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A MULTI-PERSPECTIVE FRAMEWORK FOR THE INVESTIGATION OF TOOL SUPPORT FOR DESIGN SCIENCE RESEARCH

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Research paper

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Abstract

Tool support for design science research (DSR) is increasingly recognized by the DSR community as an important but neglected area of research. Extrapolating from the achievements of tool support for more established research approaches, tool support for DSR promises to lower the barriers for the delivery of more rigorous, comparable, and, thus, relevant DSR. However, to this date, little research has looked at the challenge of providing tool support for DSR systematically. As a first step to close this gap, prior research in the form of a workshop by the DESRIST community focused on identifying an initial understanding as well as set of requirements for tool support in DSR. This paper extends and complements this prior research with a qualitative analysis of in-depth interviews (n=12) about the topic of tool support in DSR with a broad variety of design science researchers. The major contribution of this work is that it goes beyond the mere collection of requirements and uses qualitative data analysis to dive deeper into the understanding of tool support in DSR as well as associated opportunities and challenges. Based on this analysis, we developed a multi-perspective framework for the investigation of tool support for DSR, which we position as a promising foundation for future research on the emerging topic of tool support for DSR.

Keywords: Tool Support, Design Science Research, Multi-Perspective Framework, Interview Study.

1 Introduction

Design science research (DSR) is an increasingly recognized research paradigm within the broader information systems (IS) research community (Hevner, March, Park and Ram, 2004). DSR is focused on the design of better or even innovative solutions to relevant practical problems (Gregor and Hevner, 2013; Rai, 2017; Baskerville et al., 2018). A vision of increased practical relevance and higher real world impact for IS research has been driving the adoption and acceptance of DSR (Hevner et al., 2004; Gregor and Hevner, 2013; Goes, 2014; Rai, 2017; Baskerville et al., 2018). However, examples of truly relevant and highly impactful DSR seem to be rare occurrences in our top journals so far (e.g., Goes, 2014; De Leoz and Petter, 2018; Peffers, Tuunanen and Niehaves, 2018). Likely reasons for this are not only the relative "newness" of DSR as an accepted form of research (Hevner et al., 2004; Gregor and Hevner, 2013), but also the difficulty and complexity inherent to conducting, communicating, and publishing truly relevant and highly impactful DSR (Rai, 2017; Baskerville et al., 2018; Peffers et al., 2018).

For example, relevant and impactful research generally requires large scale collaborative projects with interdisciplinary teams of experts and stakeholders (Rai, 2017). However, finding the right kind of opportunities remains often serendipitous even for the most motivated DSR scholars with the best of intentions. Moreover, conducting DSR is deemed to be a very creative process requiring a broad spec-

trum of IS research methods (e.g., Nunamaker Jr, Chen and Purdin, 1990; Hevner, 2007; Baskerville, Kaul and Storey, 2015; Rai, 2017), hard to fully plan in advance, and, thus, not only demanding to execute but also perceived to be risky in times of high publication pressures (Wiener et al., 2018). Finally, even after having completed a promising DSR project, there are more challenges and questions associated with how to communicate, evaluate, and publish DSR outcomes so that the whole field can grow and mature (Gregor and Hevner, 2013; vom Brocke, Hevner, Maedche and Winter, 2017b; Baskerville et al., 2018; Peffers et al., 2018).

Existing research about DSR has been striving to improve upon the status quo in a variety of ways (e.g., Hevner et al., 2004; Peffers, Tuunanen, Rothenberger and Chatterjee, 2007; Peffers et al., 2018; Gregor and Hevner, 2013; Baskerville et al., 2015, 2018). An increasing concern about *tool support for DSR* is a new development in this line of research, which promises to improve the productivity of researchers by helping them to do tasks more effectively and efficiently (e.g., Contell, Díaz and Venable, 2017; Sjöström, 2017; vom Brocke et al., 2017a; Morana et al., 2018b). However, most of the work on tool support for DSR has been isolated and disconnected. Thus, efforts have been started to establish the topic more systematically within the DSR community (e.g., Morana et al., 2018b).

In a recent attempt to consolidate the first results, Morana et al. (2018b) summarize the outcomes of an open workshop on tool support at DESRIST 2017 in the form of a process-oriented framework. The framework describes 9 requirement categories for tool support along three major phases of DSR projects (i.e., pre-design, design, post-design). The framework is used to highlight the range and scope of possible tool support for DSR and to propose a cooperative DSR software ecosystem as a guiding vision for future work.

This paper continues this effort by substantiating, critiquing, extending, and complementing the results of the workshop based on the study of related work as well as an in-depth analysis of expert interviews (n=12) with a broad variety of design science researchers at different stages of their career (7 professors, 2 senior lecturers, 1 postdoc, and 2 PhD students). The research question we investigated is twofold: *(1) What is the current understanding of tool support for DSR within the DSR community, and (2) what are the major opportunities and challenges that are perceived in relation to this topic?*

Based on our analysis, we establish and clarify the multifaceted nature of tool support for DSR by synthesizing a framework for the investigation of tool support for DSR. Against this backdrop, we then outline opportunities for future work on tool support for DSR.

The rest of the paper is structured as follows. First, we introduce related work on the emerging topic of tool support for DSR in more depth to situate our research in the existing body of knowledge. Second, we explain our research approach in detail to allow for an assessment of our methodology and results. Third, we present our multi-perspective framework for the investigation of tool support for DSR. Fourth, we discuss our findings in terms of contributions, limitations and implications. Fifth, we close the paper with a short summary and outlook.

2 Background and Related Work

Research on tool support for DSR remains nascent so far (vom Brocke et al., 2017a; Morana et al., 2018b). Only few researchers have started to investigate how to support DSR with tools (e.g., Nagle and Sammon, 2016; Contell et al., 2017; Sjöström, 2017; vom Brocke et al., 2017a; Morana et al., 2018a; Sjöström, Kruse, Haj-Bolouri and Flensburg, 2018). For example, Nagle and Sammon (2016) present a "design research canvas", which helps data practitioners and researchers to structure their thoughts about possible design research projects. Contell et al. (2017) present an extension for the popular Chrome web browser, which can help DSR novices learn about conducting DSR projects by scaffolding an appropriate project structure and supporting some of the individual research steps (e.g., prompting for needed inputs, etc.). Sjöström (2017) presents a design process exploration tool that makes it possible to explore data about design processes, which is otherwise hard to make use of, by visualizing data ingested from source code repositories and document collections. Vom Brocke et al. (2017a) present mydesignprocess.com, a web service focused on facilitating the structured documenta-

tion of complex DSR projects. Morana et al. (2018a) present the "design canvas", a high-level overview of design projects inspired by the business model canvas (Strategyzer AG, n.d.) that is also integrated into mydesignprocess.com. Sjöström et al. (2018) present how evaluation tools can be directly integrated into design artifacts to allow for faster and more comprehensive evaluations.

As can be gleaned from the preceding research overview, tool support for DSR is still a very much emerging topic that has not gained much research attention. Moreover, so far most of the efforts remain mostly isolated and disconnected. Researchers seem to focus on their own needs and the development of isolated tools to cover those needs rather than to work together on building a shared vision and ecosystem of interoperable tool support for DSR. In a first step towards changing this status quo and establishing the topic of tool support more systematically within the DSR community, an open workshop on tool support was conducted at DESRIST 2017 (Morana et al., 2018b). 28 DSR scholars from a variety of backgrounds were gathered at the workshop to brainstorm about the potential of tool support for DSR and articulate a comprehensive overview of possible avenues for tool support. Towards this end, a two-staged research process was pursued. In the first stage, participants were asked to write down aspects of DSR that could or should be supported with tools. Tools were defined very broadly and could encompass methodological as well as software tools. In the second stage, these requirements were gathered, grouped and collated into a *three-phase framework of DSR projects* (i.e., pre-design, design, post-design).

Morana et al. (2018b) present the result of the workshop in the form of a three-phase framework of tool support requirements (or opportunities) for DSR. In this framework, the pre-design phase pertains to activities that occur mainly before a DSR project starts to engage in actual design work, the design phase captures activities that occur alongside the main design work, and the post-design phase aggregates activities that happen after the main design work of a DSR project has concluded. The framework respects that DSR projects are inherently iterative and often messy and, thus, recognizes the possibility of circling back to prior phases. Altogether nine *requirement categories* of opportunities for tool support (RC) and 27 specific *requirements* (R) have been identified and placed within one of the three recognized phases.

A general limitation that Morana et al. (2018b) mention regarding their framework is that although it provides a comprehensive overview of the opportunities for tool support as perceived by the workshop participants at DESRIST 2017, it cannot be viewed as complete. For example, no thorough review of the literature was undertaken as part of the development of the framework. A second limitation (or feature, for that matter) can be seen in the generic and abstract three-phase focus of the framework. DSR is generally understood to be a very problem-centric research approach that will necessarily vary and shift with the problem under investigation. However, there is no reflection of this contextual nature to be found in the framework. For example, while evaluation is certainly a fundamental activity in DSR that can be supported by tools as outlined in the framework, it remains unclear when specific evaluation tools may be useful and how they should relate to or interact with other tools. On the other hand, not specifying these relationships allows for more flexibility while interpreting the framework, which may be useful to accommodate a broad spectrum of different DSR approaches (Peffers et al., 2018). A third limitation may be found in the lack of a prioritization or evaluation of tool support opportunities. In the framework, all listed requirements are simply stated without any assessment of possible impact, tractability, risk, or necessity of further research. For example, it is unclear whether and how requirements relate to each other and what the consequences of implementing tool support for a subset of requirements might be. Thus, altogether the framework can be lauded as a promising step towards stimulating the discussion around tool support for DSR and facilitating the exploration of general opportunities in this space, but it is only a first step for a collaborative and cumulative research program on tool support for DSR.

Another framework which may be considered in the context of tool support for DSR is the *DSR roadmap* developed by Alturki et al. (2011). The DSR roadmap synthesizes prior research on DSR methodology into a comprehensive guideline for carrying out DSR projects. It does so in much greater detail than other DSR methods papers (e.g., Peffers et al., 2007; Kuechler and Vaishnavi, 2008) and provides a detailed overview of what activities should be carried out in a DSR project. As opposed to

the pre-design, design, and post-design phases of Morana et al.'s (2018b) framework, the DSR roadmap frames DSR projects in terms of Hevner et al.'s (2004) three cycle view of DSR (i.e., design, relevance, and rigor) and, thus, its interactions with the (real world) environment and the academic knowledge bases. It is more detailed in terms of the DSR process than the three phase framework of Morana et al. (2018b), which makes it more helpful in terms of highlighting opportunities for process-based support for DSR projects (e.g., suggestion of next best step). However, this makes it also more restrictive in terms of DSR processes that would conform to this framework.

One of the main insights of the DSR roadmap in relation to tool support are the opportunities emanating from cross-cutting concerns such as knowledge and risk management in DSR projects. For example, Alturki et al. (2011) recommend a central design repository (CDR) as a means of helping to structure and organize the design knowledge in a DSR project. A CDR is envisioned as tool that can collect and aggregate information and knowledge about design products as well as design processes created or used within a given project. While the CDR is scoped to a specific DSR project, it seems feasible that a CDR could also facilitate the interchange of design knowledge across DSR projects via links to the academic knowledge bases. In terms of Morana et al.'s (2018b) framework, such a tool seems to cut across a broad set of requirement categories (i.e., RC2, RC3, RC4, and RC7). Thus, the CDR indicates that the requirement categories of Morana et al. (2018b) do not necessarily map cleanly onto classes of specific tools. Additionally, the DSR roadmap also highlights potential opportunities for tool support, which are missing from Morana et al. (2018b). For example, DSR risk management may be supported with tools (e.g., Pries-Heje, Venable and Baskerville, 2014), however, has not been mentioned at all in Morana et al. (2018b).

A limitation of the DSR roadmap in terms of its utility for tool support research is that even though it recognizes that DSR projects need to interact and align with the (real world) environment and existing academic knowledge bases, the interactions articulated are incomplete. For example, while some interactions are explicitly modelled (e.g., abduction of solution feasibility via researcher's mind/experience that is shaped by existing kernel theories), others are not (e.g., role of researcher's mind/experience in all other steps, detailed relationships between the CDR and the academic knowledge bases, or the necessarily occurring interaction between the real world and the DSR project during naturalistic evaluation). Although some discretion should be given to the authors to emphasize specific relationships over others, it remains unclear what criteria where used to decide which relationships to include or exclude. Another limitation regarding the DSR roadmaps utility for tool support is an incompleteness in terms of the opportunities that it recognizes for tool support. For example, while the DSR roadmap outlines some areas which have not been mentioned in Morana et al. (2018b) (e.g., DSR risk management), it fails to highlight the importance of collaboration in DSR projects, which has been emphasized in Morana et al. (2018b). Thus, the DSR roadmap provides a valuable additional perspective on opportunities for tool support in DSR projects. It cannot replace but complements the three-phase framework presented by Morana et al. (2018b) with a more detailed, process-oriented view of DSR projects.

A more holistic theoretical perspective regarding tool support for research in general has been advanced by Dutton (2011). Dutton (2011) reflects upon a long-term research program focused on what he terms "research-centered computational networks" (RCN) – the use of advanced IT to support research endeavors and communities. The main insight emerging from this work is that RCN are always embedded in and shaped by an ecology of complex socio-technical choices made by various actors, in particular institutions and individual researchers. For example, he highlights the complex interactions between a broad variety of cultural, institutional, legal, and disciplinary factors that shape the uptake and success of RCNs. While this understanding is important to consider during the development and introduction of tool support for DSR, it has not been reflected in research so far. For example, neither Morana et al.'s (2018b) framework nor the DSR roadmap explicitly recognize the importance of the contextual factors in their work. This paper aims to overcome this gap by building on the existing conceptual work and complementing it with the analysis of in-depth interviews with a variety of stakeholders in the DSR ecosystem to develop a more holistic understanding of tool support for DSR. Table 1 summarizes how our work relates to this extant literature.

Approach	DSR Focus	Process-centric	Stakeholder-centric	Context-aware	Research Outcome
(Morana et al., 2018b)	*Yes*	*Yes*	*No*	*No*	*Requirements-oriented framework for DSR Tool Support*
(Alturki et al., 2011)	*Yes*	*Yes*	*No*	*No*	*Activity-oriented framework for DSR*
(Dutton, 2011)	*No*	*No*	*Yes*	*Yes*	*Conceptual framework for RCN*
This work	*Yes*	*No*	*Yes*	*Yes*	*Stakeholder-oriented framework for DSR Tool Support*

Table 1. Comparison of this work with related approaches

3 Research Approach

Figure 1 summarizes our research approach, which is best characterized as the culmination of two mutually informing inquiries (i.e., *Inquiry 1: Literature Review*, *Inquiry 2: Interview Study*) that built on and informed each other with the goal of delivering an answer to our guiding research questions.

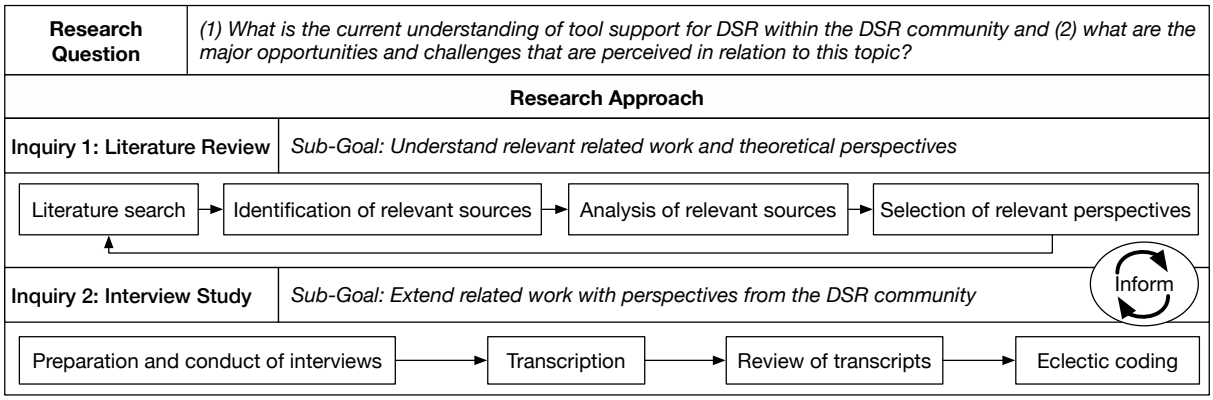

Figure 1. Overview of our research approach that combined two complementary inquiries.

3.1 Inquiry 1: Literature Review

Inquiry 1: Literature Review focused on creating an understanding of the relevant theoretical background on tool support for DSR by reviewing the existing body of knowledge on this topic. Thus, it concerned the identification, analysis, and selection of relevant literature and associated theoretical perspectives. As the research stream on tool support for DSR is very new, a systematic review did not return interesting results, thus, we focused on an iterative, creative, and narrative exploration of the knowledge base (e.g., Senior Scholar's Basket, DESRIST proceedings, Google Scholar) driven by insights from the interview study (e.g., literature recommendations) as well as more general literature searches regarding tool support for DSR and frameworks related to tool support for DSR. In turn, the insights gained through the literature review informed our interview study in terms of questions discussed and acted as sensitizing devices (Klein and Myers, 1999) during data analysis. We present the three most relevant theoretical perspective that we identified and build upon in the section on related work.

3.2 Inquiry 2: Interview Study

Inquiry 2: Interview Study focused on creating an understanding of the relevant personal experiences and perspectives of key stakeholders in the context of the larger DSR ecosystem with the goal of enriching and extending the existing body of knowledge on tool support for DSR. We conducted this

study as few research so far had tackled the topic of tool support for DSR in depth and more data needed to be generated.

In a first step, interviews were prepared and conducted. Preparation concerned the recruitment of interviewees as well as the development of an interview guideline. For the recruitment of interviewees we contacted the participants of the DESRIST 2017 workshop on tool support, some of which were supportive of this research and agreed to be interviewed, as well as leveraged our own personal network to recruit additional participants to get a diverse set of interviewees. Altogether 12 DSR scholars were recruited (11 male, 1 female), spanning different career stages (7 with 10+ years of experience, 3 with 5-10 years of experience, 2 with less than 5 years of experience), mostly based in Europe (10 based in Europe, 2 based in Australasia, 0 based in the Americas), all of them having published at least one paper at an international conference, most of them having published in journals, and half of them having been participants in the DESRIST 2017 workshop on tool support.

The interviews were semi-structured and consisted of three general sections with open ended questions that were pragmatically chosen to get interviewees to reflect about the topic of tool support: *demographics* to get a sense of the interviewee (e.g., "How long do you know about DSR?"), *understanding of DSR and tool support* to elicit personal perspectives and insights (e.g., "What do you think of tool-support for DSR? For example, how would you define it?"), and *review of tool support requirements* to discuss and critique the framework presented in Morana et al. (2018b) (e.g., "What do you think about the gathered requirements? Are they comprehensive? Do you see ways of improving the classification?"). The interview guideline was trialed with a colleague in person and generally well-received by all interviewees (e.g., "This was an interesting interview. I initially thought that 1.5 hours talking about a topic that is not my core topic would be difficult but it was not worrying at all. Some insights even on my side."; Interview 7). The interviews had an average duration of just over one hour (ranging from 41 minutes to 01:27 hours), resulting in 12:22 hours total recorded interview time with over 180 pages (at 2500 characters per page) of transcriptions.

In a second step, the interviews were manually transcribed. In a third step, the interview transcripts were sent to the interviewees for review and feedback. Some interviewees responded with small corrections and feedback, which was incorporated into the transcripts before the coding step started. In a final fourth step, the first author of the paper used MaxQDA 2018 Standard (VERBI GmbH, 2019) to analyze the transcripts with an eclectic coding procedure (Saldaňa, 2009). Figure 2 summarizes the coding procedure and gives an excerpt.

Saldaňa (2009) defines an eclectic coding approach as an assemblage of several coding methods that are pragmatically combined to answer the research question. To facilitate this approach, he suggests a pool of possible coding methods that are either classified as *first cycle coding,* focused on the initial coding of data, or as *second cycle coding,* aimed at analytically refining and relating categories to each other. Against this backdrop, our coding procedure is generally described as a two-step process that pragmatically combines two first cycle coding methods (sic., *structural coding* (Saldaňa, 2009, pp. 66–70) and *domain and taxonomic coding* (Saldaňa, 2009, pp. 133–138)) with one second cycle coding method (sic., *theoretical coding* (Saldaňa, 2009, pp. 163–167)). This overall coding process was informed and guided by three *sensitizing devices* (e.g., Klein and Myers, 1999) that emerged from our preparatory work, namely, our research questions, critiques of Morana et al.'s (2018b) framework expressed in the interviews, and Dutton's (2011) understanding of RCN.

The initial structural coding was strongly guided by the research questions and consisted of the coding of content-based or conceptual phrases to break down interviewees understanding of *DSR*, *tool support*, and *tool support in DSR* into specific *goals*, *opportunities*, *challenges*, and *considerations*. For example, as detailed in Figure 2, the goals interviewees assigned to tool support for DSR were coded as two high-level goals, namely, *automation* and *support/help,* with the later one having multiple, more concrete sub-goals.

The domain and taxonomic coding was inspired by critiques of Morana et al.'s (2018b) framework expressed in the interviews as well as Dutton's (2011) understanding of RCN, which both highlight the relevance of a stakeholder- or network-centric perspective that has so far been absent from re-

search on tool support for DSR (see Section 2). Thus, our application of domain and taxonomic coding was focused on eliciting the major categories of stakeholders in the DSR ecosystem. We identified several instances and types of stakeholders relevant to DSR being mentioned, which we then condensed into major categories with appropriate analytic labels. For example, as exemplified in detail in Figure 2, several interviewees highlighted the importance of journals, conferences, and other means of communal knowledge exchange, which we then grouped under the analytic label *DSR Community*. In total, we identified three major core categories of stakeholders (sic., DSR Community, DSR Projects & Programs, DSR Scholars) that make up our domain of interest, which we labeled *DSR Network* in reference to Dutton's (2011) RCN.

In a second-step we applied theoretical coding to substantiate and validate our understanding of the relationships between the core stakeholders by systematically coding the links between them. For example, interviewees highlighted how the personal knowledge of DSR Scholars can affect DSR Projects & Programs (see Figure 2). The coded links helped to validate and substantiate the tight interconnectedness and mutual dependency of the three proposed core stakeholders and, thus, justifies their grouping under a common label.

While all manual coding procedures are inherently subjective, the authors aimed to ensure intersubjective agreement regarding the validity of the coding results by periodically reviewing the coding results together as well as in discussion sessions with a third experienced DSR scholar. A more detailed overview of the conducted interviews, demographics of interviewees, the complete interview guideline as well as a high-level coding distribution are omitted here due to space limitations but are provided as supplementary material (https://osf.io/b57yt/; Herwix and Rosenkranz, 2019).

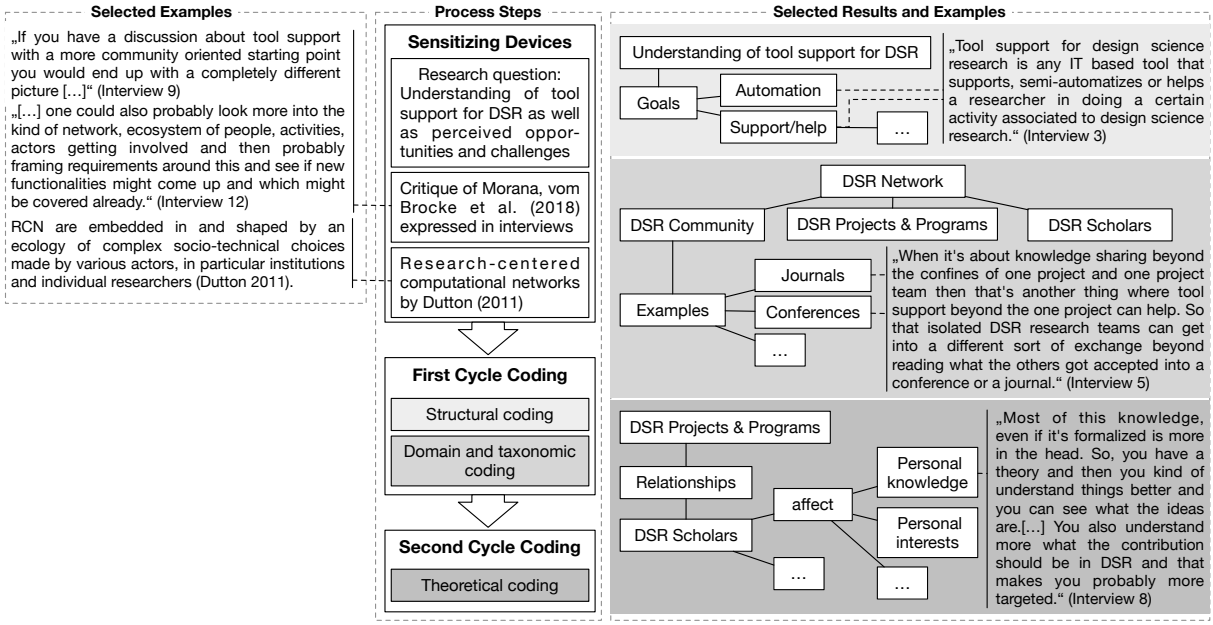

Figure 2. Overview of our eclectic coding approach based on Saldaňa (2009).

4 The Multiple Perspectives of Tool Support for Design Science Research

During the analysis of our data (i.e., literature and interviews), it became clear that tool support for DSR is a complex phenomenon that touches a variety of stakeholders and needs to be considered from different perspectives if the goal is to design and instantiate efficacious solutions (Dutton, 2011). *"We need to recognize that aspect – there is no best tools – it depends on the person, the problem, it is all context-specific"* (Interview 2). Consequently, we focused on identifying the most relevant stakeholders and perspectives which need to be considered in relation to tool support for DSR. In the context of our research, we identified three interrelated core actors and associated perspectives as strongly rele-

vant to any kind of tool support for DSR, namely, *DSR Communities* and a *Community Perspective*, *DSR Projects & Programs* and a *Project Perspective*, *DSR Scholars* and an *Individual Perspective*.

4.1 Community Perspective

Several interviewees have raised the importance of *DSR Communities* and a *Community Perspective* when talking about tool support for DSR as there is much to learn from the experiences of other researchers, especially regarding tool support.

> *The tool support will depend on [contextual] factors, not on the fact that it's DSR. [...] But this [knowledge about tools] will be very helpful, as a way of [...] structuring a wiki or a knowledge base. So that the community can stay up to date and [we should say], look as a community, let's create this knowledge base to help the community grow.* (Interview 2)

As summarized in Figure 3, we define *DSR Communities* as shared interest groups which aim to coordinate or support *DSR Projects & Programs* and/or *DSR Scholars*. This definition emerged to capture the wide range of communities that exist in the DSR Ecosystem ranging from IS journals such as JAIS, to conferences such as DESRIST, and virtual communities such as mydesignprocess.com. Thus, taking a Community Perspective, tool support focuses on the inter-project and inter-scholar infrastructure that enables the smooth running of what we have come to call the *DSR Network* – the whole cluster of interrelated actors or entities that we refer to when we talk about the research field or discipline of DSR. The core stakeholders to be considered from the Community Perspective are DSR Projects & Programs and DSR Scholars as these are the main constituents and drivers of DSR Communities.

We propose three high-level categories of tool support opportunities, namely, *Portfolio Management, Knowledge Management,* and *Resource Management*, to cover the broad spectrum of concerns that are relevant to the efficacious functioning of the DSR Network. For example, Portfolio Management captures opportunities around the coordination of DSR Projects & Programs around problem libraries as mentioned by Morana et al. (2018b). Knowledge Management opportunities were very prevalent in the interviews as the interview guideline touched on the perceived state of sharing and reusing knowledge in DSR (e.g., *"in the end we will be talking about repositories [and] we will have to agree in the community about the classifications and the dimensions of these repositories"*; Interview 7). Resource Management relates to opportunities for improving the resources available to the DSR Network (e.g., *"take away a few fears of those who try it for the first time. Who have the experience of being out of control, it's a bit of a chaotic process in the end"*; Interview 5).

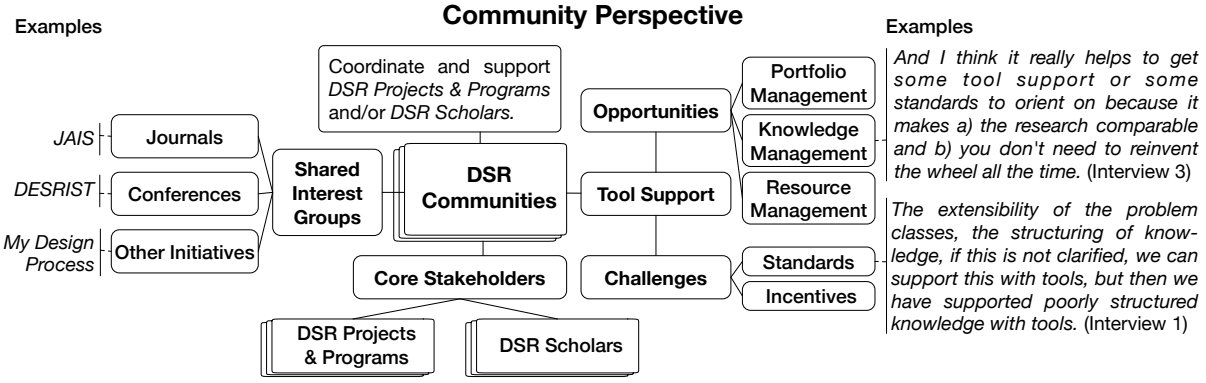

Figure 3. Examples of our analysis for the Community Perspective on tool support for DSR.

However, in addition to the potential opportunities, major challenges for community-focused tools were raised as well, namely, *Standards* and *Incentives*. For example, the challenge of coordinating and establishing standards for tools was flagged (e.g., *"Well, I think, again, agreeing on standards is one important thing. Because when we don't agree on standards we will reject the others because everyone will follow their own required standard";* Interview 3) and setting efficacious incentives is always a challenge (e.g., *"and it is very easy to develop a thinking and vision of knowledge management and*

sharing and co-creation romance and in theory and on paper it all looks great but then it practice it comes down to cost vs. benefit ratios, to incentives and that kind of thing"; Interview 12).

To sum up, the Community Perspective emphasizes the need to consider concerns relating to DSR Communities, such as coordination and standards, in the investigation of tool support for DSR.

4.2 Project Perspective

Many interviewees commented from a *Project Perspective* concerned with tool support for *DSR Projects & Programs*, a focus which is also strongly reflected in the framework by Morana et al. (2018b).

> *For me the definition [of tool support for DSR] would be that this are tools that, on the one hand, allow you to record the design process and project that you are working on and, on the other hand, development tools that help you to realize the actual artifact that you are doing.* (Interview 6)

As summarized in Figure 4, we define *DSR Projects & Programs* as projects or programs focused on improving *Problem Contexts* through the design and evaluation of interesting artifacts. This definition emerged from a general understanding of DSR as a problem solving paradigm (Hevner et al., 2004) and the general perspectives expressed in the interviews. This definition separates DSR from routine design by requiring that design artifacts need to have the property of interestingness (Davis, 1971) but does not limit the focus or type of Problem Contexts and can, thus, cover a variety of genres of DSR (Peffers et al., 2018), for example, the development of IS design theories (e.g., Markus, Majchrzak and Gasser, 2002) or action design research (e.g., Sein et al., 2011). Thus, taking a Project Perspective, tool support focuses on supporting specific DSR Projects & Programs. The core stakeholders to be considered from the Project Perspective are DSR Communities and DSR Scholars as these are the main constituents and drivers of DSR Projects & Programs.

We propose six high-level categories of tool support opportunities, namely, *Project & Program Management, Knowledge Management, Resource Management, Design Execution, Evaluation,* and *Communication & Dissemination*. We chose these categories thoughtfully to align with our data, existing conceptual understandings in academic research (e.g., Project & Program Management, Knowledge Management, Resource Management) as well as the general self-conception of DSR expressed at the DESRIST 2017 workshop on tool support (e.g., Design Execution, Evaluation, and Communication & Dissemination; Morana et al., 2018b).

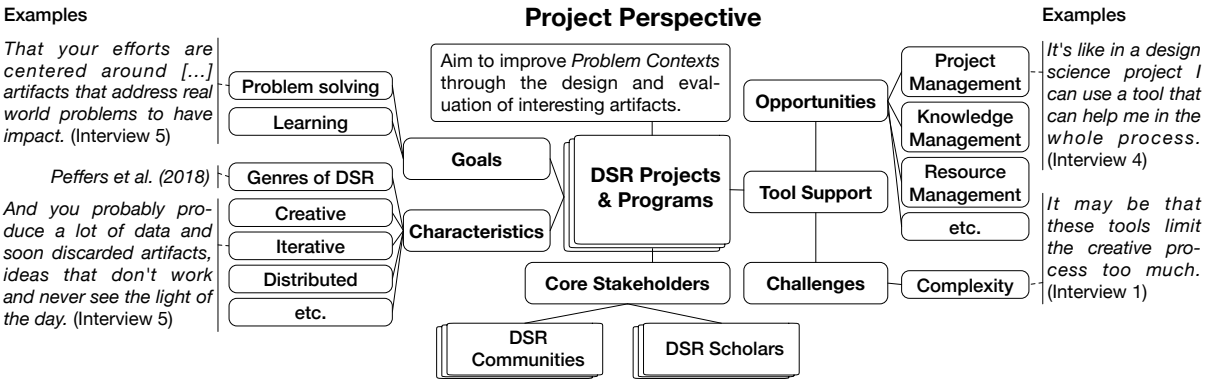

Figure 4. Examples of our analysis for the Project Perspective on tool support for DSR.

Due to the length restrictions of this paper, we focus our following description on the topic of Knowledge Management because it was widely seen to provide crucial opportunities for tool support. For example, the importance of being able to document and reflect about design processes was acknowledged in all interviews. Moreover, one interview developed to focus on the potential upsides and challenges of having structured ways of talking and reasoning about problem contexts in terms of clearly defined problem classes and subclasses (e.g., *"if we develop tools that stimulate the discussion about how the formulation of this knowledge can look like and even if it is still completely wrong in*

the first version [...] in the end this contributes to our capability to structure our knowledge better."; Interview 1). The need for tool support to facilitate the management of design knowledge across design iterations and product versions was another possible tool support opportunity mentioned by an interviewee (e.g., *"if we have a [big] project and we need to optimize the output, the artifacts, again and again, then we need a tool to document everything and know how each cycle evolved."*; Interview 4) as well as Morana et al. (2018b).

Regarding challenges for tool support from the Project Perspective, the *Complexity* of DSR Projects & Programs was a common theme across interviews. For example, the need for tools to respect and deal with the creativity, diversity and uncertainty inherent to DSR was mentioned several times (e.g., *"one fundamental thing for me in DSR is that, essentially, you are much less in control as in other kinds of research. It's creative, it's unpredictable. So how do you support the unexpected content wise and process wise?"*; Interview 5). Furthermore, it was highlighted how challenging but important it is to set up tools that everyone in a DSR project is comfortable with, given different backgrounds, needs, or organizational realities (e.g., *"I think for me it's, whenever I am doing a DSR project, I will probably do it in cooperation with industry. That means that they already have a sophisticated set of tools for their development processes. As a researcher coming in, I can't really change that."*; Interview 9).

To sum up, the Project Perspective emphasizes the need to consider the complex needs and requirements of DSR Projects & Programs in the investigation of tool support for DSR.

4.3 Individual Perspective

Users in the form of *DSR Scholars* have an *Individual Perspective* on tool support for DSR as the use of any IT is highly contextual (e.g., Legris, Ingham and Collerette, 2003). Specifically, DSR Scholars are always in the background when the topic of tool support for DSR is discussed because, in the end, users need the know-how about when and how to use appropriate tools to support their work: *"A fool with a tool is still a fool"* (Interview 7).

As summarized in Figure 5, we define *DSR Scholars* as agents who aim to engage in efficacious *DSR Projects & Programs* and *DSR Communities* to support their career and/or personal interests. This definition was chosen to include not only experienced, senior DSR Scholars or academic professionals but also novice DSR Scholars (e.g., PhD students) and even citizen scientists (Dutton, 2011). A major aspect of all DSR Scholars is that they have diverging personal contexts that are shaped by different career aspirations, interests, skills, experiences, or backgrounds. Thus, taking an Individual Perspective can facilitate the integration of tool support for DSR into the personal contexts of its users. The core stakeholders to be considered from the Individual Perspective are DSR Communities and DSR Projects & Programs as these are the foci and drivers of DSR Scholars.

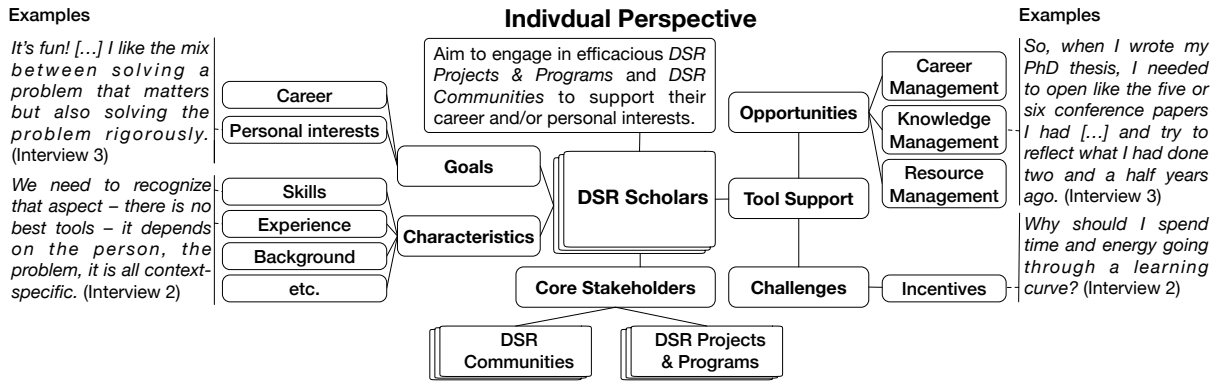

Figure 5. Examples of our analysis for the Individual Perspective on tool support for DSR.

We propose three top-level categories of tool support opportunities, namely, *Career Management, Knowledge Management,* and *Resource Management*. These categories aim to reflect the major concerns of DSR Scholars that may be supported with tools. For example, an interviewee highlighted that

DSR Projects & Programs are generally considered to be riskier than more traditional forms of IS research (e.g., *"I think the main problem right now, when it comes to publishing, is that there is a huge divergence between different scholars in what good DSR is. I mean, it is very common, both in conferences and journals, that you get completely opposed reviews."*; Interview 9). This makes career planning challenging and in turn provides opportunities for tool support (e.g., tool support for selecting an appropriate journal). Also, managing personal knowledge and resources across DSR Projects & Programs are evident opportunities for tool support (e.g., Bush, 1945) if one takes the Individual Perspective.

Regarding challenges for tool support from the Individual Perspective we used the label *Incentives* to summarize the challenges that occur due to the complex incentive structures that DSR Scholars generally find themselves in. For example, scholars often need to make difficult trade-offs between what should be done in a perfect world and what can be done in the light of publication pressures as well as personal background, skills, and commitments (e.g., *"I would [...] recommend to look very closely into, what really would be value generating and what would only be considered additional work. And looking very much into the incentives that would be another stream of research which I wouldn't underestimate"*; Interview 12).

To sum up, the Individual Perspective emphasizes the need to consider the complex personal contexts and incentives of DSR Scholars in the investigation of tool support for DSR.

4.4 A Multi-Perspective Framework for the Investigation of Tool Support for Design Science Research

We summarize the multiple perspectives on tool support for DSR that we identified in Figure 6. As we highlighted in the preceding sections, the topic of tool support for DSR should be considered from the three interrelated perspectives (i.e., Community Perspective, Project Perspective, and Individual Perspective) of the three core actors in DSR (i.e., DSR Communities, DSR Projects & Programs, and DSR Scholars) to be able to appreciate the multifaceted nature of the topic.

A Multi-Perspective Framework for the Investigation of Tool Support for DSR

0. ***Meta Perspective:***
   Focus on tool support from a meta perspective to enable coordination and collaboration.
1. ***Community Perspective***:
   Focus on tool support from the perspective of *DSR Communities*.
2. ***Project Perspective***:
   Focus on tool support from the perspective of *DSR Projects & Programs*.
3. ***Individual Perspective:***
   Focus on tool support from the perspective of *DSR Scholars*.

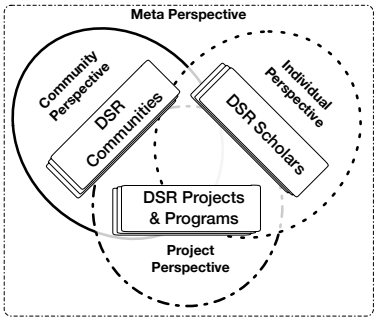

Figure 6. An overview of the multiple perspectives on tool support for DSR.

For example, the *Community Perspective* focuses on tool support from the perspective of *DSR Communities* and, thus, emphasizes the opportunities and challenges for tool support with the goal of improving the performance of DSR Communities (e.g., shared design knowledge repositories). Importantly, the Community Perspective recognizes DSR Projects & Programs and DSR Scholars as major stakeholders of DSR Communities and, thus, the Community Perspective is overlapping with and should be informed by these associated perspectives.

The *Project Perspective* focuses on tool support from the perspective of *DSR Projects & Programs* and, thus, emphasizes the opportunities and challenges for tool support with the goal of supporting or improving the performance of specific DSR Projects & Programs (e.g., tools for project planning and documentation). Importantly, the Project Perspective recognizes DSR Communities and DSR Scholars as major stakeholders of DSR Projects & Programs and, thus, the Project Perspective is overlapping with and should be informed by these associated perspectives.

The *Individual Perspective* focuses on tool support from the perspective of *DSR Scholars* and, thus, emphasizes the opportunities and challenges for tool support with the goal of supporting or improving the performance of individual DSR Scholars (e.g., tools for career management). Importantly, the Individual Perspective recognizes DSR Communities and DSR Projects & Programs as major stakeholders of DSR Scholars and, thus, the Individual Perspective is overlapping with and should be informed by these associated perspectives.

In addition to these three perspectives directly focused on tool support for DSR, we also suggest to explicitly recognize the existence of a *Meta Perspective* focused on the underlying conceptual and theoretical foundations of tool support for DSR that aim to enable the collaboration of relevant stakeholders and the coordination of research activities (e.g., as exemplified in this work). As Figure 6 visualizes, the Meta Perspective frames and defines all other perspectives. It aims to provide a common and shared foundation on which all relevant stakeholders can agree and build on.

5 Discussion

Our multi-perspective framework can be differentiated from existing frameworks related to tool support for DSR in so far as it explicitly recognizes relevant stakeholders and perspectives on the topic, which had been missing from prior research (see Table 1). In particular, it complements the process-oriented framework of Morana et al. (2018b), which investigates tool support for DSR from the Project Perspective, with an encompassing stakeholder- or network-centric framework that allows for a more contextual and holistic investigation of tool support for DSR. With our proposed differentiation of perspectives, we advocate for the common scientific practice of distinguishing between related levels of analysis (e.g., micro, meso, macro; Dopfer, Foster and Potts, 2004) and aim to facilitate the comprehensive investigation of a complex problem context. For example, our framework highlights tool support opportunities related to resource management from the Community Perspective (e.g., improving the availability of resources that can be enlisted for DSR) which have so far not been considered by other research on the topic.

Future research is encouraged to build on our work and investigate how extant frameworks on tool support for DSR (e.g., Alturki et al., 2011; Morana et al., 2018b) could be further integrated with our framework to achieve a common understanding that is widely shared and accepted. For example, research projects on tool support for DSR could refer to the framework to clarify how they have considered the three interrelated perspectives on tool support for DSR that we have identified. Moreover, they could also relate to, build on, or critique the tool support opportunities and challenges that we have presented (e.g., to derive specific requirements and features for tools).

Another avenue would be the extension and further development of our framework. At the moment, our framework is focused on the clarification of the foundations of tool support for DSR on a conceptual level and does not make full use of all insights that were generated from our interview study. Next to the three core stakeholder categories presented in this paper, we identified four additional major stakeholder categories (tentatively labeled *problem contexts*, *practice networks*, *academic networks*, *societies*), which were also perceived as relevant to the DSR Network but are omitted here due to space limitations and need to be explored in future work.

Moreover, in the interviews we explicitly talked about the relationship between tool support for DSR and tool support in other disciplines but cannot provide a comprehensive discussion on this important topic in this paper. Needless to say, most interviewees agreed that it is possible and desirable to learn from extant research on tool support, especially engineering-oriented disciplines (e.g., mechanical engineering, medicine, etc.). We argue that our proposed framework is abstract enough to provide a suitable foundation for the systematic investigation of tool support in diverse areas and, thus, can help to structure future work focused on systematic learning from other (or even across) disciplines. For example, it should be possible to extend our framework into a tool to diagnose and compare specific tool support contexts (e.g., Ostrom and Cox, 2010). This may be achieved through the definition of a more comprehensive ontology of relevant stakeholders and their relationships (e.g., define sub-classes for the core actors of DSR, elaborate on the nature of their relationships, and clarify the roles of and rela-

tionships to additional relevant stakeholders). Such an extended framework could then provide a foundation for the organization of knowledge about tool support in general and eventually lead to the construction of knowledge repositories that could support the work on and dissemination of tool support.

Regarding limitations, we do not claim completeness of the framework but argue that it provides a well-grounded, parsimonious, and extensible foundation for future work that goes beyond existing research on tool support for DSR. For example, while we have not systematically considered existing work on tool support for research and science in general, we have started to synthesize a common perspective from existing thinking in the DSR community. However, we cannot claim that our results have been rigorously evaluated or completely reflect the interests and opinions of all DSR scholars. The sample of DSR scholars which have been interviewed and, thus, contributed to this work, was strongly "European-biased". Nevertheless, we argue that our data set is still worthwhile to explore as it provides an in-depth view into the European perspective on tool support for DSR, which may be extended with, compared to, or contrasted to other cultural perspectives in future research. In addition, we did not have time to systematically gather feedback by outside researchers on the framework, yet. Therefore, it could be worthwhile to discuss and work on the framework with additional DSR scholars, for example, in the context of further interviews, in a workshop setting, or in a Delphi study. Moreover, the description of the framework and its application is very concise and somewhat limited due to the length-restriction of this paper but could be extended in the future to make the work more accessible and useful to a broader audience.

6 Conclusion

This paper complements existing research on tool support for DSR with an in-depth interview study of a wide variety of DSR scholars. Based on the interviews with relevant stakeholders as well as supporting literature we derive a comprehensive multi-perspective framework that provides a stakeholder-oriented lens on tool support for DSR, which had been missing from prior research. Going beyond existing work, our framework helps to more clearly highlight and break down the inherent complexity of the topic in a comprehensive, well-grounded and systematic way. Thus, our work contributes to the conceptual foundations that underlie tool support for DSR (i.e., the Meta Perspective). We hope that this work will facilitate and inspire more cohesive and cumulative research on tool support for DSR and, thus, over time improve the efficacy and, ultimately, impact of all our research. In this spirit, we encourage DSR scholars to collaborate to challenge, revise, extend, and improve our work.

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