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A decade of design in digital government research

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ABSTRACT

Digital government research often centers on information technology artifacts designed for the purpose of improving access to or processes within government. Because of the centricity of the technology artifact, much of this research builds upon theories and prescriptions adapted from the information systems discipline. In information systems, the study of artifact design has benefitted from the adoption of the rigor and generalizability enabled by design science research. The purpose of this paper was to provide an overview of design science principles guiding the construction of technological artifacts, which we use to examine a decade of digital government research articles that fall into the design science camp. We assess these articles, using the guidelines of Hevner, March, and Park (2004) for conducting and presenting design science research; we identify common strengths and gaps; we recommend how digital government researchers may benefit from applying a grounded view of design to expand the generalizability of their work; and finally, we conclude the paper with a discussion of ways to open up the narrow focus of design science to a broader understanding of the impact of external factors, such as the environment and organizational milieu, on the complex setting most digital government innovation inhabits.

1. Introduction

This paper provides an overview of how design science principles have been applied in the first decade of digital government research. The intent of digital government scholarship is, in large part, to affect the design, implementation, and use of information and communication technologies (ICT), which leads to improvements in the function of government. Digital government has advanced from a planned strategy to a common occurrence over the past ten years of practice and study. Because of the attention given to the information technology artifact in both information systems (IS) and digital government, we frame our evaluation of digital government design research by drawing on the IS design science paradigm.

In the case of IS, researchers focus on how best to design and implement ICT which help people (often situated in large formal organizations) to use information to organize and accomplish their work efficiently and effectively. This "design perspective" focuses attention on the particulars of the ICT and its arrangements. Design science research is not new in IS. Indeed, several recent special issues of top information systems journals (e.g., *Management Information Systems Quarterly*, the *Scandinavian Journal of Information Systems*, and the *European Journal of Information Systems*) feature exemplars of design science contributions. Significant design-related advances are central to other IS venues such as the *Journal of Management Information Systems, Decision Support Systems*, and the annual *Workshops on Information Technologies and Systems (WITS)* proceedings.

Broadly speaking, much of the research on information systems falls into one of two camps, behavioral or design, no matter the intellectual community in which this research is done. In behavioral research, the focus is on the uses, or impacts of uses, of ICT on individuals or organizations. Here, ICT is typically conceptualized as a static set of features or functions, and the focus is the roles, behaviors, and social actions of designers or users. The design camp places the technological artifact at the center of the research, with the objective of understanding how to best construct this artifact to meet user or organizational requirements. The results achieved in the two camps are often complementary in that innovative approaches to technology artifact design can result from or lead to changes or improvements in their subsequent use and the performance of their adopters. Likewise, insights on user behavior, social arrangements, and outcomes can be turned into design principles, particular design features, or influences on the design of the technological artifact.

Where does digital government fit within this dichotomy? Is design science an important paradigm for digital government researchers? Not surprisingly, much of the research published in digital government venues is about digitizing government work; that is, constructing a technological artifact for the goal of supporting current or improved government processes. Notably, each of the first nine International Conferences on Digital Government (dg.o) includes many presentations that focus on the design of an innovative technological artifact. In this tenth year of dg.o, we inspect the conference's proceedings to ascertain the influence of the design research paradigm on this field.

To assess these contributions relative to design science, we use the guidelines of Hevner et al. (2004) for conducting and presenting design

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science research. From this, we identify common strengths and recommend how digital government researchers may benefit from applying a grounded view of design to expand the generalizability of their work. We conclude the paper with a discussion of ways to broaden the focus of design science to take a more engaged stance relative to the impact of external factors such as the environmental milieu and organizational actions viz. the design of digital government systems.

2. Literature review

2.1. Design science

Several articles proposing frameworks to understand and classify design science research have been published from within the information systems discipline and beyond. We build here on the work of March and Smith (1995), and view design science as a prescriptive brand of research, which is focused on rigorously building or examining artifacts that aim to serve human goals. Design-oriented research starts with a problem—not just a generic phenomenon of interest but a specific and significant deficiency that requires both diagnosis and prognosis (Norman, 1990). As a scientific endeavor, theory informs and guides the approach to diagnosing and prescribing (Simon, 1969). Design science involves research investigating both created products (the artifact) as well as creation processes (designing). Some have advocated for the design perspective to be seen as a "Science of Design" (e.g., Hevner et al., 2004).

2.2. Information systems and design science

Simon (1969) advised that design science should strive to be a "body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process." (p. 58). Since then, and despite a shared interest in artifacts, design science within IS research has often been seconded to behavioral research. So, what has been the intellectual development of design science within information systems over the past four decades since Simon's siren call?

March and Smith (1995) address the "intellectually tough" element by extending the natural versus design science debate, arguing that IS research—in its quest for both rigor and relevance—benefits from both the governing laws identified in natural science inquiries, as well as the problem-solving orientation of design science investigations. Walls, Widmeyer, and El Sawy (1992, 2004) deal with formalizability by offering a detailed description of the elements of IS design theory. More recently, Gregor and Jones (2007) propose to extend this work by arguing for a greater focus on the dynamic elements required to examine mutable artifacts. Teachable doctrines can be found in Boland and Collopy's (2004) edited book in which thought-leading researchers like Weick, Orlikowski, and Lyytinen discuss how design can be used as a framework for guiding practitioners into better management practice.

Hevner et al. (2004) draw attention to empirical requirements by highlighting three exemplary studies investigating IS design. Their paper also emphasizes the analytic requirement of design research by offering principles and criteria by which design research could be evaluated. Given that their seven guidelines (as summarized in Table 1) provide the dimensions of our analysis later in this paper, a detailed description of them is in order.

- First, the *design as an artifact* guideline signifies that something must be developed—be it a construct, a model, a method, or an instantiation. This guideline recognizes both the centrality of the artifact (Orlikowski & Iacono, 2001), but also that routine design does not qualify as design science research—innovativeness is required.
- Second, the *problem relevance* guideline signifies that the artifact must address a problem in the field. This guideline recognizes the importance of assessing the utility of the artifact based upon its ability to resolve an interesting everyday issue facing practitioners.
- Third, the *design evaluation* guideline signifies that an artifact-improving feedback loop must be incorporated in the designing process. This guideline recognizes that there are various methods for evaluating artifacts—e.g., field experiments, observational case studies, and simulations.
- Fourth, the *contributions* guideline signifies that the outcome of the design research must be new and interesting. This guideline emphasizes that design-related contributions add value to at least one of three areas: the designed artifact itself, theoretical foundations, and methodological insights.
- Fifth, the *rigor* guideline signifies that design research efforts require internally and externally valid evaluation criteria as well as evaluation procedures for justifying problem-resolution claims. This guideline recognizes that rigor and relevance are sometimes seen as being in tension, but that both are essential to quality design research.
- Sixth, the search process guideline signifies that design work requires iterations involving alternative solutions for development, over time. This guideline recognizes that optimal solutions are often not feasible, and that "satisficing" (Simon, 1969) solutions also provide valuable contributions.
- Seventh, the communication guideline signifies that both academic as well as practitioner audiences be addressed when disseminating design research findings. This guideline recognizes that different audiences require different presentation formats and often different descriptive details regarding the designed artifact.

As can be seen in the application of these seven guidelines, as well as the other literature mentioned, contemporary IS design science research is covering the ground Simon saw as important in order for the study of design science to be seen as viable.

As we noted, design research has achieved more recognition and increased visibility within IS in the recent past. March and Storey (2008), in the introduction to the *MISQ* special issue on design, contend that design science methods are needed to better construct IT artifacts that contribute to the value of a firm or organizational performance, as well as to suggest new approaches to artifact design that would increase the likelihood of performance enhancement. They refer to the success of the National Science Foundation's Science of Design program and the highly regarded Design Science Research in Information Systems and Technology (DESRIST) conference as indicators of the momentum underway to recognize artifact-based contributions.

One of the articles in the *MISQ* special issue (Pries-Heje & Baskerville, 2008) describes a "Design Theory Nexus," and proposes

Table 1
Design guidelines from Hevner et al. (2004).

Guideline	Description
Guideline 1: Design as an artifact	Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation
Guideline 2: Problem relevance	The objective of design science research is to develop technology-based solutions to important and relevant business problems
Guideline 3: Design evaluation	The utility, quality, and efficiency of a design artifact must be rigorously demonstrated via well-executed evaluation methods
Guideline 4: Research contributions	Effective design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations and/or design methodologies
Guideline 5: Research rigor	Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact
Guideline 6: Design as a search process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment
Guideline 7: Communication of research	Design science research must be presented effectively both to technology-oriented as well as management-oriented audiences

eight theories of design depending on project features such as problem complexity, resources required, and whether or not user identities are known by the developer. These features describe how ill-structured, or "wicked" the problem underlying the proposed artifact or design process is, suggesting that not all artifacts can be or should be constructed or modeled in the same way. While the nexus is an important advance toward encapsulating the wide expanse of methods and approaches for designing, building, and testing artifacts, it leaves out many of the sociotechnical factors that would complicate the application of the eight suggested approaches.

This artifact-centric view of design is in sharp contrast to the social science perspective on design taken by Weedman (2008) in the *EJIS* special issue. Here, the author distances herself from the "information systems" approach to design as being too prescriptive. She adopts a "social science" design theory to better understand the role of the user as a partner in systems design. It is interesting to note that both views build from Simon's *Science of the Artificial* (1969) for early guidance. The difference in approach stems not from the emphasis on process over product, as both are covered by the work of Walls et al., Hevner et al., and Gregor and Jones, but from an emphasis on qualitative ("understand how design is done") versus quantitative/optimization ("develop the best possible designs and methods for design") methods. Given the current thinking of many pursuing design in IS, many would likely consider Weedman's social science design approach as falling into the "other camp," behavioral research that forms the other side of design science work within information systems.

Another article in the *EJIS* special issue presents taxonomy of digital services to provide an initial understanding of the similarities and differences among these services and their providers (Williams, Chatterjee, & Rossi, 2008). They see categorization as a precursor to the creation of a set of design principles, which would eventually extend their descriptive understanding of design knowledge to the prescriptive realm, a goal that design scientists should all seek.

In essence, both the design and behavioral camps advance important and legitimate goals for information systems researchers. Taken independently, the research from either camp fails to achieve a full understanding of what designers need to know in order to describe or craft an artifact that takes its environment fully into account. Twenty years ago, Markus and Robey (1988) decried the creation of such camps in their critique of the technological and organizational imperatives. It is time for both "behavioral" and "design science" researchers to stop thinking about which camp their research resides in, and begin to work together to investigate how principles for effective design interact with the sociotechnical environment in which they reside or from which they emerge.

Another debate within design research is the degree to which researchers constructing artifacts should ground their studies in established theoretical works. Some design science proponents have acknowledged that design researchers have lost sight of design-relevant literature that could be used to inform and validate their investigations (Iivari, 2007). By focusing on validating their propositions by constructing artifacts, design researchers risk ignoring established concepts in their quest to prove new ones. While design researchers engage in scientific design (e.g., employing concepts from natural sciences to enhance speed of data retrieval), they are not fully engaged in design science if they are not factoring in the full range of sociotechnical elements influencing the situated artifacts being examined. In other words, one implication for this narrow view of design research is the potential to ignore context in design research—potentially limiting researchers' ability to generalize to other environments. Attending to context is particularly important in researching environments that are influenced by political dynamics, as is the case for digital government.

2.3. Design of digital government applications

Digital government research publications are replete with examples of artifact-centric research. Although this body of research spans information systems and computer science, communications, public policy, and many related governmental disciplines, one common theme is the design of a technology-based system.

What is interesting to note is the lack of alignment with the behavioral or design science camps so carefully preserved in the IS literature. A cursory review of three articles in a recent issue of *Government Information Quarterly*, for example, illustrates this point. Each of the three document a single governmental system: the Internet Payment pilot (IPP) (Fedorowicz, Gelinas, Gogan, & Williams, 2008), Online Procedures Enhancement (OPEN) for civil application (Kim, Kim, & Lee, 2008), and the National Digital Information Infrastructure and Preservation Program (NDIIPP) (Kwon, Pardo, & Burke, 2008). The IPP case describes the interaction of technical, political, operational, and economic factors that motivated the design approach taken for this pilot application. The OPEN system is presented in light of three dimensions of institutionalization and four anticorruption strategies, evolving into a prototype for a national system. NDIIPP recommends the creation of a community of practice to facilitate partnership efforts and strategies for collaboration.

Is the deep but narrow treatment of these case studies a good sign for digital government research? Does it reveal a lack of attention to those qualities of design-based research that render the results generalizable beyond the functional domain of the case under study? Or does it indicate a broader sociotechnical perspective on design on the part of digital government researchers? In the next section, we present an assessment of prior studies in the digital government domain to assess the role of design and the design perspective in the findings presented at past Digital Government conferences.

3. Method

In the United States, digital government research coalesced about a decade ago when the National Science Foundation initiated an annual conference (the Digital Government conference or "dg.o") to showcase the research it funds in this area. The conference program represents some of the leading work in the field, and provides a useful cross-section and characterization of the subject matter and methodological approaches of this research over time. We chose to study all of the proceedings in the 9 years of dg.o history to better understand the role of design science in digital government work and to analyze the rigor of the studies exhibiting a design focus.

The proceedings of the dg.o conferences are included in the ACM Digital Library. Table 2 shows the number of research papers included in each year's proceedings, as reflected by each conference's Table of Contents, found in the ACM Digital Library.[1] A key word search simultaneously using "dg.o," "digital government," and "design" yielded 414 items in the ACM's Guide database. A review of each paper's abstract to assess the centrality of an IS-related artifact was then performed. Per Hevner et al. (2004), an IS artifact could entail a construct, a model, a method, or an instantiation of a system. Based upon a desire to focus on end-user impacting information systems, a number of categories of papers were excluded from this review:

- Computational artifacts (e.g., algorithms) specifically built for stand-alone statistical packages;
- Prescriptions for implementation strategy (e.g., promoting IT standards, or generic calls for participatory design independent of a particular system);
- Prescriptions for designing artifacts other than IS-related (e.g., processes, government buildings, office spaces, organizational structures); and
- Conceptual frameworks.

[1] Note that the Digital Library does not contain a Table of Contents for the 2001 conference, so that year's population data is missing from Table 2. The 2001 conference papers themselves are in the Digital Library, and were included in the analysis.

Table 2
Sample and population figures from dg.o conference proceedings.

Year	Total number of research papers in proceedings	Number of research papers 6 pages or longer	Number of papers meeting selection criteria
2000	22	22	3
2001	n/a	n/a	8
2002	101	73	15
2003	116	21	9
2004	142	10	2
2005	42	11	0
2006	65	19	4
2007	26	24	3
2008	39	35	9
Total	553	215	53

In general, some description of a system, or a system development method leading to a specific system, was required to be included in this review. When a paper's abstract did not provide enough detail to determine the centrality of the IS artifact, we reviewed the full article. In addition, poster session papers that were shorter than two pages in length were excluded (e.g., project status reports, system demos). This stage of the review resulted in 82 of the 414 papers being identified as being "design science relevant."

Of these 82 papers, only those six pages and longer were included in the final set reviewed. This length criterion was established to ensure that papers had adequate space to include enough detail about the design science aspects of their study. We did so because holding papers to rigor and relevance criteria would be difficult to meet within such strict page constraints. This stage of the review resulted in 53 of the 82 papers being kept. The Appendix contains the authors, conference years and titles of the 53 papers included in our analysis. As shown in Table 2, 39% of all dg.o research papers met the specified length criterion. Of those meeting the length restriction, approximately 25% fit the design-related criteria outlined above.

The 53 papers were then classified using six of the seven IS design science guidelines found in Hevner et al. (2004)—these are summarized above in Table 1. The first three guidelines involve descriptions, and the next three guidelines involve demonstrations. The guideline "*communication of research*" was not included in the coding since each paper was published in the dg.o proceedings—a venue for both academics and practitioners.

A rating (*full*, *partial*, *none*) was assigned to each paper for each guideline, depending upon the paper's adherence to the specific guideline. The rating assigned to each paper was based upon the degree of adherence to each principle—rather than the validity of content—since the coders are not experts in all of the researched domains.

Two researchers participated in the coding process. The primary coder reviewed all of the articles while the secondary coder reviewed a quarter of them to determine interrater reliability. A third researcher provided objective feedback on the coding work based upon the IS design science guidelines (Hevner et al., 2004). Given the small number of papers coded, it was possible to resolve the small differences and reach consensus through negotiation. And, no major differences in coding arose from this process. The ratings for each of the 53 papers are included in the Appendix.

A paper earned a *full* rating for the *artifact* guideline if a viable artifact was described in detail-including characteristics (what the artifact consists of), capabilities (what the artifact does), and some type of graphic or visual representation of the artifact. This graphic could include programming code lines for systems incorporating algorithms or software languages. A *full* rating for *relevance* was given if the authors described the problem in detail—including the target beneficiaries of the artifact and how the artifact would address their specific issues. Our rationale for requiring a target user group description is that a paper cannot fully express its relevance without fully describing the problem being addressed by the artifact—which in turn requires a description of those affected by "the problem." A *full* rating for *evaluation* was given when the authors described some external validation assessing the efficacy of the artifact. This treatment includes a detailed description of future evaluations for earlier stage research projects, or specific citations of other papers from the same project team that detailed the evaluation that had previously taken place.

The next set of guidelines involves demonstration. A *full* rating for *contribution* was given when the authors demonstrated both novelty and value for the artifact described. We avoided needing to know whether an artifact was truly novel in a particular domain by only requiring an explicit and logical statement of novelty by the authors. A *full* rating for *rigor* was given if enough evidence independent of the authors themselves was provided to demonstrate reasonableness for the claims of the paper. In other words, a full rating was given when reviewers were not forced simply to "trust" the authors' personal assessments regarding the assertions made in the paper. A *full* rating for *search* was given when the authors demonstrated that the artifact met some generalizable needs as part of an overarching research effort.

4. Analysis

4.1. Distribution across conferences

The 53 papers in this review are distributed unevenly across the years covered by the dg.o conference proceedings. There are no papers from the 2005 conference and few papers from other years. Four years (2002 with 15, 2003 and 2008 with 9, 2001 with 8) account for the majority we analyzed. An informal examination of the conference history was conducted to see if a difference in the conference focus might account for this unevenness.

The Digital Government conferences were initially funded by the National Science Foundation to provide a forum for the presentation of progress on ongoing NSF-funded projects. More recently, the conference begat the formation of the Digital Government Society of North America: its current sponsor. The requirement for ongoing NSF grants to be represented at each dg.o conference no longer stands. A review of the number of design-centric papers shows no correlation with the evolution of the conference sponsorship or NSF requirements.

Another possibility for the differences among the years could be that the Call for Papers has changed over time. An examination of the Call for Papers for each of the nine conferences suggests that a top priority of the conference has always been to provide a forum for interdisciplinary research spanning the computing and social sciences.[2] However, even given this interdisciplinary orientation, all of the Calls prior to 2008 list separate tracks for Information Technology and Social Science research. In 2008, the explicit Social Science Research track is dropped, while IT remains the focus of many of the suggested topic areas. This may account for the increase in 2008's design-oriented papers.

4.2. Fit with Hevner

Each paper was reviewed to classify its adherence to the first six design science research guidelines (see Table 1). Adherence was then coded as "full," "partial," or "none." The results of the analysis are included in Table 3.

Of the 53 papers reviewed, 46 met all of the guidelines to some extent. Only four were deemed to fully meet the Hevner criteria; another four came close, by partially addressing only one or two of the guidelines. As can be seen from Table 4, the four meeting all guidelines were all published in 2007(1) or 2008(3). In contrast, another seven were missing coverage of one or more guidelines, and these were published in 2001(3), 2002(2), 2004(1), and 2007(1). While we

[2] The Calls for Papers of all conferences were found on the web with the exception of 2000 and 2002. For these two years, the conference web site was reviewed for their discussion of desired paper topics for submissions.

Table 3
Overall assessment of adherence to Hevner guidelines.

Coding result	Number of articles (%)
All guidelines considered fully met	4 (8%)
All guidelines fully met except for one or two partially met	4 (8%)
All met to some extent, but more than two only partially met	38 (72%)
At least one guideline not met	7 (13%)

cannot determine a pattern with this small of a sample, the trend seems encouraging: design-oriented digital government researchers are becoming more cognizant of how to provide a thorough explication of their work's contribution.

Table 5 show how well each of the six guidelines were met by the 53 papers. Three of the guidelines (one, two, and six) were covered by all the papers. Three quarters of the papers described a viable artifact in adequate detail, although given that artifact existence was a central tenet of the paper selection criteria, this is neither surprising nor impressive. Guideline five, on rigor, was least likely to achieve a full rating. This is an unfortunate insight on the quality of design-related digital government research as published in this venue and deserves careful consideration by digital government researchers employing a design science tradition. On average, less than half of the papers reached the expected level of attention to these six guidelines, signaling an opportunity to educate the design-oriented digital government researcher on the merits of a rigorous and generalizable approach to artifact design and evaluation.

4.3. Reliance on design literature

While each of the papers in this sample centered on the design or use of an IT artifact (that is, they conformed at least partially to Hevner's first guideline), it does not immediately follow that each paper was purposefully written to conform to the science of design. To help understand the degree to which authors relied on established design science literature, the reference list of each article was checked for the inclusion of seminal design sciences works (e.g., Hevner et al., Walls et al., Simon, and the like). Only one of the papers (Robertson, 2008) explicitly relied on this design science literature. Several used the work of Shneiderman (1998) as the basis of user interface design research. Others relied on design perspectives found in the literature of human–computer interaction (e.g., Carroll, 1997). Still others built on related specific design theories such as database design principles or algorithm design.

4.4. The four exemplar articles

Tables 3 and 4 and the Appendix show that only four recently published articles were found to fully meet all the guidelines of Hevner et al. All four of these articles present a single case study of the design or testing of a technology artifact. The variety of artifact instantiations, reference literatures, and evaluation methods in the four papers illustrate the wide range of artifact-centric studies reflected in the sample under study. Descriptions of the papers, and their adherence to the guidelines of Hevner et al., are covered below.

Table 4
Distribution of guideline adherence across time.

Year of publication	All guidelines met	All guidelines at least partially met	One or more guidelines not met
2000	0	3	0
2001	0	5	3
2002	0	13	2
2003	0	9	0
2004	0	1	1
2005	0	0	0
2006	0	4	0
2007	1	1	1
2008	3	6	0

Table 5
Distribution of guideline adherence.

Guideline	Fully met, *n* (%)[a]	Partially met, *n* (%)	Not met, *n* (%)
1. Artifact	41 (77%)	12 (23%)	0
2. Relevance	25 (47%)	28 (53%)	0
3. Evaluation	21 (40%)	27 (51%)	5 (9%)
4. Contribution	21 (40%)	29 (55%)	3 (6%)
5. Rigor	13 (25%)	39 (74%)	1 (2%)
6. Search	18 (34%)	35 (66%)	0
Average	23.2 (43%)	28.3 (53%)	1.5 (3%)

[a] Percentages may not add up to 100 due to rounding error.

Chen, Chen, Zhao, Hamid, Saleem, and Chartterjee (2008) constructs a web-based modeling and simulation application artifact to assist in the regulation of insurance rate making. The artifact addresses a general problem of data integration and a more particular problem of improving damage assessments for hurricane incidents. The evaluation of the artifact involved both statistical validation as well as qualitative assessments from state agency officials. The paper contributes methodological elements to digital government literature by identifying a data integration strategy based upon a customized synthesis of several existing techniques. While little appeal is made to design science literature, the rigor of the study is demonstrated through citation of other prior supportive theoretical and empirical work, as well as by a detailed description of the criteria and procedure used to assess the system integration plan. The design and integration of the system are discussed in the broader context of a complex system development effort. The results are communicated through the dg.o proceedings as well as directly to state officials. We note that the paper focuses on technical design issues, with little to no discussion of the social context within which the system is to be used.

The Matsunaga, Tsugawa, and Fortes (2007) paper also centers on the technical issues surrounding the development of a system, in this case describing how Service-Oriented Architecture can aid in interoperability of cross-agency collaborations. The artifact addresses the problem of meeting interoperability and efficiency requirements in the context of international digital government projects. The evaluation of the artifact involved a detailed proof-of-concept case study. The paper contributes methodological elements (i.e., web-services wrapping technique). The authors demonstrate rigor by providing definitional clarity on numerous concepts and by contrasting their project to several others—giving the reader a better understanding of the study's distinctive strengths. The paper builds upon a discussion of the general applicability of its approach, pointing out how the case example they describe can assist in a wide range of governmental needs. The results are communicated through the dg.o proceedings, and directly to international development partners on the project.

Robertson's (2008) paper is the only one of this set that provides an explicit design science context and argument for the artifact design issues identified. Several technological features are developed as part of a web-based search tool ("prosthesis") aimed at improving voter data gathering about candidates. The artifact addresses the problem of meeting voter information and efficiency requirements in the face of their limited knowledge of formulating appropriate queries. The evaluation of the artifact involves a controlled experiment. User reaction is both measured and described in a socially cognizant context. The paper contributes designed artifact elements by showing that minor changes in design have significant effects on voter search strategies. The author appeals directly to design science literature and demonstrates rigor by providing details for the experimental design. The paper builds upon a discussion of the general applicability of its approach, illustrating how the proof-of-concept exercise they conducted can assist in a wide range of governmental needs. The results are

communicated through the dg.o proceedings and are reported to the National Science Foundation. The author begins and ends the paper by advocating for the broader use of design science as a referent domain for digital government research.

The paper of Saleem, Luis, Deng, Chen, Hristidis, and Li (2008) introduces a model and prototype system to facilitate collaboration and communication during disaster preparation and recovery. The artifact addresses the problem of using ICT to prepare for and overcome terror attacks and natural disaster. They base their argument in support of their system on the needs of a range of business and emergency management members—who in turn assess the effectiveness of the artifact. The model and prototype they have built are driven by this socially situated assessment that contributes to literature by incorporating private businesses and their needs for operational continuity. Although they do not refer to sociotechnical design in the paper, they do provide a good example of how social and technical requirements should and do interact. The authors demonstrate rigor by describing the superiority of their approach over rival approaches to solving the emergency preparedness problem. The search for a feasible and general solution is described through discussion of other alternative means of establishing a business continuity information sharing infrastructure. The search for a solution also includes discussion of how the current research fits into the overall research plan. The results are communicated through the dg.o proceedings as well as directly to the various public and private sector collaborators that assisted in the project's design and deployment activities.

All four of the exemplar papers present detailed and well-supported descriptions of the design and implementation of a complex IS. However, they range in their reliance on design science (from none to a very explicit call), and also on how overtly they consider the socially situated setting of the artifact they prescribe (again, from not at all, to full recognition of its import). The differences noted in the presentation of each of these studies illustrate the stark contrast in the authors' reliance on the design science paradigm, and also their recognition of the interplay among technical and social design requirements.

5. Discussion and future research

Design-centric research now appears regularly in many digital government venues. Like design-oriented research in IS, the theoretical quality and generalizability of the findings vary significantly from study to study. Few digital government studies self-identify as belonging to this research paradigm; others present their technological artifact as a case study without grounding in a common methodology or design science framework or theory.

In this paper, we evaluated how digital government design research has been conducted in the recent past to show how closely it aligns with the evolving design science framework initially presented by Hevner et al. in 2004. While several researchers have suggested improvements to the Hevner guidelines, these guidelines continue to be the basis for framing the technical considerations that researchers need to consider in order to provide useful, generalizable results that extend beyond a limited case scenario. We found little evidence of dg.o research that is purposefully grounded upon the IS design science prescriptions of Hevner et al. or those of others. While the digital government community does a reasonably good (although neither comprehensive nor extensive) job of conforming to design science guidelines, it does so without benefiting from or contributing to the relevant extant literature in this area.

This review and analysis of dg.o literature leads us to suggesting three recommendations for design research in digital government.

- First, digital government design research should be more deeply connected to extant design science literature. Most research has drawn on prior work on technology functions and features without recognizing how prior studies of design might inform their innovation.
- Second, artifact-centric research should move beyond one-off presentation towards more prescriptive and generalizable contributions connected to design science guidelines. We note that such guidelines are not limited to those evolving in the information systems literature, although those are *a propos* to much digital government work. Rather, researchers should attend to and prescribe a wide range of design work depending on the nature, scope, and method of the design in question.
- Finally, in practice, artifact designers are confined by financial, organizational, and political realities that extend beyond technical requirements. Few of these papers indicated the contribution of their work beyond the technical benefits of the artifact. Researchers are wise to consider social realities when designing and examining situated artifacts.

5.1. Bridging design and behavioral research

Given the specific demands of digital government research—such as understanding rules, policies and institutional structures in which digital government technologies and systems must work—it is imperative that design-oriented research extends its focus to include the artifact and its interplay with the surrounding environment. Much current design science research and rhetoric explicitly centers on design characteristics of an artifact to meet specific requirements for organizational, governmental, or business use. These requirements may arise from detailed study and interaction with professional practice or from more abstract theoretical foundations. A too-narrow view of the science of design places undue emphasis on the artifact and shortchanges the nature of its social embedding and social shaping. This brings to mind the distinction between taking a “tool view” versus “ensemble view” to distinguish between the technologically focused work taking place versus the sociotechnological research that should be occurring (Orlikowski & Iacono, 2001). This division is particularly acute in digital government research (which is distinctive because of its larger and more complex environmental setting). So, even something as technologically simple and bounded as a software module arises from and is shaped by social interactions that are, in turn, framed by organizational logics—leading that module's design to be different in digital government (versus commercial) settings. Design researchers must look beyond technical opportunism or elegance in framing a design. As part of their analysis, they must consider that the framing of a design—more specifically, identifying the problem or opportunity—is done in the context of organizational needs and, particularly, the needs of powerful groups within organizations.

To be sure, the design of any system is driven in part by what currently exists (e.g., user technical skills, legacy systems). This leads to organizational computing environments that look more like old on new (or new at the edges and older in the middle). A description of an IT innovation must extend beyond the artifact itself to include the contribution of, and impact on, its users, organizations, and environment.

Better engaging the mutual interests of design and behavioral perspectives leads to much potential for future research. In general terms, digital government-focused design research should recognize that (1) technical design reflects institutional power and (2) technical design builds on and does not replace previous technical design (leading to increasing complexity). The first suggests that social arrangements are often more malleable in the short run than are technical arrangements. However, in the longer term, social arrangements (hierarchy, skill, culture, and other sources of organizational and social power) are more likely to drive adaptations to the technical arrangements than the reverse. The second suggests that technical change always increases complexity. Both of these are valid and important aspects of necessary, rigorous artifact evaluation in order for the artifact to demonstrate relevance to practice.

Digital government research, by its very nature, will continue to prize the technological artifact at its center. In order to truly understand and benefit from the distinguishing features of technology-involved case studies, the next decade of digital government research should recognize and advance both technological and social foundational contributions to the process or product of artifact construction.

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Appendix. Alphabetical listing of dg.o conference papers on artifact design

Author	Year	Title	Artifact	Relevance	Evaluation	Contrib.	Rigor	Search
Adali, S., Harrison, T. M., & Zappen, J. P.	2002	Connected kids: Community information system design and development	Partial	Full	Partial	Partial	Partial	Full
Adam, N., Artigas, F., Atluri, V., Chun, S., Colbert, S., Degeratu, M., et al.	2001	E-Government: Human-centered systems for business services	Full	Full	Partial	Partial	Partial	Partial
Ambite, J. L., Arens, Y., Bourne, W., Davis, P. T., Hovy, E. H., Klavans, J. L., et al.	2002	A portal for access to complex distributed information about energy	Full	Partial	Full	Full	Partial	Full
Ambite, J. L., Arens, Y., Gravano, L., Hatzivassiloglou, V., Hovy, E., Klavans, J., et al.	2000	Simplifying data access: the energy data collection	Full	Partial	Partial	Full	Partial	Full
Ambite, J., Shahabi, C., Schmidt, R., & Philpot, A.	2001	Fast approximate evaluation of OLAP queries for integrated statistical data	Full	Partial	Partial	Partial	Partial	Partial
Banga, B., Landis, E., Tolle, T., Delcambre, L., & Phillips, F.	2002	User needs assessment for the adaptive management portal	Partial	Partial	Full	None	Partial/ none	Partial
Borning, A., Sevcikova, H., & Waddell, P.	2008	A domain-specific language for urban simulation variables	Full	Partial	Full	Partial	Full	Partial
Carr, D. B., Chen, J., Bell, B. S., Pickle, L., & Zhang, Y.	2002	Interactive linked micromap plots and dynamically conditioned choropleth maps	Full	Full	Partial	Partial	Partial	Partial
Chau, M., Atabakhsh, H., Zeng, D., & Chen, H.	2001	Building an infrastructure for law enforcement information sharing and collaboration: Design issues and challenges	Full	Full	None	Partial	Partial	Partial
Chen, H., Atabakhsh, H., Petersen, T., Schroeder, J., Buetow, T., Chaboya, L., et al.	2003	COPLINK: Visualization for crime analysis	Partial	Partial	Partial	Partial	Full	Full
Chen, H., Atabakhsh, H., Zeng, D., Schroeder, J., Petersen, T., Casey, D., et al.	2002	COPLINK: Visualization and collaboration for law enforcement	Partial	Full	Partial	Partial	Partial	Partial
Chen, S.-C., Chen, M., Zhao, N., Hamid, S., Saleem, K., & Chatterjee, K.	2008	Florida public hurricane loss model	Full	Full	Full	Full	Full	Full
Cheng, W., Chou, C., Golubchik, L., Khuller, S., & Samet, H	2001	Scalable data collection for internet-based digital government applications	Full	Partial	None	Partial	Partial	Partial
Chun, S. A., Atluri, V., & Adam, N. R.	2002	Dynamic composition of workflows for customized e-Government service delivery	Partial	Partial	None	Partial	Partial	Partial
Degeratu, M., & Hatzivassiloglou, V.	2002	Building automatically a business registration ontology	Full	Full	Partial	Full	Full	Partial
Degwekar, S., DePree, J., Beck, H., Thomas, C. S., & Su, S. Y. W.	2007	Event-triggered data and knowledge sharing among collaborating government organizations	Full	Full	Partial	Full	Full	Full
Duncan, D., Kum, H.-C., Flair, K., & Wang, W.	2004	Successfully adopting IT for social welfare program management	Full	Full	Full	Partial	Partial	Full
Esperanca, C., & Samet, H.	2000	Experience with SAND-Tcl: A scripting tool for spatial databases	Full	Partial	Partial	Full	Full	Partial
Gupta, A., Memon, A., Tran, J., Bharadwaja, R. P., & Zaslavsky, I.	2002	Information mediation across heterogeneous government spatial data sources	Full	Partial	Partial	Partial	Partial	Partial
Hovy, E., Philpot, A., Klavans, J., Germann, U., Davis, P., & Popper, S.	2003	Extending metadata definitions by automatically extracting and organizing glossary definitions	Full	Partial	Partial	Partial	Partial	Partial
Huang, Y., Contractor, N., & Yao, Y.	2008	CI-KNOW: Recommendation based on social networks	Full	Partial	Full	Full	Partial	Partial
Iyengar, R. K., & Malyankar, R. M.	2002	A method for automating text markup	Full	Partial	Partial	Partial	Partial	Partial
Jackson, L. S.	2003	Preserving state government web publications: First-year experiences	Partial	Partial	Full	Partial	Partial	Partial
Kang, H., Plaisant, C., & Shneiderman, B.	2003	New approaches to help users get started with visual interfaces: multi-layered interfaces and integrated initial guidance	Full	Full	Full	Full	Partial	Partial
Karr, A., & Sanil, A.	2001	Web-based systems that disseminate information but protect confidential data	Full	Partial	Partial	None	Partial	Partial
Kerrigan, S., Heenan, C., & Law, K. H.	2002	Regnet: An infrastructure for regulatory information management and compliance assistance	Full	Partial	Partial	Partial	Partial	Partial
Kerrigan, S., Heenan, C., Wang, H., Law, K. H., & Wiederhold, G.	2003	Regulatory information management and compliance assistance	Full	Full	Partial	Partial	Partial	Partial
Kules, B., & Shneiderman, B.	2003	Designing a metadata-driven visual information browser for federal statistics	Full	Full	Partial	Full	Partial	Partial
Kum, H.-C., Duncan, D. F., & Stewart, C. J.	2008	Supporting self-evaluation in local government via KDD	Full	Full	Full	Full	Partial	Full
Kum, H.-C., Duncan, D., Flair, K., & Wang, W.	2003	Social welfare program administration and evaluation and policy analysis using knowledge discovery and data mining	Partial	Full	Full	Partial	Partial	Partial
Lin, C., Hu, P. J., Schroeder, J., & Chen, H.	2002	Examining user acceptance of COPLINK technologies by law enforcement officers: A survey study	Full	Partial	Full	Full	Full	Full

(*continued on next page*)

Appendix (*continued*)

Author	Year	Title	Artifact	Relevance	Evaluation	Contrib.	Rigor	Search
MacEachren, A., Hardisty, F., Gahegan, M., Wheeler, M., Dai, X., Guo, D., & Takatsuka, M.	2001	Supporting visual integration and analysis of geospatially-referenced data through web-deployable, cross-platform tools	Full	Partial	Partial	Full	Partial	Partial
Malyankar, R.	2001	Maritime information markup and use in passage planning	Full	Partial	Partial	Full	Partial	Partial
Marchionini, G., Haas, S., Plaisant, C., Shneiderman, B., & Hert, C.	2003	Toward a statistical knowledge network	Full	Full	Partial	Partial	Partial	Full
Marchionini, G., Hert, C., Liddy, L., & Shneiderman, B.	2000	Extending understanding of federal statistics in tables	Full	Full	Partial	Full	Full	Full
Matsunaga, A., Tsugawa, M., & Fortes, J. A. B.	2007	Integration of text-based applications into service-oriented architectures for transnational digital government	Full	Full	Full	Full	Full	Full
Philpot, A., Ambite, J. L., & Hovy, E.	2002	DGRC AskCal: Natural language question answering for energy time series	Full	Partial	None	Full	Partial	Partial
Purpura, S., & Hillard, D.	2006	Automated classification of congressional legislation	Partial	Partial	Full	Partial	Full	Partial
Robertson, S. P.	2008	Design research in digital government: a query prosthesis for voters	Full	Full	Full	Full	Full	Full
Saleem, K., Luis, S., Deng, Y., Chen, S.-C., Hristidis, V., & Li, T.	2008	Towards a business continuity information network for rapid disaster recovery	Full	Full	Full	Full	Full	Full
Samet, H., & Brabec, F.	2002	Remote thin-client access to spatial database systems	Full	Partial	Partial	Partial	Partial	Partial
Samet, H., Brabec, F., & Hjaltason, G.	2001	Interfacing the SAND spatial browser with FedStats data	Partial	Partial	Partial	Full	Partial	Partial
Shapiro, S., & Coglianese, C.	2007	First generation e-rulemaking: An assessment of regulatory agency websites	Full	Full	Full	None	Partial	Partial
Suchan, T. A.	2002	Usability studies of geovisualization software in the workplace	Full	Full	Full	Partial	Partial	Partial
Tanin, E., & Samet, H.	2002	APPOINT: An approach for peer-to-peer offloading the internet	Full	Partial	Partial	Full	Partial	Full
Tanin, E., & Samet, H.	2003	Improving access to large volumes of online data	Full	Partial	Full	Full	Partial	Full
Tauro, C., Ahuja, S., Manuel A. Perez Quiones, Kavanaugh, A., & Isenhour, P.	2008	Deliberation in the wild: A visualization tool for blog discovery and citizen-to-citizen participation	Full	Partial	Partial	Partial	Partial	Partial
Tyworth, M., & Sawyer, S.	2006	Organic development: A top-down and bottom-up approach to design of public sector information systems	Partial	Full	Full	Partial	Partial	Partial
Velez, I., & Velez, B.	2006	Lynx: An open architecture for catalyzing the deployment of interactive digital government workflow-based systems	Full	Partial	Partial	Partial	Partial	Partial
Yang, H., & Callan, J.	2008	Ontology generation for large email collections	Full	Partial	Full	Partial	Partial	Partial
Zappen, J. P., Adali, S., & Harrison, T. M.	2006	Developing a youth-services information system for city and county government: Experiments in user-designer collaboration	Partial	Full	Full	Partial	Full	Partial
Zappen, J. P., Harrison, T. M., & Watson, D.	2008	A new paradigm for designing e-Government: Web 2	Partial	Full	Partial	Partial	Partial	Full
Zeng, D., Chen, H., Tseng, C., Larson, C. A., Eidson, M., Gotham, I., et al.	2004	Towards a national infectious disease information infrastructure: A case study in West Nile virus and botulism	Full	Full	None	Partial	Partial	Full

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