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Transparency in design science research

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ABSTRACT

Research transparency promotes openness and trust in the process, evidence, contributions, and implications of scientific inquiry. Information Systems (IS), as a pluralistic research community, must address transparency in relation to its use of multiple research methods appropriate to complex socio-technical contexts and challenging research questions. This commentary presents a set of important transparency challenges and actionable guidance for the Design Science Research (DSR) community. We propose a DSR Transparency Framework containing six forms of transparency: process, problem space, solution space, build, evaluation, and contribution. For each, we discuss challenges with guidance to achieve effective DSR transparency throughout the publication process.

1. Introduction

Research transparency refers to the principles and practices of being open about how a research study is conducted, with a full presentation of its assumptions, scope, processes, data, results, analyses, and implications [12]. The goal of research transparency is to engender trust by reviewers, editors, and readers (scholars and practitioners) that the research results are valid, actionable, and generalizable. Effective transparency practices address key questions: To what extent should researchers (and journals/conferences) make available additional information, such as data, artifacts, code, proofs, subjective value judgments, and guidelines for application? Are there reasonable constraints (i.e., information overload, cost) as to what should be provided and/or reviewed? What are the risks and dangers of transparency (e.g., intellectual property, overconfidence, balance of benefit and cost)?

Across all research disciplines, transparency is one of the most widely discussed aspects of scientific inquiry, with a compelling need for more open mechanisms of research communication [18,52,56,57,60,70,74,80]. Research transparency is being encouraged both at the international and national levels. *UNESCO* calls for "reproducibility, transparency, sharing and collaboration resulting from the increased opening of scientific contents, tools and processes."[1] The US White House's Office of Science and Technology Policy (OSTP) declared 2023 the *Year of Open Science*, defining Open Science as *"the principle and practice of making research products and processes available to all, while respecting diverse cultures, maintaining security and privacy, and fostering collaborations, reproducibility, and equity."*[2] The European Union has released a statement on open science as part of its Strategy 2020–2024, stating *"FAIR (Findable, Accessible, Interoperable and Re-usable data) and open data sharing is to become the default for the results of EU-funded scientific research" [91]*. The European Open Science Cloud (EOSC) is promoted as a *"trusted, virtual, federated environment that cuts across borders and scientific disciplines to store, share, process and reuse research digital objects (like publications, data, and software) that are FAIR."*[3] The

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[1] https://unesdoc.unesco.org/ark:/48223/pf0000379949.locale=en

[2] https://www.whitehouse.gov/ostp/news-updates/2023/01/11/fact-sheet-biden-harris-administration-announces-new-actions-to-advance-open-and-equitable-research/

[3] https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science/european-open-science-cloud-eosc_en

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open science issues of scientific credibility and misinformation (e.g., fake news) attract headlines with concerning implications to societal welfare, global health, safety, security, and human well-being. Trust in the results and guidance from scientific studies is in decline and greater research transparency is needed to return societal and institutional confidence in scientific findings [56].

The IS research community has engaged this discussion, with issues of research transparency highlighted in an editorial in *MIS Quarterly* [12]. The editorial addresses the research plurality of the IS community that welcomes a diversity of research approaches, methods, and genres in our field as we strive to address complex research questions with socio-technical solutions. The editorial provides broad guidance on how IS journals should address research transparency in their review processes and publications but, also, calls on the various research subcommunities to determine their own distinctive approaches to support the goals, costs, and benefits of research transparency. This commentary is a response to that call targeted to the design science research (DSR) community. While some initial thinking on DSR transparency has appeared [28,63], we contend that a better appreciation of the full range of DSR transparency needs and practices is required to inform both the research and practice communities.

An inclusive definition of "information-technology practitioner" suggests that a broad range of members of society may benefit from DSR knowledge. Only 20 years ago, practitioners were mainly members of the IT profession, thoroughly knowledgeable in both hardware and software [13,39,58]. Now, in principle, anyone can be an IT practitioner, including front-line organizational employees [59], managers [42], and members of the general public, including marginalized communities and children [73,89]. Practices such as drag and drop programming, automated machine learning, rapid and online deployment, and gamified development interfaces, mean that prescriptive DSR knowledge can benefit broad audiences and, hence, should be widely and transparently disseminated.

This commentary presents a set of important questions and challenges for the design science research community to address research transparency in DSR projects. We focus on the characteristics of DSR that distinguish it from other forms of research. The DSR paradigm has its roots in the sciences of the artificial [69] and seeks to advance human knowledge through the creation of innovative and useful artifacts and, further, to understand how and why these artifacts affect the quality of human life [7,37,41,65]. Designed artifacts embody the ideas, practices, capabilities, and products of how to solve real-world problems using innovative information technology. As such, the DSR community must address particularly meaningful issues of research transparency due to close researcher and practitioner collaborations and real-world contextual interventions with innovative design artifacts.

2. Background – The open design movement

A DSR project extends the boundaries of human and organizational capabilities by designing new and innovative socio-technical system artifacts [66] and generating design knowledge [84] in the form of entities such as constructs, models, methods, instantiations [37], and design theories [29,41]. Broadly speaking, DSR adds to knowledge of how things can and should be constructed or arranged (i.e., designed), usually by human agency, to achieve desired goals. Research transparency must be addressed throughout a DSR project from planning through execution to the dissemination of the research results (e.g., operational IT systems and human behavioral processes) with both theory and practice implications.

Our position on research transparency in DSR draws from a review of *open design* movements and literature. The concept of *open design* originated in varied fields of product development with emphasis on shared design documentation and collaborative development of tangible objects [9,26]. Active research directions of open design include innovations in 3D printing, crowdsourced design projects, and manufacturing as a service (MaaS) [64]. The incorporation of software capabilities in open design projects has led to the *open-source software* (OSS) community, which has revolutionized how software systems are built, evaluated, used, and evolve [22,23]. Indeed, modern IT and society would not be the same without open-source systems such as the Linux operating system, Apache web server, Hadoop, Mozilla Firefox browser, and the Python programming language. OSS provides significant benefits in measures of development productivity and system quality. Corporate engagements with the OSS community have led to radically new approaches for more open, responsive, and collaborative design methods [25].

The concepts of *open innovation* align closely with goals of open design. Corporate open innovation encourages the exploration of a wide range of external resources and innovation opportunities to complement internal research and development activities [16,90]. The open innovation paradigm is disruptive to intellectual property traditions and, thus, presents many challenges in implementation [45].

We find that the concepts and goals of *open design* and *open innovation* match well with the objectives of DSR transparency. DSR projects must produce both practical and scientific contributions via new design artifacts and a fuller understanding of why the new designs provide greater efficacy in the form of nascent design theories and extensions to theories of human behavior in the use of novel artifacts [29]. From an IS perspective, such DSR contributions include digital innovations [33], human behavior processes, and combinations of human-machine interactions [2], such as systems that integrate AI processes and human decision-making behaviors [35]. Further, like many kinds of research, DSR is a collaborative effort, so open sharing and collaboration should also be a key requirement.

The field of IS can benefit from research transparency frameworks being developed in other scientific disciplines. While an extensive review of existing transparency requirements and checklists is outside the scope of this commentary, we recognize the significant on-going transparency efforts in fields such as medicine (e.g. Equator Network Reporting Guidelines[4]), social sciences [50], and computer science [17]. While many transparency concerns are common to all scientific fields, IS has unique challenges as highlighted by Burton-Jones et al. [12].

We begin by proposing a DSR Transparency Framework with six fundamental forms of transparency corresponding to six features that distinguish DSR projects from other types of information systems research. We highlight the key challenges of transparency requirements for each feature. We then discuss the risks and costs of achieving transparency in the scientific review and publication processes. Finally, we present conclusions and guidelines for organizing and managing DSR projects to satisfy the objectives of open and transparent science.

3. DSR transparency framework

We build the transparency framework on extant work that conceptualizes DSR as an iterative build and evaluate process (design cycles) in the intersection of both the environment (relevance cycle) and the academic knowledge base (rigor cycle) [32]. Against this background, we identify six distinguishing DSR features [36] with respective research transparency challenges, constituting the transparency framework as illustrated in Fig. 1. We show the project flow through the six DSR features and the interactions of the project with two key external entities, the project environment and the applicable knowledge bases [34]. These provide the application domain context and the extant scientific design knowledge, respectively, for a DSR project. In the following six subsections, we briefly describe each of the DSR transparency dimensions and highlight key challenges for each.

The proposed framework is intended to give researchers a set of considerations for improving transparency in DSR projects. We contend

[4] https://www.equator-network.org/

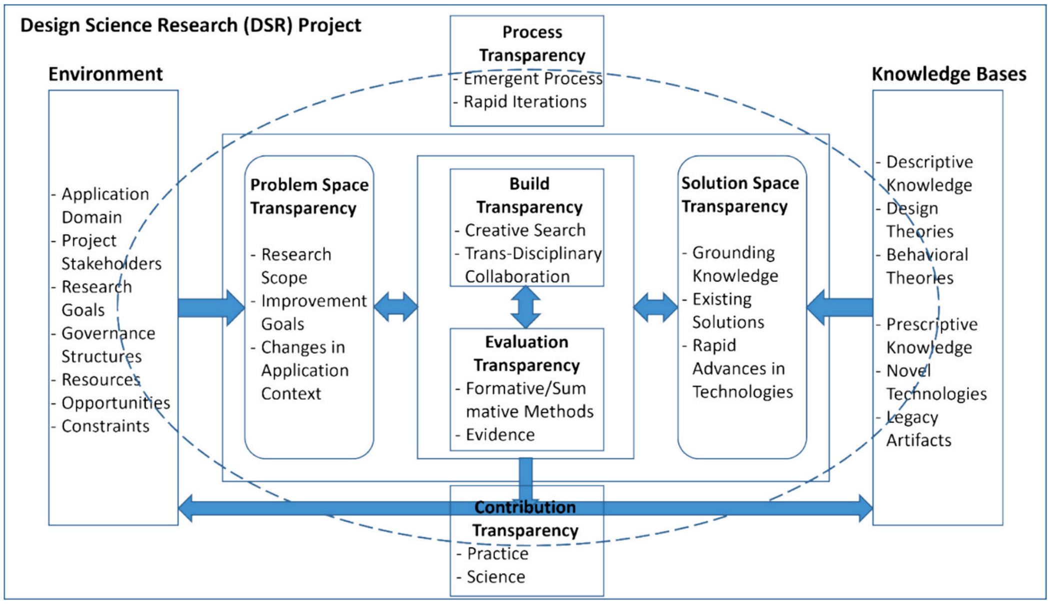

Fig. 1. The DSR project with six transparency features

that transparency considerations are an essential activity in a DSR project, not an additional or excessive responsibility. By the same token, the DSR transparency framework should inform editors and reviewers, without driving burdensome requirements to meet all transparency features in DSR projects. Authors, editors, and reviewers must judge the appropriate levels of transparency required in DSR publications.

3.1. Process transparency – The challenge of emergence

Process transparency refers to clarity and completeness in communicating the actions performed to generate the design artifacts and knowledge contributed by a DSR project. While a DSR project plan may start with a well-defined intended process, project execution will frequently require alterations to it. In fact, such process *emergence* is essential to research learning. An iterative emergent DSR process supports the selection and integration of appropriate research methods for building and evaluating innovative design artifacts as the research evolves. The goal of agile and rapid design cycles, with decision points at the end of each cycle, allows projects to 'fail fast' and to identify productive paths to satisfactory solutions. DSR transparency demands well documented decisions to describe and justify the emergent process of rapid activity cycles performed in the project. Thus, the emergent scientific process can be documented to achieve full DSR process transparency and may itself provide a novel research contribution. A transdisciplinary DSR project can also discover a novel combination of disciplinary research processes and methods during investigation of the research problem.

Three components of DSR process transparency can be distinguished. First, process transparency provides an account of the many specific activities conducted during a DSR process. While high-level process models define phases (e.g., DSRM [61], ADR [68], [54]), which help to contextualize activities, process transparency involves documenting processes based on actual usage. A log file summarizing all activities in a timely and logical order can support documenting the process. Second, given that the DSR process evolves, process transparency also includes providing reasons for why specific activities, such as design choices [46], have been conducted. For each activity, there is a cause and an expectation for the activity that explains why it is performed, just as there is an outcome. Third, processes happen in a context [85], which should be transparent so that other researchers can assess and build on a research contribution. Often, documenting the context is only possible to an incomplete degree, given the lack of a commonly agreed terminology to describe the complex socio-technical context typical for DSR projects [86]. In the interest of transparency, it is important to make a fair effort to communicate the most relevant contextual factors that determine decisions in a DSR project.

To assist researchers in recording the evolving DSR process, tools for creating and capturing digital trace data can be helpful. There is a stream of research on tool support in DSR [31,53,83]. Effective tools have been developed to support journaling the DSR process as well as for creating an activity log to be referenced online for submissions and publications [85]. Research on DSR process transparency can benefit from advancements in other areas of IS research, specifically Business Process Management, where digital trace data serve as the basis for capturing and visualizing processes by computational methods [1,6]. From a DSR perspective, the use of tools should involve as little effort as possible and not restrict the work of the researchers or require time-intensive documentation requirements. Recent research has investigated the use of mobile devices, for instance, to capture components of the DSR process while working in the field and in organizations. For example, Gau et al. [24] reports on the development and evaluation of a prototype, "the DSR Buddy", which supports voice recordings and voice-to-text from mobile devices to facilitate the practicality and efficiency of process transparency in DSR.

3.2. Problem space transparency – The challenge of continuous change

A detailed understanding and description of the research problem and its positioning in an application problem space are essential to demonstrate the relevance and potential research contributions of a DSR project. Three key components describe the problem space: the *bounded research scope* within the application context, the *project improvement goals* for solution acceptance, and the *timeframe* of the project.

The application domain information provides a rich description of the problem in context; covering aspects such as characteristics of the problem domain, key stakeholders who will affect and be affected by the design solution, and the resources (e.g., technologies, systems, budget, schedule) available for solving the given problem. Transparency might entail providing well-defined boundary conditions on the research problem. The problem scope allows targeted research contributions and clearly defined application domain impacts. The DSR project has to be clear on the purpose and scope [41] of a developed design theory, related artifact, and presented instantiation [40]. Precisely articulating the problem class and subsequent problem instances addressed can help other researchers understand where potential evolutions of the problem can occur.

The second key design component in the problem space addresses the solution goals and requirements for how well the design artifacts solve the problem in context. Improvement goals can include a rich mix from the categories of technology (e.g., security, reliability, performance), information quality (e.g., accuracy, timeliness), human interaction (e.g., usability, user experience), and societal needs (e.g., accessibility, fairness) [38]. The description of these *solution requirements* and related *evaluation criteria* provides rigorous acceptance criteria for evaluating potential solutions and establishes guidance for both formative and summative evaluations of the project [81].

Timeframe transparency provides important information that goes beyond the written content of a paper. For instance, knowing that a study was conducted a few or many years ago changes how the results will be perceived. For instance, in a world without the Internet, artifacts and design theories are totally different. Similarly, to state it bluntly, in a timeframe where popular technologies are applied for (nearly) every problem (e.g., blockchain technology, generative AI, conversational agents), one could doubt if the developed design is driven by needs and requirements or the wish to apply a new and exciting piece of technology.

The critical transparency challenge is that the problem space is continually changing. In the context of DSR, this means that a single contribution might be one of many in a larger, longitudinal project that develops increasingly better artifacts. Evolving results are evaluated in varying application contexts with the aim of addressing some recurring challenge. Subsequently, the burden to provide satisfactory utility and formulate generalized design knowledge is not placed on a single study [11]. Instead, incremental improvements are accumulated over time because the resources of every DSR project are limited [4] and intermediate results contain valuable contributions to research and practice [84]. However, DSR projects are often standalone endeavors and results, either in form of artifacts or design knowledge (e.g., design principles or design theories), are rarely reused [14,84]. Reusing results of a singular DSR study comes with high levels of uncertainty and risk. For instance, uncertainties arise about to whether the results are dependable and whether they will fit a more general or different DSR problem space.

This leads to the question: What is the meaning of reproducibility and replication in DSR? For example, the intervention of a novel artifact in a system environment will change (e.g., improve, disrupt) the system in ways that significantly alter the research problem for the next DSR cycle. Reproducibility that requires returning to the previous system state makes little sense when the research goal is to evolve the environment with continual design improvements [84]. The issue of DSR replication is studied in Brendel et al. [10], who conclude that the authors of the original study as well as the authors of a potential replication of a design theory should engage with the differences in environments. Understanding the influence of the ever-evolving environments on theory provides its own opportunities to develop knowledge (e.g., why a certain change reduced the utility of an artifact).

3.3. Solution space transparency – The challenge of knowledge grounding

For DSR to be rigorously grounded, it is important to review extant contributions in the DSR knowledge bases [21,29]. This includes exploring available solution spaces to identify applicable grounding theories and potential technology solution candidates or solution approaches. The key transparency challenges are capturing and appropriately using applicable knowledge from both technical and behavioral knowledge bases in supporting the DSR project.

Rigorous literature reviews provide transparency in the process of capturing extant knowledge in the solution space [43,75,82]. Specifically, a comprehensive review supports the documentation of the search process, including the relevant search strings, timeframes, and databases. Due to the multitude of possible solutions and the rate at which new solutions are emerging, transparency in the search process serves to bound the scope of the search. A thorough literature review provides information about what existing grounding theories have been identified, what limitations they face in meeting the requirements of a particular problem, and what aspects of a problem they already cover satisfactorily.

The DSR solution space also provides many existing socio-technical system solutions in the application context. Identifying innovative technologies and extant artifacts supports the building of new solutions on top of current technology platforms, defining improvement goals in relation to current baselines, and finding new opportunities for novel research contributions to both practice and theory in the application context. Further, searching the solution space can help identify technology innovations relevant to solving the problem. The goals of technology are to grow the knowledge bases of purposefully designed artifacts to improve human capabilities both physically (e.g., tool use) and mentally (e.g., decision-making). As science, technology, and behaviors advance, they display a complex set of interactions and relationships. New technologies are driven and enabled by science, but, more often, scientific advances are driven and enabled by the emerging uses of technology [5]. Thus, solution space transparency involves identifying innovative technologies (e.g., blockchain, artificial intelligence [87]) and the potential benefits and costs of applying selected technologies in the DSR project.

Making transparent the effective use of extant knowledge applies to all scientific research but is particularly important for the evolving nature of DSR projects. Without a clear presentation of appropriate research methods, extant research literature, and existing systems and technologies, the presentation of a developed artifact or design theory may be met with doubt and low level of assigned confidence. Solution space transparency concerns not only the design and evaluation iterations, but also how the environment and the knowledge base are engaged.

3.4. Build transparency – The challenges of human cognition

The essence of DSR is enabling and supporting human cognitive abilities of creativity, reasoning, and collaboration in the design and building of innovative artifacts. Build transparency is truly challenging as our abilities to capture and communicate human cognitive processes are not well understood. What then are reasonable expectations for transparency in the building of novel artifacts? We briefly discuss challenges and tractable opportunities to support research transparency surrounding cognitive activities.

While creativity may be hard to represent and communicate, the search processes of design creativity can be logged. Points of creative insights can be recorded even if the creative processes (e.g., how a certain idea emerged in a workshop) are not fully understood. Closely related to creativity is the human cognitive facility to reason and judge ideas at various stages of the search process. Without the ability to narrow the field (i.e., bound the design solutions), it would be impossible to refine many good ideas down to one satisfactory design artifact. This is a delicate area of human cognition since it involves self-criticism, self-esteem, and motivation. While creativity often calls for divergent thinking, rigor calls for convergent thinking to refine ideas into practical artifacts and actions [3]. Capturing the steps of the solution design search process and the search methods is a transparency challenge.

The composition of a collaborative design team has a significant influence on the resulting design artifacts. Issues like diversity and personality traits can affect the collaborative performance of design teams. Additional challenges arise when bringing together multidisciplinary teams to address complex problems. For example, Weedman's [88] study of design collaboration between earth scientists and computer scientists finds difficulties from the different perspectives of collaborators, such as differing levels of tolerance for ambiguity. Dickhaut et al. [19] analyze codification techniques for sharing design information among members of interdisciplinary research teams. Understanding these collaboration challenges will help in the formation and training of effective teams. DSR projects must be transparent on how teams are built and how collaborative design activities are supported.

3.5. Evaluation transparency – The challenge of stakeholder confidence

DSR projects must demonstrate rigorous evaluation activities to build stakeholder confidence in the design solution of practice artifacts and formal design theories. The DSR project team should select rigorous and appropriate evaluation methods to integrate and balance technical artifact qualities with behavioral qualities of human interactions that engage the artifact [72]. This socio-technical evaluation duality is challenging and can require research skills in a wide range of evaluation methods, both technical and behavioral, depending on the project. The application context involves constraints and an appreciation of the environment and externalities within the environment to which the system must adapt. Data sources can be qualitative or quantitative; primary or secondary (including public sources). The research team must have the skills to use appropriate evaluation tools and techniques. The transparent reporting of the project evaluations will face two significant challenges: (i) separating formative and summative evaluations and (ii) presenting convincing evaluation evidence.

Evaluation methods will be different for formative evaluations in the rapid cycles of creating the artifact versus summative evaluations of the completed artifact in the application context [81]. Transparency entails matching the formative and summative evaluation methods to the opportunities and resources available in the project. Formative evaluations provide a more controlled environment for measuring improvements as the artifact is refined. Summative evaluations are dependent on the opportunities to assess the artifact in real-world applications. We note that not all DSR projects can test new design artifacts in realistic environments. In such cases, opportunities for evaluations in artificial environments are appropriate (e.g., simulations, focus groups). Given the variety of methods and application scenarios for evaluations, transparency of both the process and the results of the evaluation are important in DSR. The transparent presentation of evaluation evidence in both formative and summative stages supports increased confidence in DSR artifacts and research contributions.

Confidence in the ability of the artifact to satisfy the problem is predicated on the rigor of its evaluations and the resulting presentation of clear evidence of goal attainment and measurable improvements. *Fitness for use* evaluations assess the ability of an artifact to perform in the current application context with the current set of goals in the problem space [27]. *Fitness for evolution* evaluations assess the ability of the solution to adapt to changes in the problem space over time. This type of evaluation is critical for application environments in which rapid technology or human interaction changes are inevitable and successful solutions must evolve. These two forms of evaluation focus on very different measures of goodness with varying presentations to achieve needed rigor and transparency to achieve stakeholder confidence in the research results.

3.6. Contribution transparency – The challenge of balancing science and practice impacts

A DSR project will make contributions to both the practice application environment and the scientific knowledge base through innovative design artifacts and design theories in the areas of technology, human behavior, and socio-technical systems [37]. The relevance of a DSR project depends on deploying the innovative artifacts in the application context to demonstrate convincing evidence of the existence and extent of goal improvements. The impacts of the practical research contributions are the effective solutions to the research problems and stakeholder satisfaction with the results.

The rigor of a DSR project determines the extent to which new scientific knowledge is added to the application domain knowledge bases. Based on the innovative artifacts and their practice interventions, the research team will reflect and build design theories that generalize and communicate new scientific knowledge. A fully formed theory is not expected in any one single project, but there should be some reflection on the advance in design knowledge that is being made. Design knowledge is seen as ranging from implicit representation in the descriptions of the form and functions of an artifact to explicit representation in nascent design theory (such as design principles) or well-developed design theory. Transparency means that such new knowledge is articulated for use and extension in subsequent DSR projects.

Transparency of DSR scientific knowledge includes distinguishing between descriptive knowledge and prescriptive knowledge [29,51]. Each knowledge type gives rise to unique transparency concerns and informs different research audiences. Descriptive knowledge seeks to explain and predict phenomena of interest. Ideally, this knowledge type is value free. It can guide action only indirectly, insofar as the understanding of phenomena can be combined with appropriate values and thus suggest change. In contrast, prescriptive knowledge is actionable. It encapsulates rules, principles, and actionable theories that suggest general or specific courses of action to attain goals. It is value laden in that the desirable course of action is explicitly incorporated in this knowledge type.

Correspondingly, we define two types of DSR contribution transparency. *Descriptive transparency* seeks to serve the scientific community by describing the project activities to verify, validate, reproduce, and extend design-oriented descriptive and explanatory knowledge by other scholars. There is a host of challenges related to this form of transparency (e.g., what, when and where to share, sharing standards) and this conversation is mostly internal to the DSR community. The understanding of descriptive transparency can be accomplished by closely considering transparency issues and solutions already actively debated by behavioral scientists [12].

Even greater challenges relate to *prescriptive transparency*. This contribution transparency seeks to increase the visibility of prescriptive knowledge such that the resulting knowledge of "how" can be used by practitioners to implement the desired change. Although design scientists may benefit from greater prescriptive transparency as they seek to reuse existing design knowledge [14,30], the key beneficiaries are practitioners looking to apply DSR results to solve real-world problems. While channels for the dissemination of DSR results to the scientific community are well-known, channels to share new DSR artifacts with practitioners are not. Although academic-industry dialogues exist, they are rarely institutionalized and systematic. It is a challenge to establish meaningful engagement with practitioners to understand their transparency needs. The practitioner community is open, heterogeneous, and constantly changing. It is often not immediately accessible for consultation and consensus building. New kinds of academic-practitioner connections may be required to foster effective dialogue. Research on requirements elicitation and participatory design in highly heterogeneous, distributed settings (where stakeholders are also commonly practitioners) is needed [8,47,92].

The problems faced by practitioners are unique and always somewhat different from the context used in relevant DSR studies. Furthermore, it may be challenging for practitioners to understand the abstract language of DSR prescriptions [14,15]. Sharing artifacts, design principles, and other outputs of DSR may not always provide full design guidance [46]. As a result, DSR scholars may consider going beyond the traditional approaches to sharing. This may include not only the sharing of the implementation code, but also details of the implementation to support practitioners who will need to adapt the innovative solution artifact to their operational environment.

DSR researchers may consider making extra effort in making their work more accessible. This may include republishing scientific articles in practitioner-oriented outlets (such as industry journals).[5] With the widespread use of social media and content sharing technologies, an underutilized approach is to convert publications into even more accessible formats, such as virtual reality, simulations, animations, and videos. Indeed, the DSR community has already begun to explore these new formats to better communicate their findings to wider audiences. For example, Li et al. [44]'s "TheoryOn"[6] artifact is a public search engine, which is well documented by instructions and video tutorials.

4. Risks and costs of DSR transparency

Along with the benefits of openness, there are important risks of transparency requirements being onerous and costly. DSR projects involve designing, developing, and evaluating artifacts; often over several iterations in complex and changing environments. In this context, transparency requirements that either follow a standard checklist not addressing the distinguishing aspects of DSR or impose strict transparency requirements for all aspects of a complex study over time with multiple iterations of artifacts, can impose unnecessary burdens on researchers. Several key DSR transparency risks are discussed here.

4.1. Ex-post DSR-ification

"Ex-post DSR-ification" refers to the malpractice of framing a project as a DSR study in retrospect, which had in fact been neither set up nor conducted as such. The risk centers on the need to reframe the research project and retrospectively (ex-post) generate the required transparency materials. As editors, referees, or readers, we have repeatedly received/read papers that were based on industry projects that apparently had received a (not very convincing) DSR overcoating in retrospect. Obviously, many purely practice-oriented projects also comprise elements, such as iterative build and evaluate cycles as described by Hevner et al. [37]. Furthermore, the practice-oriented and problem-solving nature of DSR, as well as the breadth of questions, theories, and methods that DSR covers, seem to lure inexperienced researchers into thinking that DSR might constitute a good option for providing a scientific overlay to their projects by ex-post reflection and abstraction. Clearly, the structured approaches described by many DSR articles provide very valuable guidance also for projects that are primarily practice oriented.

Conversely, it certainly does not follow that practice-oriented projects lacking theoretical foundation should be converted in retrospect into DSR papers. Such endeavors have low prospects of getting published in good-quality IS outlets. What has surprised us more in this context is that, even as an author of articles describing empirical studies that had never been set up with a DSR lens, we have received recommendations from referees and even from editors (from other IS sub-communities) that we might alternatively try to frame the manuscript as a DSR paper. While the advice may have been given with the best intentions, the impression among scholars from other IS sub-communities that framing a study as a DSR study in retrospect is a realistic path to publication is problematic with respect to transparency.

4.2. Uniqueness of artifact instantiations and contexts

As described in Lukyanenko and Parsons [46], every information system consists of a myriad of features. Consequently, "there might be multiple instantiations that are consistent with a design proposition within a design theory" (p. 1344). As a result, the outcomes observed may result from ancillary choices by the designer. While replication studies are challenging to implement (and publish) in most disciplines, the large set of attributes composing the instantiation of an artifact and its environment may be particularly difficult to document and to replicate in the DSR domain. To avoid sheer endless descriptions of each possible feature of an artifact and its environment in DSR articles, online appendices should try to cover a broad spectrum of potentially relevant information and to provide a detailed documentation including an extensive set of visualizations, screenshots, detailed lists of survey items, etc. In addition, authors can increase transparency by providing explanations or rationales to account for specific design choices made when these are not implied by stated design principles [46].

4.3. Overly abstract and complex language

Another danger to transparency arises from a particular strength of DSR research, the ability to abstract complex design and implementation particulars, such as design principles, design theories, constructs, models, and general methods. Doing so permits establishing the connections with reference theories (that are also formulated using abstract language) as well as it enables claims about general classes of design problems and solutions, applicable across many settings. At the same time, the practice of abstracting design fosters a stronger tendency than in other empirical disciplines and communities to use complex, generic and abstract language, with many community-specific and practitioner terms. Common terminology must be transparent to both practitioner and researcher audiences. Clearly, terms like "affordances" have become natural to use for anyone in the DSR community (and obviously also convey a set of theoretical underpinnings). Yet even such seemingly well-established terms create barriers to access and to understanding by those outside of the DSR sub-community. Such sub-community-specific technical terms make DSR rather difficult to access even for researchers from other IS-sub-communities, let alone for practitioners. As part of that, after translating some findings that are expressed in particularly complex terms into plain language, sometimes the essence left is rather obvious or trivial. In many cases, a helpful exercise to avoid that issue is trying to explain the main findings of a manuscript briefly and in plain words to persons who are not part of the community (at a minimum, this will help researchers to become aware of terms that are not understood by smart people outside of the DSR sub-community). Such methodological techniques as focus groups and applicability checks, which are commonly used in DSR to elicit from the practitioner community feedback on the relevance and feasibility (e.g., [44,48,78]), can also be used to evaluate the accessibility of the design solutions and the language in which they are presented. The language of research papers can also be evaluated using techniques such as Flesch-Kincaid, and online tools (e.g., www.readable.com) [71]. Finally, the impressive language capabilities of generative AI tools, such as ChatGPT, can facilitate making DSR language more accessible. These tools can paraphrase the components of the paper and the artifact (e.g., user manual, interface instructions) and specifically target a particular audience of interest to the project (e.g., software engineers, database developers, 10-year-olds). Naturally, there are additional constraints on the use of generative AI tools in research, which must be considered, such as issues related to fairness, ethics, as well as compliance with the publishers' regulations.

4.4. Artifact maintenance and update costs

The complexity of artifacts might lead to additional costs in achieving a high level of transparency due to the need to make an artifact available for use by others, or to provide enough information for it to be replicated. Also, making a research artifact available for others can bring long term commitments, such as the need to update the artifact as technology changes or to maintain a repository of artifacts. Producing and maintaining design artifacts during the review and publication of

[5] Examples of such efforts include: (1) a *Management Science* paper, Tiefenbeck et al. [77], which informed a policy-oriented paper in *Nature Energy* [76]; and (2) a *DSR Cases* book, [86] of exemplary DSR projects presented in a manner accessible to PhD students and other researchers with a general interest in DSR.

[6] https://www.theoryon.org

research papers is laborious and can be seen as a distraction from the core objective of solving real-world problems with artifacts. Consequently, mandating access to executable artifact implementations should be considered with extreme caution. At the same time, DSR as a community, needs to reflect on the constituents it is striving to serve and continue exploring innovative ways to provide convincing demonstrations of the artifact in use, while remaining sensitive to incurring excessive effort and cost.

4.5. Proprietary information with privacy and security risks

The promise of DSR is creating artifacts to solve real-world problems. Transparency requirements face the challenge of protecting the privacy and security of the participants and informants who provided the data (and for action research, also of the organizations). In making solutions accessible to wider audiences, DSR scholars may inadvertently reveal security vulnerabilities or undermine intellectual property.

For example, if the programming code for a real-world system is to be shared, it may expose the system that implemented this code to hackers. This could be as simple as, for example, revealing instances of sloppy code when handing SQL queries. This may open the door to SQL injection attacks on the system. When thousands of lines of code are freely available for scrutiny, a simple search may reveal such vulnerability. Likewise, if in the name of full transparency, entire project code as well as implementation details are shared, this may inadvertently reveal organizational secrets. As some DSR solutions are implemented to address commercial problems (e.g., a common practice in action design research [68]), transparency may disclose proprietary know-how and undermine intellectual property and competitive advantage. In many cases, sharing the entire code base may not be realistic.

The sensitive nature of many DSR interventions necessitates a measured approach to transparency. One possibility could be exploring partial code sharing. A solution potentially useful for practitioners is to share all the code, but at different levels of openness – as-is code for non-sensitive components and obfuscated (specifically modified for protection) code for the sensitive ones [67]. Another solution may lie in using pseudocode that communicates some of the important aspects of the solution without revealing the sensitive details. This work can also be supported by research on code encryption, anonymizing, and obfuscation, to which the DSR community may also contribute with innovative solutions to these evolving challenges.

4.6. Managing DSR transparency in the review and publication processes

In recent years, research transparency has become a major focus for information systems journals, with requirements for authors to post a set of transparency materials on an external research repository. DSR projects can engage in open science repositories [20], which allow for the centralized storage and organization of research materials. These platforms allow researchers to store data, code, and other materials related to their research projects in a centralized location. This both enhances transparency and enables private collaboration and version control, helping researchers work together more efficiently and ensuring everyone has access to the most up-to-date project version. As the publication date approaches, researchers can then share their work publicly using a suitable sharing license.

DSR researchers face further challenges to include all essential details in academic papers, particularly with the iterative approach of DSR research and the limits of a journal article [55]. Often at the request of the reviewers, DSR researchers skip the description of the artifact's creation and present the final artifact and its evaluation. By sharing code and intermediate process steps alongside the main manuscript, authors can present high-level findings while directing interested parties to the transparency material for more detailed descriptions.

Most top-ranked IS journals provide guidance for quantitative and qualitative studies, but no such guidance is currently given specifically for DSR.[7] We in the DSR community have a tremendous opportunity to create manageable requirements for transparency and rigor using open science repositories. As Baskerville et al. [7] state: "[d]esign science research (DSR) [has] great potential to address the relevance versus rigor gap in information systems (IS) research." For example, DSR manuscripts can point to the artifact's instantiations and evaluation as part of the manuscript's transparency material. Transparency material can include code, videos, simulations, or digital diaries to provide transparency and corroborate the rigor of our approach. Like our qualitative colleagues, we can populate our repositories with not only technical artifacts [53], but also emails, meeting minutes, proposals, progress reports, and internal documentation that captures design decisions throughout the DSR research process [93].[8]

However, with this opportunity to capture the DSR cycle through repositories, the DSR community should be sensitive to the risk of adding prescriptive requirements that add unnecessary steps for those wishing to publish. A recent publication in CAIS indicates that publishing DSR work in highly rated IS journals remains a challenge [79]. DSR scholars providing frameworks and requirements for DSR research have good intentions. However, multiple, and sometimes conflicting guidelines have resulted in confusion and disagreement about the types of research contributing to design knowledge [49,62].

5. Discussion

Burton-Jones et al. [12] identify six key dimensions of transparency: purpose, audience, content, mechanism/venue, timeframe, and dangers. Each of these provides a unique perspective on transparency, broadly addressing the questions why, who, what, how, when, and why not. The distinctive features of DSR discussed in the previous sections create specific transparency issues that might not apply, or that might apply differently, to other forms of IS research. We expand our discussion on the first three of these key dimensions as they apply to DSR transparency.

Consider *purpose*. Concerns here revolve around the goals or objectives of being transparent about different aspects of the DSR process, product (artifacts), and impact. Table 1 summarizes, for each of the goals identified by Burton-Jones et al. [12], the distinctive characteristics of DSR with respect to that goal and their implications for transparency. In general, DSR entails more uncertainty than other forms of IS research due to imprecision in problem statements, complexity of the design process, and the difficulty of replicating situated implementations. Transparency efforts, therefore, should aim to reduce these uncertainties in ways that satisfy stakeholders, while keeping in mind the additional burden that might be imposed on researchers.

In terms of *audience* (Table 2), Burton-Jones et al. [12] recognize that transparency has different audiences, each of which might have different interests and concerns. For authors and reviewers, transparency provides a record of what was done during a research project, which in DSR can be essential due to the complexity of projects and the myriad of design decisions, including some that are incidental to the main goals of a project. Transparency provides a permanent record of these for authors and helps reviewers understand the design process and decisions. For other researchers and external stakeholders, there might be interest in reusing artifacts. In such cases, transparency of the artifact itself (e.g., making source code available) is necessary for reuse, but can impose a heavy burden on authors.

In terms of *content* transparency (Table 3), DSR differs from other forms of IS research in that it often produces a functional artifact, such as software. If the artifact is fully transparent, this creates additional

[7] See here for MISQ Transparency guidance: https://misq.umn.edu/research-transparency

[8] See here for an example of an Open Science Repository for Qualitative Research: https://osf.io/zqe84

Table 1
Purposes of DSR transparency.

Why (Goal)	DSR Focus	Distinctiveness	Implications
Trust in results	Situated artifacts have many unique properties	Exact replication is often impossible	Different forms of evidence should be provided to engender trust
Promote application	Design principles/guidelines	DSR is oriented to bringing about change in the world with prescriptive knowledge contributions	Application of DSR might need more detailed instructions to be useful to, e.g., practitioners Replication is not just about the results or evaluation, but about the process that generates the artifact
Facilitate pedagogy	Articulate repeatable process(es)	Frameworks for doing DSR are not as widely known or understood as for other approaches	In absence of a framework, greater burden on DSR researchers to explain more details of what was done in a language that is also accessible to a broader audience (researchers from other communities and practitioners)
Promote innovation and generativity	Creative designs measured for utility Outputs of DSR are often more readily available to be used by others	Easier in DSR to be transparent about (e.g., share) research output	Opportunity for DSR
Demonstrate accountability to society	Accountability lies in extent to which artifact solves a problem	Problem-driven focus makes DSR more relevant	Problem definition (is the right problem being addressed) is a key aspect of accountability in DSR
Facilitate reanalysis and replication	Frequently, settings and interventions cannot be replicated (interventions change the world). However, sometimes parallels behavioral (e.g., depending on the type of evaluation)	Interventions in controllable vs. uncontrollable settings	DSR research should explicate as much of the context as possible, recognizing that replication is extremely challenging or impossible for artifacts deployed in the field

Table 2
Audience for DSR transparency.

Who	DSR	Distinctiveness	Implications
Authors Reviewers	Indeterminacy of design requires many decisions to be made during a project	Many DSR design decisions can be permanently recorded in transparency materials to aid recall	Need for tools to document design process
Other Researchers	Artifacts may be directly used or adapted by other researchers	DSR produces artifacts that can be used in subsequent DSR projects	Sharing artifacts is a useful way of disseminating knowledge, but can impose a burden on researchers at both ends
External Stakeholders (practitioners, managers, policy makers)	DSR aims to address real-world problems of relevant stakeholders	Artifacts may be used as or modified and adapted by relevant stakeholders	Making artifacts available and usable can be useful, but can require much effort from authors. Supporting any potential adaptations can also be valuable.

Table 3
Content of DSR transparency materials.

What	DSR	Distinctiveness	Implications
Data, method, code, materials, proofs, empirical demonstrations	Constructs, models, methods, instantiations	Process of artifact creation differs from other paradigms	Articulating design decisions that go beyond the scope of design principles is necessary to understand the instantiation validity of an artifact
Review process	Research outputs are frequently functioning artifacts	Reviewers might benefit from access to a functional artifact (e.g., software)	Additional opportunity to demonstrate the usefulness and usability of the artifact
Researchers' respective contributions and interests	Researchers might work closely with practitioners	Artifacts might have commercial value	Importance of declaring such interests
Researchers' interpretations, deliberations, value judgments			See first row of this table

opportunities for other researchers and practitioners to interact with the artifact to better understand its capabilities, limitations, and value. In some cases, the artifact might have commercial value and/or the researcher might have an interest. These issues both enhance the need for transparency in DSR research. However, they also might increase the transparency risks (e.g. proprietary information being exposed) and costs (e.g., maintenance of the implemented artifact) for DSR researchers relative to those who use other research approaches.

Traditional mechanisms and venues for providing transparency materials have limitations for DSR use. Journal articles and text-based repositories permit only artifact descriptions, making it difficult to demonstrate the artifact in use. DSR can benefit from additional mechanisms/venues to demonstrate artifacts, including videos and other multimedia materials, providing access to operational artifacts (where feasible), and providing demonstrations of artifacts at academic or practitioner conferences and other venues.

6. Conclusion and future research

Research transparency provides sufficient information for relevant stakeholders to have greater confidence in the validity, appropriateness, utility, and limitations of research studies. For DSR, each of these issues is central. Therefore, there is an opportunity for researchers to strengthen their work by providing *appropriate* transparency material guided by the six features of the DSR Transparency Framework. Much of this material might be accumulated during appropriately documented DSR activities; in fact, adequate DSR transparency requirements will primarily go hand in hand with the requirements for good systems development, project control, and knowledge management. Indeed, there are already established practices of documentation when developing IT artifacts. Some of the products of IT development, such as event logs, feature requests, service and bug reports, and conceptual models, can be re-used at little to no cost, as artifacts of DSR transparency. In that sense, DSR transparency requirements become a useful set of guidelines for adequate documentation, most of which should be done in any case for the sake of the project and possible knowledge transfer within and beyond the organization, rather than represent an additional burden to the project.

In this commentary, we consider the importance of transparency for DSR and conceptualize how transparency can be ensured throughout a DSR research project and its publication process. We propose a six-feature DSR Transparency Framework, containing the features of process, problem space, solution space, build, evaluation, and contribution. For each of these features, we derive challenges that need to be addressed and provide actionable guidance for meeting transparency requirements, as summarized in Table 4. Against this background, we derive the risks and costs of transparency for DSR as well as how to manage the publication process. Lastly, we engage the key transparency dimensions proposed by Burton-Jones et al. [12], mapping them to DSR. In conclusion, we see great benefits in increasing transparency in DSR but we as a community must be aware that means to increase transparency are different for DSR compared to other research approaches (e.g., experimental research). To this end, we contribute by starting this important discourse both within and outside the DSR community.

There are several intriguing research directions to pursue toward achieving satisfactory DSR transparency goals. The six-feature DSR Transparency Framework could be improved by adding additional key DSR features or by making the framework more concise and rational for researchers and practitioners. The interplay among features can be further investigated to understand trade-offs with a goal of achieving an effective balance among desired DSR transparency features. The risks and costs of transparency, as discussed in Section 4, would be considered during this trade-off analysis.

Future experiences with the DSR Transparency Framework and its improvements should eventually result in well-defined, prescriptive transparency checklists and practices that would be followed by all DSR projects. Other scientific fields, such as medicine, have proposed such checklists (e.g. Equator Network Reporting Guidelines). However, we believe that it is premature to propose detailed, prescriptive transparency checklists for DSR projects in IS. This commentary is an initial step to spark a discussion that will lead the DSR community over time to develop a set of best practices and prescriptive checklists for enhanced scientific transparency in our research.

DSR projects can be studied to assess whether performing the transparency requirements proposed in this commentary results in meeting the transparency goals presented in Table 1. Can we provide evidence that DSR projects with greater transparency are more trusted, more valued, more cited, or more-reused? If we could isolate each of the six DSR transparency features for study, which of the features are the most significant in achieving these goals? Empirical investigations of how transparency features are implemented and how they result in goal-achievement will allow the DSR community to better focus its efforts and resources.

Table 4
DSR transparency challenges and guidance.

Transparency Feature	Challenges	Guidance
Process	- Process Planning - Emergence of Actual Process	- Record Process in terms of Activity, Reasoning, and Context - Use Process Capture Tools
Problem Space	- Stakeholder Engagement - Bounded Project Scope - Continuous Change in Problem Space - Reproducibility of Results	- Represent Problem Space in terms of Application Context, Improvement Goals, and Time/Space - Define Research Questions and Goals
Solution Space	- Extant Knowledge Bases: Descriptive and Prescriptive - Evolving Technologies - Transdisciplinary Grounding	- Perform Literature Reviews - Appropriate Relevant Solution Technologies - Collaborate with Contributing Disciplines
Build	- Human Cognitive Skills of Creativity, Reasoning, and Collaboration - Design Search Processes	- Design Novel Artifacts in Collaborative Teams via Creativity and Reasoning - Employ Support Environments to Enhance Cognitive Skills
Evaluate	- Rigorous Evaluation Methods both Formative and Summative - Convincing Research Evidence - Stakeholder Confidence in Results	- Perform Formative Evaluation in Rapid Design Cycles - Intervene with Artifact in Context for Summative Evaluation - Assess Fitness for Use and Fitness for Evolution
Contributions	- Practice Impacts - Scientific Impacts as Descriptive and Prescriptive Knowledge	- Balance Practice and Science Contributions - Report Project Progress in terms of Projectability, Fitness, and Confidence - Publish Research Results and Contributions in Scientific and Practice Literatures

CRediT authorship contribution statement

Alan R. Hevner: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Jeffrey Parsons:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Alfred Benedikt Brendel:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Roman Lukyanenko:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Verena Tiefenbeck:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Monica Chiarini Tremblay:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Jan vom Brocke:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization.

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Data availability

No data were used for the research described in the article.

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