitioners already knew.

Next, we illustrate an application of these principles in the analysis of a particular stress management mobile application.

6 Illustrative Example

One of the coauthors of this essay, in a team of researchers, has conducted an analysis of available mobile applications (apps) that help users to cope with stress [61]. They began with both systematic sampling of apps from major application stores and snowball sampling using reference from online articles on digital stress management. After several screenings, they ended up with more than 100 apps for further analysis. They wanted to find out the theoretical basis for each stress management approach that has been operationalized in the apps. It was clear that they were interested in identifying the intention of the designers of each app. Consequently, the analysis concerned only the anticipated consequences. The following is an excerpt of the analysis protocol for a particular anonymized app as a means of illustration.

- **Digital artifact:** An AI counsellor app.
- **Whose point of view:** They took the designer perspective.
- **Using which assumption:** They assumed the app as a static artifact.
- **Which component:** They were mainly concerned with the content of the app.
- **Instrumental dimension:** The AI counsellor can converse naturally with users. Users can share their thoughts, feelings, and experience in an anonymous, neutral setting and receive uplifting responses from their personal AI counsellor. Users can release their anxiety and plan appropriate mitigation mechanisms. The mitigation mechanisms range from simple daily reminders of activities or events that users have claimed to elicit positive emotions to a step-by-step guide to relaxation.
- **Aesthetics dimension:** Clean layout dominated by bluish green tones. The AI counsellor is represented as a friendly-looking penguin that changes its facial expressions and gestures according to the context of the conversation. The space designed for user interaction with the counsellor looks similar to conventional chat windows.
- **Symbolic dimension:** The penguin character has juvenile features (cuteness) that symbolize openness, friendliness, honesty, non-judgmental attitude, and sincerity. It is expected to make users feel safe within their comfort zone and free to voice their inner thoughts. The conventionally designed chat window lets users feel familiar as if they were talking to a best friend. The color scheme has a calming effect.
- **Historical dimension:** The app was developed as an unexpected outcome of a research project that originally aimed to build machine learning models to detect depression, using sensor feeds from the phone.
- **Unanticipated consequence:** Due to high user acceptance, the mobile app has been used to coach both parents and children in bullying issues.

From the excerpt we see that the principles of design archaeology work well for the analysis of a single artifact. The researchers repeated the same procedure for all apps in the sample to make sense of each of them individually. The design archaeology of individual artifacts was then followed by a cross-case analysis, where they tried to discern similarities and differences among the tools and identify their underlying support mechanisms (consult [61] for a further account on the study).

7 Discussion and Conclusion

This essay takes a step towards a design archaeology in Information Systems DSR. Our analysis is based on the differentiation between (1) digital artifacts as deployed, contextual, and observable configurations of physical and digital materialities and (2) design knowledge as (abstract) knowledge about these artifacts and their construction. We further attend to the context-specificity of digital artifacts, both in terms of past contexts and present contexts. We thus suggest that an analysis of digital artifacts with the purpose of generating abstract design knowledge needs to be an analysis across contexts and across time.

Drawing on insights from the field of archaeology, we suggest that a design archaeology of digital artifacts must consider key analytical dimensions in terms of historical, instrumental, symbolic, and aesthetic dimensions; (1) define the level of analysis including different viewpoints such as designer and user; (2) attend to both functional and symbolic properties of the artifact in its context(s) of use; and (3) attend to both anticipated (intended) and unanticipated (unintended) consequences—both negative and positive.

What we discuss in this essay should be seen as a preliminary step toward a more comprehensive design archaeology approach and its application in DSR research and reporting practice. We identify several important directions for future works. First, we aim to come up with a hands-on framework or template of design archaeology for DSR researchers. Second, we imagine that guidance on how to integrate the results of design archaeology into the DSR body of work would be useful in accommodating diversity in DSR-related publications. Third, we deem it important to discuss the whole spectrum of design archaeology, for instance, how to integrate the analysis of individual artifacts and find patterns to make sense of classes of artifacts.

Summing up, we contend that the systematic observation of designed artifacts and their deployment in organizational and inter-organizational contexts can add an important methodological approach to the toolbox of DSR researchers. The exploration of artifact performances and outcomes that transcend the defined boundary conditions in particular—and the study of how these effects are related to specific design features and design decisions—may create important insight and further our knowledge about the design of digital artifacts. Studying real-world designs of the past and present may open the DSR community towards more like-minded colleagues contributing to the derivation of design knowledge, specifically those with an interest and experience in conducting empirical research. This, in turn, may lead to an increase in contributions to the field, and thus can foster knowledge on solving relevant problems of society.

Acknowledgement. This research is funded by the Research Fund of the University of Liechtenstein (Forschungsförderungsfonds der Universität Liechtenstein).

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