The Origins of Design Principles: Where do… they all come from?

Sandeep Purao[1(✉)], Leona Chandra Kruse[2], and Alexander Maedche[3]

[1] Bentley University, Waltham, USA
spurao@bentley.edu
[2] University of Liechtenstein, Vaduz, Liechtenstein
leona.chandra@uni.li
[3] Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
alexander.maedche@kit.edu

Abstract. This essay reports the results of a reflective study to explore the question: *where do… design principles come from*? While a consensus is slowly emerging about the structure and content of design principles, the origins of design principles remain open to scholarly explorations and debates. Scholars have suggested, and speculated about several paths to identifying design principles, such as reflecting on the design efforts, looking to source theories, and even examining prior design products in an archaeological manner. We bring together these threads to develop a framework that consists of four dimensions, each an unsettled concern: (a) what can and should be the key influences on design principles, (b) when can and should design principles be generated, (c) who can and should identify design principles, and (d) how can and should design principles be documented? Two illustrative examples demonstrate how these dimensions may be used to identify, elaborate and defend the design principles as knowledge outcomes. We conclude by outlining some next steps for deeper, thoughtful investigations of the origins of design principles.

Keywords: Design principles · Origins · Design science research · Framework

1 Motivation

As scholars have continued to engage in design science research (DSR) [12], they have implicitly embraced the spirit of pragmatism [20], and accepted design principles as the predominant way to capture prescriptive knowledge about the design of information systems artifacts [28]. Following their status as a customary and *de facto* norm for documenting and sharing knowledge from a DSR effort, there is an emerging consensus about the content and structure of design principles [4, 15, 27]. Scholars have suggested that such 'design principles' [2] contain wisdom "…about creating other instances of artefacts that belong to the same class" [28]. However, some fundamental questions (about the nature and origins of knowledge in design principles) have remained. We explore one such question in this essay: *design principles: where do… they all come from?*

S. Hofmann et al. (Eds.): DESRIST 2020, LNCS 12388, pp. 183–194, 2020.
https://doi.org/10.1007/978-3-030-64823-7_17

Our question reflects deeper concerns about generating [6] and accumulating prescriptive design knowledge [4] from DSR efforts. These concerns have been the undercurrent of much scholarly work. Consider the following received schemas and wisdom about what constitutes design principles. Sein et al. [28] propose formalization of learning into design principles as part of an action design research approach, suggesting that they should be 'theory-ingrained.' Gregor et al. [16] borrow and extend ideas from the field of architecture to suggest that design principles can and should reflect form and function of the designed artifacts. In [13] design principles are suggested as a way to formalize knowledge gained from DSR efforts.

Precursors to these conceptualizations are ideas that have originated outside the DSR community. Bunge [5] describes technical knowledge and technological rules, and classifies design knowledge into substantive and operative theories. A substantive theory provides knowledge about objects, whereas an operative theory prescribes action. Van Aken [30] suggests a different term for these outcomes: technological rules to characterize products in management research that prescribe courses of action. Gibbons et al. [32] set forth another perspective on this mode of knowledge production, calling it Mode 2 knowledge, and point to the possibilities about how this recognition may reform established practices of scholars. They describe Mode 2 knowledge as problem-based trans-disciplinary knowledge that is heterogeneous, hierarchical, transient, more socially accountable, and reflexive (in contrast to Mode 1 knowledge, which represents traditional scientific knowledge inspired by the Newtonian model). These ideas emphasize how scholars beyond the DSR community have grappled with understanding and representing this new knowledge form that the DSR community calls design principles.

The clearest exposition may be attributed to [27] who mapped design research as ideal-typical mode of research and further developed the idea of knowledge outcomes. They succinctly describe these as design propositions: "in Situation S, to achieve Outcome O, perform Action A." Prior work [10] has built on these precursors to summarize different types of outcomes and knowledge contributions that DSR scholars emphasize. In spite of such efforts, that acknowledge the importance of clarifying such knowledge outcomes, it remains difficult to understand "how to get there." Broad methodological mandates (e.g. [28]) rarely go beyond suggesting reflection, and scholarly debates, while they describe what the design principles may contain [15], do not clearly identify the space of possibilities for discovering and articulating the design principles. Without such guidance, we describe the challenge for DSR scholars in the words of two master songwriters: "*where do … they all come from?*" We hope to provide a first approximation of the key dimensions that define the space of possibilities for discovering design principles, drawing on and extending much prior research.

We proceed as follows. In Sect. 2, we develop a framework defined by four key interrogatives. Section 3 showcases illustrative examples to show how the framework may be used by researchers to make decisions about, and reflect on their decisions to discover design principles. Section 4 provides concluding remarks and points to next steps to guide the investigation.

2 Key Dimensions

To explore the question – *where do … they all come from* – we followed a reflective research approach, treating the design principles as an abstract artifact produced by the DSR scholars. The inputs to our reflective research approach included: (a) a review of work that we have briefly summarized above, (b) an examination of research results published in recent proceedings of the DESRIST conference, and (c) ongoing conversations with scholars within the DSR community who described what we realized may be seen as potentially incompatible approaches to the generation of design principles. Therefore, we do not claim that our effort is driven by a singular or overarching theoretical perspective that may allow us to "derive" the different dimensions. Instead, it is the outcome of reflections that combine knowledge gleaned from the multiple sources we point to above. For example, the review of prior work (source 'a' above) clearly pointed to possibilities for different influences on discovering design principles; the examination of work in proceedings of the design science conference (source 'b' above) revealed clear differences in how different researchers viewed the role of design principles in designs science efforts; and the conversations with scholars in the design science community (source 'c' above) provided insights into how it may be necessary to acknowledge and integrate multiple paths to discovery of design principles. We describe the four dimensions that define our framework as key interrogatives that can define the space for the discovery and generation of design principles. The interrogatives are intended to be inclusive of the set of possibilities. However, we do not yet claim to be comprehensive, i.e., the interrogatives we suggest may not be all-encompassing. With this description and caveats, we turn to the four dimensions. Each is described as an interrogative, and elaborated by drawing on the sources above.

Dimension 1: Influences

- We begin with the first dimension, expressed as the interrogative: *what can and should be the key influences on design principles?*

This interrogative is not about the content of design principles. Instead, it asks us to think about what a DSR scholar may and should consider as inspiration for and/or inputs to the discovery and generation of design principles.

- One source of influence is prior theories (described elsewhere as kernel theories [31]), and acknowledged by DSR scholars as necessary with the phrase "theory-inspired design principles" [28]. These are necessary also because they can provide the justificatory grounding [14, 23].
- Another source that can provide inspiration for the discovery of design principles would be the design effort by the research team, acknowledged in prior work as the need for reflection and formalizing [28]. In essence, engaging in the design effort allows the research team to capture not only what worked, but also what did not work (the so-called blind alleys in a design process).
- A third, somewhat obvious, influence would be the outcome of the design efforts, such as an instantiated artifact [25], along with the features and capabilities of the artifact.

The newly designed IT artifact (and any associated work practices) would be tangible results that future designers may seek. The design researchers may, therefore, look to these as inspiration for the discovery of design principles.

- A final, sometimes overlooked input is likely to be results from formative and summative evaluation as discussed by [4] as essential for design science research. The design researchers may use these results to emphasize those elements from the research effort that have produced the desired outcomes.

It is tempting to categorize these influences (e.g. internal vs. external, or theory-based vs. design-based or in some other manner, for example, following the genres suggested by [1]). We have, instead, favored the enumeration strategy because it allows a more specific examination of the pros and cons for each of these influences, and allows room for dialog. For example, if the research team were to consider only prior theories as the influences on design principles (e.g. [22]), it is possible that they may risk the criticism that the design efforts are merely application of prior research (and therefore, akin to consulting). If the research team argues that only design efforts should be considered as the influence on the design principles, then they face the risk that the work will be described as atheoretical tinkering. On the other hand, if the research team does not consider the influence of research efforts, the design principles may adequately acknowledge or convey the difficulties in moving from the problem space to the solution space. Next, if the research team does not consider evaluation results as part of the effort to formulate the design principles, then their proposals for design principles may be perceived as a version of "trust me" [33]. However, if the research team only describes and relies on practitioner and user inputs to justify the design principles, then they may be criticized for "not asking the why question." This brief contemplation points to the overwhelming sense that these influences and inspirations should not be seen as mutually exclusive. Instead, they represent a multiplicity of opportunities to discover the design principles, which may require iterations to explore each source individually and with one another.

Dimension 2: Temporality

- The second dimension can be expressed as the interrogative: *when can and should design principles be generated?*

This interrogative encourages the research team to consider several alternatives, some that may be closer to the norms that are part of the contemporary practice for conducting design science research, and others that may challenge these norms.

- First, we note that some methodological prescriptions for DSR [33] and action design research (ADR) [28] suggest that the research team should engage in the discovery of design principles as part of their design-evaluate iterations [33] and build-intervene-evaluate (BIE) cycles [28].
- Next, methodological guidance also points to a separate learning and reflection stage [28] that emphasizes the need for considerable refinement and formalization of design principles during this separate stage. The methodological prescriptions do not preclude

both – the derivation of tentative design principles throughout the design research process, and then, the refinement during the final reflection stage with the advantage of hindsight.

- A third possibility as illustrated in [9] and [29] is to formulate the design principles before implementing the artifact. This approach corresponds to what Iivari calls Strategy 1 in DSR [19]. We note the likely overlap between this possibility and the reliance on only one of the many sources (prior theories) we identified as part of the previous dimension.
- A fourth, potentially interesting position may be to consider discovery of design principles after deployment of the artifact. This may be a possibility in projects that follow the ADR [28] approach because of the pre-established working relationship with industry partners.
- A final possibility is one that is put forward by [8], who go beyond the tight coupling between the time for conducting the DSR effort, and the generation of design principles. They suggest returning to influential and/or successful IT artifacts from the past (whether or not they were part of a DSR project) for the purpose of generating design principles (see, e.g. [17]).

The alternatives enumerated above can be examined for appropriateness and effectiveness in a variety of ways. For example, some scholars may argue that reserving the effort needed to generate design principles for the end of the research process would provide the research team the time necessary for careful reflection. Others may argue that doing so only at end of research cycle will mean that the researchers will miss the opportunity for refinement. Researchers engaged in DSR efforts may agree that the design efforts often tend to be time and effort-intensive, and careful reflection may need to wait. However, if the design principles are not outlined (at least in a rudimentary form) during the design-evaluate or BIE cycles, the opportunities to iterate and refine, and incorporate practitioner viewpoints may be missed (see, e.g. [24]). The option to reflect and generate the design principles 'post-deployment' may not be available for all research projects. However, if available, exercising this option may provide the DSR scholars with new ideas about what the deployment effort may reveal, beyond a proof-of-concept. The final alternative aimed at generating design principles from past influential and/or successful IT artifacts following an archaeological approach may present valuable opportunities for design science because it may allow them to build a body of knowledge from these successful efforts [17]. However, this option may be critiqued because it will limit the ability to capture the design principles during the design effort and instead, force the researchers to rely only on the artifact and its use. In the absence of a window into the underlying design processes, the effort to capture design principles may face the iceberg effect [18], where only the tip of the efforts and features may be visible to the researchers who visit the artifact, with significant details and efforts hidden from the view.

Dimension 3: Actors

- This dimension can be expressed as the interrogative that asks the researchers to carefully consider: *who can and should identify design principles?*

This interrogative is aimed at considering the different actors who may be involved in the generation of design principles. These may be different actors involved in the DSR efforts, with the word 'artiste' indicating the need to consider the unstructured, craft component necessary in this effort.

- One straightforward response to this interrogative may be that it is the researchers engaged in the DSR effort who would be responsible for and in the best position for identifying and articulating design principles. Methodological prescriptions [28] implicitly grant this role to the DSR team.
- However, such a response may negate the possibility for incorporating inputs from users or practitioners who may provide valuable insights. Consider, for example, an IT artifact that addresses a concern related to healthcare delivery [35] or one that is related to sustainability and climate change [29]. In such cases, it may be critical to collaborate with relevant stakeholders (e.g., physicians, nurses, and employees involved in a sustainability initiative) for the discovery of design principles, to ensure that they acknowledge the domain knowledge.
- A third possibility may be to either expand the research team to include new academic partners, or even hand over the responsibility for articulating the design principles to an entirely new team of scholars.

The accepted norm within the DSR community suggests that the specific task of generating design principles is often taken on by the DSR team [3], sometimes, with the addition of new actors added to the research team [24]. The clear advantage for the research team itself to engage in the derivation of design principles is that members of the team are intimately familiar with the research, and therefore, in the best position to discover the design principles. On the other hand, it may be argued the research team may be 'too close to the effort,' and therefore, may not be best placed to engage in the reflection necessary for identifying design principles. The addition of new partners to the research team (new DSR scholars and/or domain experts) may help with this concern. The addition of new scholars familiar with prior theories may be of value in the task of generating design principles. A logical extreme for this position (handing over this responsibility to a new research team) may, however, present some difficulties. It is likely that such hand-over will promote greater reflection. However, the lack of context and not having access to lessons learned during the DSR effort may result in design principles that may be more rigorously connected to prior theory but less grounded in the design effort. These opportunities and concerns may also apply if an archaeological approach is used to generating design principles from past IT artifacts (owing to the iceberg effect mentioned earlier), even though the approach also advocates collecting hindsights from the designers who built the artifacts [7].

Dimension 4: Content

- The final dimension can be expressed as the interrogative: *how can and should design principles be documented?*

This concern has been the topic of much exploration within the DSR community as well as in other disciplines, perhaps because it deals with ideas of content and structure and therefore, more stable (as a result, more directly amenable to scientific inquiry). The content of design principles reflects "what should be articulated in a design principle," and the container refers to "how it should be packaged."

- One dominant alternative here is the formulation by [27] that we have described earlier, copied here for ease of reference: "in [situation] S, to achieve [outcome] O, perform [Action] A."
- Another possibility is to follow the distinction that is suggested in [13]: form vs. function. Here, it is described how the content of design principles may focus on either the structure (form) of the artifact or the capabilities (function) of the artifact.
- We note that a more common format of design principles has, however, been simple assertions, where the DSR team provides a simple articulation without placing these design principles in different categories.
- Elsewhere, more elaborate structures have been proposed for different kinds of design principles [6] such as materiality-oriented and action-oriented design principles.
- A more recent work includes a schema that captures the anatomy of a design principle [15]. It suggests: "For Implementer I to achieve or allow Aim A for User U in Context C employ Mechanisms M1, M2, M3…. involving Enactors E1, E2, E3,… because of Rationale R".

These options may orient a DSR team to consider different possibilities for articulating design principles. It is possible that a simple and straightforward criterion for the DSR team may be easier to follow. A more nuanced and detailed representation of design principles would require greater effort from the DSR team. It may also add a level of specificity that makes the actual use of design principles more challenging for practitioners. On the other hand, it may provide the DSR community a more precise articulation of knowledge gleaned from the DSR effort, and therefore, greater opportunities for accumulation of knowledge across projects. This may explain why a number of DSR projects still continue to articulate the design principles as a simple set of assertions without any of the structures that have been suggested by [6, 13, 27] or others. Figure 1 summarizes the four dimensions.

We emphasize that these four dimensions are not intended to be comprehensive. As described earlier, our work has followed a reflective research approach drawing on (a) prior work related to design science research, (b) outcomes from design science research published in design science conferences, and (c) ongoing conversations with scholars in the design science community. We add that the dimensions may not be seen as independent. A decision along one of the dimensions may suggest appropriate possibilities or constraints for another dimension. As an example, the decision to expand the research team by adding new researchers for the purpose of identifying design principles *may* lead to acknowledging a greater influence of prior theories on the generation of design principles. We turn next to two illustrations.

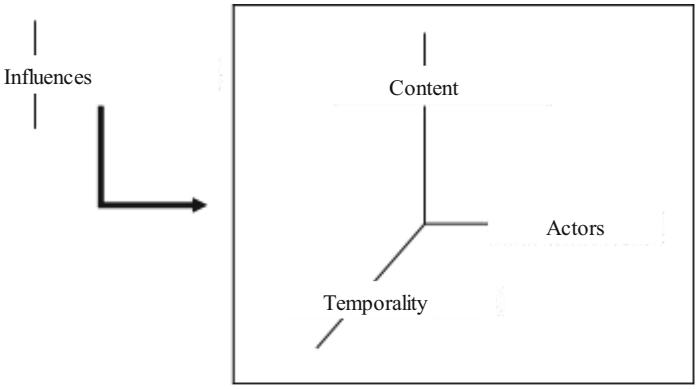

Fig. 1. The four dimensions

3 Illustrative Examples

To illustrate the potential of the dimensions proposed, we refer to two recently published papers in the Design Science conference that describe DSR projects, and present design principles derived from the DSR efforts.

The first describes a DSR project to design conversational agents for energy feedback [11]. The starting point for the effort was prior empirical studies that have shown that providing feedback can encourage consumers to use energy more sustainably. With this starting point, the DSR effort investigated how conversational agents (such as chatbots) can be designed for energy feedback with a natural and intuitive interface. The paper presented design principles based on existing literature, instantiated these in a text-based conversational agent and evaluated in a focus group session with industry experts (Table 1).

Table 1. Example 1 - energy feedback with conversational agents

Category	Description
Project	Design energy feedback with conversational agents
Artifact	Conversational Agent
Evaluation	Focus group evaluation with practitioners
Prior Theories	Feedback theory
Stakeholders	Consumers, Utility service provider

The second illustration highlights a DSR study that was aimed at supporting organizational sensemaking as part of sustainability transformation [29]. The researchers did so by developing design principles for a sensemaking support platform and refining them in three iteration rounds. Table 2 summarizes the general information about this study.

Table 2. Example 2 – supporting sensemaking for organizational transformation

Category	Description
Project	Supporting organizational sensemaking in sustainability transformation
Artifact	A sensemaking support systems
Evaluation	Focus group evaluation with stakeholders, analyzing log data
Prior Theories	Sensemaking, the role of IS in sensemaking, affordance,
Stakeholders	Every organization member

Table 3. Using the dimensions for example 1

Dimension	Application
Influences	The design principles *followed tenets of feedback theory*, and how these could be used for the specific domain: feedback about energy use
Temporality	Initial, tentative versions of design principles were formulated *before design*, they guided the design and research activities, and were *revised*
Actors	Junior researchers within *the research team* formulated initial versions, which were then refined by more experienced researchers. Final versions were *tested with representatives from an industry partner*
Content	*The format* proposed by [Chandra et al. 2015] was used as a skeleton to articulate the design principles. The design principles were subjected to informal evaluation via focus groups with the stakeholders

Table 4. Using the dimensions for example 2

Dimension	Application
Influences	Initial design principles were formulated based on *kernel theories* of sensemaking process. The final versions were influenced through *iteration* and evaluation
Temporality	Initial design principles *before design and implementation*. The DSR team kept *refining* those principles during design, implementation, and evaluation
Actors	*The research team* formulated the initial design principles. The final set of design principles resulted from several evaluations and iterations that *involved stakeholders*
Content	*A specific format* [Chandra et al. 2015] was followed to describe both user activities and the key functionalities of the sensemaking support platform

We explore how each interrogative dimension can be used to understand how the research team identified design principles from the DSR efforts (Tables 3 and 4).

The examples illustrate how the dimensions we have outlined may be used to understand and appreciate the choices that the research team would make for identification of design principles.

4 Next Steps

The question we have explored in this paper is a difficult one – partly because most of us may believe we already know the answer, and partly because it is difficult to peel back the layers of uncertainty that researchers face. Although some prior work such as [15] has tackled design principles in depth, and others have identified different genres (e.g. [1]), it has been difficult to chart out the terrain in a pragmatic manner so that the alternatives that design science researchers face can be laid bare. The emerging consensus is providing some guidance about the structure of design principles [15], but empirical studies about the use of design principles continue to point to new puzzles [7]. An exercise to explore the origins of design principles cannot, therefore, be merely driven from a theoretical perspective. It must respond to the challenges that design science researchers face as they engage in DSR efforts. What makes these challenges especially complex is that the concerns are often resolved by the researchers within the specific research context, but the researchers find it difficult to articulate a general version of the concerns. This is precisely our effort with the dimensions and the interrogatives. Our effort is, therefore, to consciously avoid starting with concepts such as affordances or materiality (see discussion in [6]) and map these towards possible operationalizations. Instead, we have attempted an approach that starts with the simple interrogatives, the questions that the design science researchers face, in a bottom-up approach that respects the pragmatic starting points that the DSR community has adopted. When a DSR team engages in a design science project, the immediate challenges are rarely about generating design principles (see, e.g. [21]). Although the team acknowledges the need to extract and articulate design principles as a way of generating knowledge, the immediate challenges are often about choice of technology layers, dealing with external stakeholders, obtaining and managing the resources needed for research conduct. As the research team addresses these challenges, it is important to be aware of dimensions that they should consider so that the eventual knowledge outcomes – design principles – can be discovered, captured, articulated and defended. The interrogatives we have suggested can provide these starting points.

Our effort has been to explore the origins of design principles. To paraphrase the words of two master songwriters[1], we have posed the question: "all the lonely Design Principles – where do they all come from? all the lonely Design Principles – where do they all belong?" This, in turn, has allowed us follow a reflective research approach and identify four dimensions that define key decisions that the research team may make to obtain these answers. The dimensions we have identified point to several configurations. We note that these dimensions are meant as a guideline and should not be followed blindly so as to restrict future work. The paper identifies and describes these four dimensions, which a DSR team may use to reflect on possible configurations. By examining these,

[1] These are lines from the song Eleanor Rigby, in the Album Revolver, lyricists: John Lennon and Paul McCartney.

a DSR team would then be able to identify and/or evaluate the options for discovery of design principles. There are considerations that the design science researcher may use, such as the maturity of the project [13], progression towards a meso-level theory [34], whether the project fits a particular quadrant (e.g. exaptation) suggested by [13], and others. Exploring these possibilities remains on our future agenda.

References

1. Baskerville, R.L., Myers, M.D.: Design ethnography in information systems. Inf. Syst. J. **25**, 23–46 (2015)
2. Baskerville, R., Pries-Heje, J.: Explanatory design theory. Bus. Inf. Syst. Eng. **5**, 271–282 (2010)
3. Blaschke, M., Riss, U., Haki, K., Aier, S.: Design principles for digital value co-creation networks: a service-dominant logic perspective. Electron. Markets **29**(3), 443–472 (2019). https://doi.org/10.1007/s12525-019-00356-9
4. vom Brocke, J., Winter, R., Hevner, A., Maedche, A.: Accumulation and evolution of design knowledge in design science research – a journey through time and space. Assoc. Inf. Syst. (2020)
5. Bunge, M.: Scientific Research II: The Search for Truth. Studies in the Foundations Methodology and Philosophy of Science. vol. 3/II. Springer, New York (1967)
6. Chandra, L., Seidel, S., Gregor, S.: Prescriptive knowledge in IS research: conceptualizing design principles in terms of materiality, action, and boundary conditions. In: 48th Hawaii International Conference on System Sciences, pp. 4039–4048 (2015)
7. Chandra Kruse, L., Seidel, S., Purao, S.: Making *Use* of Design Principles. In: Parsons, J., Tuunanen, T., Venable, J., Donnellan, B., Helfert, M., Kenneally, J. (eds.) DESRIST 2016. LNCS, vol. 9661, pp. 37–51. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-39294-3_3
8. Chandra Kruse, L., Seidel, S., vom Brocke, J.: Design archaeology: generating design knowledge from real-world artifact design. In: Tulu, B., Djamasbi, S., Leroy, G. (eds.) DESRIST 2019. LNCS, vol. 11491, pp. 32–45. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-19504-5_3
9. Chanson, M., Bogner, A., Bilgeri, D., Fleisch, E., Wortmann, F.: Blockchain for the IoT: privacy-preserving protection of sensor data. J. Assoc. Inf. Syst. **20**(9), 1274–1309 (2019)
10. Dwivedi, N., Purao, S., Straub, Detmar W.: Knowledge contributions in design science research: a meta-analysis. In: Tremblay, M.C., VanderMeer, D., Rothenberger, M., Gupta, A., Yoon, V. (eds.) DESRIST 2014. LNCS, vol. 8463, pp. 115–131. Springer, Cham (2014). https://doi.org/10.1007/978-3-319-06701-8_8
11. Gnewuch, U., Morana, S., Heckmann, C., Maedche, A.: Designing conversational agents for energy feedback. In: Chatterjee, S., Dutta, K., Sundarraj, Rangaraja P. (eds.) DESRIST 2018. LNCS, vol. 10844, pp. 18–33. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-91800-6_2
12. Goes, P.B.: Design science research in top information systems journals. MIS Q. **38**(1), iii–viii (2014)
13. Gregor, S., Hevner, A.R.: Positioning and presenting design science research for maximum impact. MIS Q. **37**, 337–355 (2013)
14. Gregor, S., Jones, D.: The anatomy of a design theory. J. Assoc. Inf. Syst. **8**, 313–335 (2007)
15. Gregor, S., Chandra Kruse, L., Seidel, S.: The anatomy of a design principle. J. Assoc. Inf. Syst. (2020)

16. Gregor, S., Müller, O., Seidel, S.: Reflection, abstraction and theorizing in design and development research. In: Proceedings of the European Conference on Information Systems, Milan (2013)
17. Hanseth, O., Lyytinen, K.: Design theory for dynamic complexity in information infrastructures: the case of building internet. J. Inf. Tech. **25**(1), 1–19 (2010)
18. Herskovic, V., Ochoa, S.F., Pino, J.A., Neyem, H.A.: The iceberg effect: behind the user interface of mobile collaborative systems. J. UCS **17**(2), 183–201 (2011)
19. Iivari, J.: Distinguishing and contrasting two strategies for design science research. Eur. J. Inf. Syst. **24**(1), 107–115 (2015)
20. James, W.: Pragmatism: a new name for some old ways of thinking (1907). https://en.wikisource.org/wiki/Pragmatism:_A_New_Name_for_Some_Old_Ways_of_Thinking
21. Janiesch, C., Rosenkranz, C., Scholten, U.: An information systems design theory for service network effects. J. Assoc. Inf. Syst. (2019)
22. Johnson, J.: Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Guidelines. Elsevier, Boston (2013)
23. Lidwell, W., Holden, K., Butler, J.: Universal principles of design, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design. Rockport Pub. (2010)
24. Lukyanenko, R., Parsons, J., Wiersma, Y., Wachinger, G., Huber, B., Meldt, R.: Representing crowd knowledge: guidelines for conceptual modeling of user-generated content. J. Assoc. Inf. Syst. **18**(4), 2 (2017)
25. March, S.T., Smith, G.F.: Design and natural science research on information technology. DSS **15**, 251–266 (1995)
26. Peffers, K., Tuunanen, T., Rothenberger, M., Chatterjee, S.: A design science research methodology for information systems research. J. Manage. Inf. Syst. **24**(3), 45–77 (2008)
27. Romme, A.G.L., Endenburg, G.: Construction principles and design rules in the case of circular design. Org. Sc. **17**, 287–297 (2006)
28. Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R.: Action design research. MIS Q. **35**, 37–56 (2011)
29. Seidel, S., Chandra Kruse, L., Székely, N., Gau, M., Stieger, D.: Design principles for sensemaking support systems in environmental sustainability transformations. Eur. J. Inf. Syst. **27**(2), 221–247 (2018)
30. Van Aken, J.E.V.: Management research based on the paradigm of the design sciences: the quest for field-tested and grounded technological rules. J. M. Stud. **41**(2), 219–246 (2004)
31. Walls, J.G., Widmeyer, G.R., El Sawy, O.A.: Building an information system design theory for vigilant EIS. Inf. Syst. Res. **3**, 36–59 (1992)
32. Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M. The new production of knowledge: The dynamics of science and research in contemporary societies. Sage Publications, Inc. (1994)
33. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Q. **28**(1), 75–106 (2004)
34. Kuechler, B., Vaishnavi, V.: On theory development in design science research: anatomy of a research project. Eur. J. Inf. Syst. **17**(5), 489–504 (2008)
35. Gaudioso, C., Jain, H., Purao, S.: A patient-centered CDSS for cancer treatment decisions. Paper presented at the Pre-ICIS Workshop on Information Technologies and Systems, Dublin (2016)