



The DSR grid: six core dimensions for effectively planning and communicating design science research projects

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Introduction

The goal of design science research (DSR) is to generate prescriptive knowledge about the design of Information Systems (IS) artifacts like software, methods, models, and concepts (Hevner et al. 2004). In a wider sense, DSR intends to generate design knowledge, that is, knowledge about innovative solutions to real-world problems (vom Brocke et al. 2019). As such, DSR is considered particularly promising regarding its ability to contribute to practice through such means as digital innovation (Rai 2017) and to address our society's (grand) challenges (Becker et al. 2015), such as that of ensuring environmental sustainability (Loos et al. 2011; Pernici et al. 2012; vom Brocke and Seidel 2012).

Each DSR project is a complex matter with many aspects that must be considered. DSR is an iterative process, starting with the identification of a problem in the problem space and evaluating alternative solutions in the solution space. Through multiple iterations, a DSR project seeks to contribute means-end relationships between problem and solution spaces (Venable 2006). All DSR activities must be aligned to such intended contributions so

modifications in such positioning lead to subsequent changes in how to scope and plan a DSR project.

Multiple stakeholders are often involved in conducting DSR project, which makes it important to coordinate and communicate DSR research (vom Brocke and Lippe 2010). Stakeholders of DSR projects include researchers, industry partners, and editors. These roles should be considered in any DSR project e.g. in terms of their focus (e.g., domain expert or method expert) and seniority (e.g., Ph.D. student, Ph.D. supervisor). Such multi-stakeholder collaboration makes it important to communicate the manifold considerations of a DSR project in an efficient way. Based on our own experience as editors of DSR special issues, conferences and tracks, directors of many DSR projects and research programs, and mentors of Ph.D. students on DSR projects, we see great value in high-level representations of a DSR project that make it possible to capture on one page the project's key aspects.

Therefore, this article identifies six core dimensions of a DSR project that can lay the foundation for a high-level, one-page framework that describes DSR projects. Similar approaches have been presented in other areas of research, including conceptual modeling (Frank et al. 2014) and reference modeling (vom Brocke 2007), where frameworks (specifically, process frameworks) provide a high-level conceptualization of various parts of more complex models (vom Brocke and Buddendick 2006; Legner et al. 2019), and business modeling, where the business model canvas (BMC) in particular provides a high-level conceptualization of the information needed to plan and communicate business models (Osterwalder and Pigneur 2010). Recently, we have seen an increase in contributions that have suggested canvas models, also referred to as visual inquiry tools, for many areas, and that have suggested principles for canvas design in general terms (Avdiji et al. 2019). In the DSR literature, too,

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high-level conceptualizations have been suggested for different purposes like the Portraying Design Essence (PDE) approach's (Chandra Kruse and Nickerson 2018) goal of capturing design knowledge so as to share it eventually with other designers, and the design canvas's goal of describing DSR projects in the DSR toolset "MyDesignProcess.com" (Morana et al. 2018). The present article presents the essential conceptual entities that are relevant to capturing DSR projects and that serve as components from which researchers can choose when they are, for instance, developing their own frameworks or canvasses. We focus on essential conceptual entities rather than suggesting a rigid template structure because, depending on the purpose for and context of communicating a DSR project, adaptations to the structure may be needed.

The remainder of this article is structured as follows: First, we provide background in the form of extant work on the creation of design knowledge (DK) through DSR projects. Then we present the six core dimensions of a DSR project and describe each in detail. Next, we illustrate the six dimensions by means of exemplary DSR projects using the DSR projects presented this special issue, which also gives us the opportunity to provide an overview of the articles. Finally, we discuss implications and conclude our work.

Design knowledge creation in DSR projects

A DSR project seeks to generate DK, so to identify the dimensions of a DSR project for the purpose of planning and communicating, we look at what constitutes DK and what forms it can take. DK refers to means-end relationships between problem and solution spaces (Venable 2006). Vom Brocke et al. (2019) presented a model that describes three essential components of DK—problem, solution, and evaluation—so DK is a statement about the extent to which a solution solves a problem according to an identified level of confidence, measured by evaluation. As such, DK can be represented by various means, two of which—design entities and design theories—have been distinguished in the literature (Drechsler and Hevner 2018). Design entities are design artifacts like constructs, models, methods and instantiations, design processes, and artifact evolution processes. Design entities are the result of design processes but they can also be applied in design processes. A design theory is a set of principles and knowledge that describes and guides the development of a design artifact to attain a specific goal in the material world (Gregor and Jones 2007). It is the result of theorizing about design processes in that it makes statements about the relationships between design decisions and related effects in context. Design theories have been distinguished that address knowledge for action, knowledge for instantiation, and knowledge for design processes (Drechsler and Hevner 2018).

In simple terms, a DSR project can make two types of contributions—it can contribute to design entities or to design theory—and conducting design processes in search of solutions to problems and theorizing about such processes are what lead to these contributions. The two type of contributions and related activities are illustrated in Fig. 1.

Early contributions to DSR focused on contributions to design entities (e.g., Hevner et al. 2004 and Peffers et al. 2007). Then Gregor and Jones (2007) introduced the idea of DSR projects' producing design theory and conceptualized the anatomy of a design theory by means of six core components: purpose and scope, constructs, principle of form and function, artifact mutability, testable propositions, and justificatory knowledge (Gregor and Jones 2007). Then Gregor and Hevner (2015) outlined how both types of contributions relate to each another and how a DSR project can go beyond the design of design entities to contribute to design theory by theorizing about the design science process and the evaluation result achieved (Gregor and Hevner 2015). More recently Chandra Kruse et al. (2019) suggested a third type of DSR project that builds on design processes that are not conducted as part of the DSR project itself but at another place and time. Such research opens DSR projects up to theorize about design that is not motivated by research but by something that happened in, for example, industry or society. Drawing from archeology research, researchers have described methods for investigating design processes and artifacts empirically to generate DK. In short, three types of DSR projects can be differentiated regarding the contribution they intend to make to DK: (1) projects that contribute to design entities, (2) projects that contribute to both design entities and design theory, and (3) projects that contribute to design theory without developing a design entity as part of the same project.

Given the complexity of DSR projects and the various ways a DSR project might contribute to DK, how comprehensively and effectively a DSR project is planned and communicated can effect its likelihood of success. Such planning and communication enables researchers to reflect on and receive feedback about their DSR project in its early stages and to question and update their scope as they progress in the project. Therefore, we present the six core dimensions of a DSR project, which facilitate the effort to describe a DSR project on one page.

Knowledge	Activity	Projects	
Design Theory	Design Theorizing	3	2
Design Entities	Design Processing	1	

Fig. 1 DSR projects' contributions to design knowledge

Core dimensions of DSR projects

We present six core dimensions of each DSR project, which can have different orders and weight but are all essential to describe a DSR project comprehensively and communicate it effectively:

- Problem description
- Input knowledge
- Research process
- Key concepts
- Solution description
- Output knowledge

To visualize the six core dimensions, we chose a structure that supports the dimensions' use from various perspectives as well as the adjustment and extension of the dimensions themselves: a "grid" in which all elements are equally important and can be moved around and arranged based on the project's specific purposes. Figure 2 illustrates the DSR Grid.

Problem description What is the problem for which a DSR project must identify possible solution? Problems should be formulated by means of problem statements and characterized by positioning the problem in a problem space. Research has identified the context, described by the domain, the stakeholder, time and place, and goodness criteria, the last of which tells when a problem should be considered solved, as necessary to capture the problem appropriately (vom Brocke et al. 2019).

Input knowledge What prior knowledge will be used in the DSR project? Gregor and Hevner (2015) differentiated between Ω -knowledge and λ -knowledge, the first being descriptive, explanatory, or predictive, and the second being prescriptive (Gregor and Hevner 2015). Three types input—kernel theories, design theories, and design entities—can be differentiated for high-level communication about DSR projects.

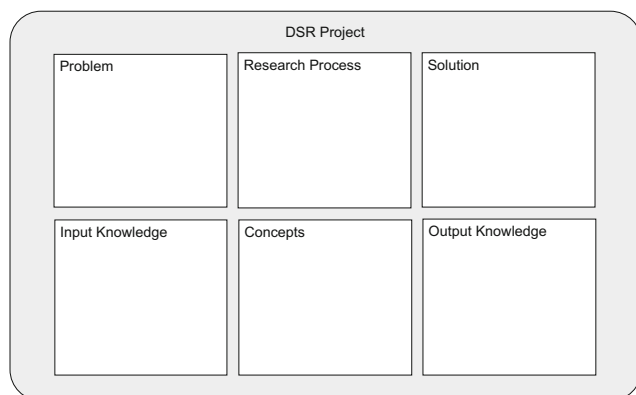


Fig. 2 DSR grid comprised of the six core dimensions of a DSR project (tiles can be moved around and extended)

Research process What are the essential activities planned (or conducted) to make the intended contribution? When the intended contribution is design entities, the process includes build- and evaluate activities (Hevner et al. 2004). We include all activities that are conducted as part of the DSR project; in particular, these activities also include grounding the design (vom Brocke et al. 2019) by, for example, conducting literature reviews (Webster and Watson 2002; vom Brocke et al. 2015), and meta-analysis (Denyer et al. 2008). We report on the build- and evaluation activities in one process since these activities are highly intertwined. Doing so also reflects the increasing consideration of concurrent evaluation and design in DSR (Sonnenberg and vom Brocke 2012). DSR tools have been developed (vom Brocke et al. 2017, Morana et al. 2018) to keep logs of the research process; such logs can complement a high-level list of research activities used to scope the DSR project in the process dimension. The process documented here may also include activities for theorizing about the design. While activities for processing the design can draw from DSR process models like the Peffers et al. (2007) model, activities for theorizing can draw from various research methods and strategies of inquiry, such as qualitative and quantitative empirical research.

Key concepts What are the most important concepts used in the research performed in the DSR project? The words used to describe the research, such as the problem and solution space that the DSR project focuses on, as well as the concepts used to describe the process and input and output knowledge must be defined clearly. A clear definition of the key concepts is particularly important to ensure a rigorous execution of the evaluation activities.

Solution description What is the solution to the problem being investigated by a DSR project? The solution description clearly states the essential mechanisms of the solution (vom Brocke et al. 2019) and how the solution is positioned in solution space by characterizing its representation as a construct, a model, a method, an instantiation, or a design theory.

Output knowledge What knowledge is produced in the DSR project? Naturally, DSR projects produce DK, classified as λ -knowledge (Gregor and Hevner 2015), but in contrast to the solution description, the DK generated through the project puts the problem and solution spaces in relation to each other (vom Brocke et al. 2019). If a DSR project does not intend to generate design theory but to generate design entities, the description of such entities does not constitute DK, as it is only the results of the design entity's evaluation in context that constitute DK. These results are then documented as output knowledge when the project is described.

Factors like the phase of the project (e.g., early planning or documenting completed research) and the stakeholder group (e.g., industry partners or editors) determine the perspectives

from which and the detail with which the six dimensions may be described. Multiple versions of the dimensions will usually be created in iterations as a project progresses, but referring to the dimensions helps researchers to consider the core aspects of a DSR project from the outset and to discuss these aspects with stakeholder groups to shape the project's profile further as it goes along.

The papers of the special issue

This special issue includes four articles that reports on DSR projects conducted in the research field of electronic markets, specifically the networked economy. We use the six core dimensions to structure how we present and outline the papers, specifically referring to the problem, the solution, the design process, the input knowledge used, and the output knowledge generated. For one of the articles, we also provide the DSR Grid. In introducing the papers in this way, we demonstrate the use and usefulness of the six dimensions for capturing a DSR project effectively.

The paper “System dynamics for corporate business model innovation” is co-authored by Thomas Moellers and Oliver Gassmann of the University of St. Gallen, Lars von der Burg from the Boston Consulting Group, and Bastian Bansemir and Max Pretzl from the BMW Group (Moellers et al. 2019). The paper addresses the problem of the lack of understanding about the environmental dynamics that are relevant to the performance of BMW's business model. The authors present “System Dynamics,” a computational approach to supporting sound decision-making during business model innovation. Five cases that leverage “System Dynamics” for business model innovation at BMW are investigated, and valuable practical and theoretical insights are derived.

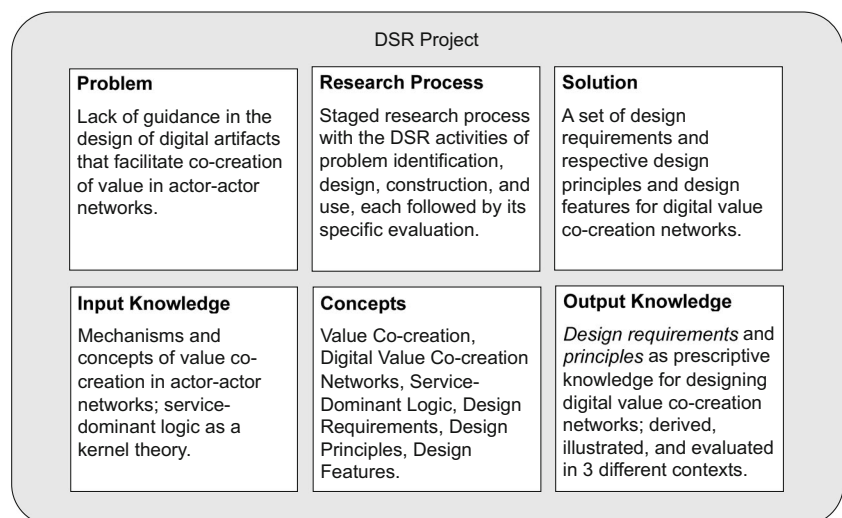
The position paper by Alan Hevner from the University of South Florida and Onkar Malgonde from Northern Illinois

University, “Effectual application development on digital platforms” argues that software development on digital platforms is faced with unique challenges and requires new approaches to be successful (Hevner and Malgonde 2019). The paper suggests a new and innovative approach for effectual application development on digital platforms that is based on the theory of effectuation from the entrepreneurship research field. The digital platform Apache Cordova is investigated, and preliminary findings show promising evidence for the potential of effectual application development methods on digital platforms.

“Design principles for a hybrid intelligence decision support system for business model validation” from Dominik Dellermann, Nikolaus Lipusch, Philipp Ebel, and Jan Marco Leimeister from the University of Kassel and the University of St. Gallen addresses the problem of how to support entrepreneurs in collecting information as part of the business model development process to reduce uncertainty in decision-making (Dellermann et al. 2019). As a key result of the DSR process, they present the artifact HI-DSS, a hybrid intelligence decision support system that integrates human and machine intelligence. They also derive prescriptive knowledge in the form of a set of design principles.

Finally, “Design Principles for Digital Value Co-Creation Networks—A Service-dominant Logic Perspective” by Michael R. Blaschke of the University of St. Gallen, Uwe V. Riss or the University of Hertfordshire, and M. Kazem Haki and Stephan Aier, both of the University of St. Gallen focusses on the problem of a lack of guidance in the design of digital artifacts that facilitate co-creation of value in actor-actor networks (Blaschke et al. 2019). The authors use a straightforward design process to develop a set of design requirements and related design principles and design features for digital value co-creation networks. For demonstration purposes, we present the six core elements capturing this project in form of a DSR Grid (Fig. 3).

Fig. 3 A DSR grid for “design principles for digital value co-creation networks—a service-dominant logic perspective” (Blaschke et al. 2019)



Implications

An abridged version of a DSR project's core dimensions can support the planning of and communication about the project. For instance, such an abridged version can communicate quickly where a DSR project intends to contribute—to design entities (type 1), design entities and design theory (type 2), or design theory without design entities (type 3)—and the information provided regarding each dimension may vary accordingly. For example, in the case of type 1 contributions the output knowledge outlines evaluation results; in the case of type 3 contributions, the problem and solution dimensions can state which design artifacts have been studied to derive design theory; and in the case of type 2 contributions, what solutions have been developed for what problems according to which process and which outcome knowledge is intended to be derived can be stated. The key concepts are useful in clarifying the terminology used, and the input knowledge shows what informs the generation of DK in the DSR project.

The six core dimensions, visualized in the form of a DSR Grid, can also help designers decide which contribution to make in a DSR project. Based on an assessment of the research context in terms of the six dimensions, an account of the extant knowledge can be generated, such as that regarding the amount and quality of the design entities that are available in the problem and solution spaces. A large number of available entities may suggest theorizing, while a small number may suggest developing entities. Likewise, high context dependency or a highly dynamic problem and solution space may call for developing situated design entities, while a more established and durable problem and solution space may suggest formulating DK in the form of design theory. Likewise, choosing a type of design entity to be developed in a DSR project may be informed by the context. For example, the development of models might be chosen in spaces where solutions can be described in sufficient detail, while the development of methods may be chosen in spaces that have many contextual constraints, so the method would guide the development of a solution in context.

The six dimensions of a DSR project are useful for researchers, stakeholders, editors and reviewers as well as readers:

Researchers The six dimensions of a DSR project help researchers improve how they plan their DSR projects. When a researcher embarks on a DSR project, the kind of contribution the project will make is often unclear. Clearly formulating the problem space positions the research so ideas for solutions can be considered. Revising how the problem is understood is part of progressing through the stages of the DSR project. Using extant DK in the field, researchers can plan to make a contribution to design entities, to design theory, or both; the research process depends heavily on this decision. Multiple

iterations of descriptions of the six dimensions help to improve how the DSR project is scoped and to align the relevant research activities accordingly.

Project partners DSR often involves multiple stakeholders (vom Brocke & Lippe 2010, 2016), so a description of the six dimensions helps to align the views of the stakeholder groups involved from both academia and practice. In this regard, descriptions of the six dimensions serve as boundary objects to facilitate discourse about how to scope and plan a DSR project. Thus, expectations management is supported so, for instance, Ph.D. students can align their goals with their supervisors and project partners alike, mitigating risk (Venable et al. 2019).

Editors and reviewers The six dimensions of a DSR project also facilitate dialogue with editors and reviewers, as the most important aspects of complex DSR projects can be characterized efficiently. Before going into detail, DSR contributions can be characterized based on a description of the six dimensions, facilitating communication and negotiation of the research's overall contribution and arrangement of activities. For example, providing a brief description of the six dimensions when submitting an article for publication can increase the efficiency and effectiveness of review processes, as the intended contribution and parts of a DSR project that lead to that contribution are communicated clearly.

Readers Characterizing a DSR project in terms of the six dimensions facilitates readers' ability to evaluate quickly to what extent an article relates to their interests. For that purpose, abstracts could be structured according to the six dimensions, or an appendix can characterize a DSR project accordingly.

The community as a whole The six dimensions can lay the foundation for developing a metadata-based descriptor for DSR projects, making it easier for researchers to find extant studies that are relevant to their projects. In that sense, characterizing DSR projects in terms of the six dimensions may foster reuse of extant contributions, thus furthering knowledge accumulation and evolution in the field. The more we are aware of and build on extant contributions, the better the quality and the greater the impact of new contributions will be, strengthening the societal contribution of our research.

Conclusion

We described six core dimensions to use in planning and communicating DSR projects: Problem description, solution description, key concepts, input knowledge, output knowledge, and research process. Given the complex

nature of DSR projects, we suggest a high-level characterization of a DSR project using these dimensions to improve how DSR projects are scoped, to align stakeholders, and to facilitate continuous questioning and readjustment of the project's scope. We ground the six dimensions in the literature on DK and identify two distinct contributions a DSR project can make, contributions to design entities and contributions to design theory. These two types of contributions lead to three types of DSR projects: those that contribute to design entities, those that contribute to both design entities and design theory, and those that contribute to design theory without developing design entities as part of the DSR project. We suggest a visualization of the six core dimensions in the form of a DSR Grid, which allows for a one-page visualization of a DSR project and is adjustable and extendable to the various purposes of DSR projects. We also illustrate the six dimensions of a DSR project based on the articles published in this special issue and discuss implications in general, as well as implications for researchers, project partners, editors and reviewers, readers, and the community as a whole.

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