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Abstract:

Despite growing interest in design science research in information systems, our understanding about what constitutes a design contribution and the range of research activities that can produce design contributions remains limited. We propose the design research activity (DRA) framework for classifying design contributions based on the type of statements researchers use to express knowledge contributions and the researcher role with respect to the artifact. These dimensions combine to produce a DRA framework that contains four quadrants: construction, manipulation, deployment, and elucidation. We use the framework in two ways. First, we classify design contributions that the *Journal of the Association for Information Systems* (*JAIS*) published from 2007 to 2019 and show that the journal published a broad range of design research across all four quadrants. Second, we show how one can use our framework to analyze the maturity of design-oriented knowledge in a specific field as reflected in the degree of activity across the different quadrants. The DRA framework contributes by showing that design research encompasses both design science research and design-oriented behavioral research. The framework can help authors and reviewers assess research with design implications and help researchers position and understand design research as a journey through the four quadrants.

Keywords: Design Knowledge, Classification, Mapping, IT Artifact, Design Science Research, Prescriptive Knowledge, Descriptive Knowledge.

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1 Introduction

The rapid digital transformation of business and society has created new challenges and opportunities for information systems (IS) research focused on design. Design research is important in fields such as engineering, architecture, business, economics, and information technology (IT (see Kuechler & Vaishnavi, 2008; March & Smith, 1995). Broadly speaking, design research in the information systems (IS) field focuses on adding knowledge about how people can and should construct or arrange (i.e., design) things to achieve some desired goal. For example, design knowledge in the IS field includes knowledge about how to construct a database to support transaction processing and querying, how to align IS with organizational strategy to achieve organizational goals, and how to employ data analytics to support effective decision making. The products of design research have significant economic and societal implications. Therefore, contributing to design knowledge has unsurprisingly become an increasingly popular IS research mode.

However, we lack a shared understanding of the nature and boundaries of design research, which has resulted in confusion and disagreement about the types of research that contribute design knowledge. For example, the following statement makes this issue explicit: “while I would be honored to join the ranks of design scientists, I do not think they would consider me to be one, according to discussions I have had with my design scientist colleagues” (Benbasat, 2011, p. 17). This uncertainty has played a role in impeding researchers from developing a coherent body of design knowledge. Perhaps more consequentially, the tendency to categorize specific research contributions in predetermined and mutually exclusive ways tends to separate research and researchers into different “camps” that often fail to communicate effectively with each other. In this paper, we focus on breaking down artificial barriers that prevent researchers from seeing how their work relates to work from other camps. Further, researchers focusing on delivering design contributions often face challenges in making decisions about how to frame their publications. A panel titled “Reflecting the Past and Peeking into the Future with Design Science Natives” that involved junior researchers and occurred at the 11th Design Science Research in Information Systems and Technologies (DESRIST) conference raised and intensively discussed this issue. For example, when looking at publishing their research, early career researchers who had developed a new artifact expressed difficulty in deciding whether they should position their work on the artifact as design science research (DSR) or, if they had carried out a relatively rigorous artifact evaluation (e.g., in an experimental study), to present it as traditional behavioral research and de-emphasize the artifact construction.

Other researchers have also noted the confusion about what the labels “design research” and “design science research” mean. Notably, Kuechler and Vaishnavi (2008) state that the label “design science research” has served to “heighten the impression among many that it *completely encompasses* IS design research” (p. 4, emphasis added). They point out, for example, that along with the engineering approach, Jay Nunamaker “showed the need for a much broader scope for design research in order to develop the knowledge base to support the constructivist methodology” (p. 4). More broadly, Iivari (2007) provided a paradigmatic analysis of information systems as a design science, which led to further debate in the *Scandinavian Journal of Information Systems*. More recently, Iivari (2015, p. 108) pointed to the ongoing problem that “labels such as ‘design science research’ and ‘design research’ are used more or less interchangeably in the IS literature without any respect to the terminology used in the 50-year history of design studies” (p. 108).

Among the different types of design-focused work, researchers have distinguished between the interior mode (construction) and the exterior mode (observation as common appears in behavioral work) (see Simon, 1996, pp. 6-13; Gregor, 2009; Baskerville, Baiyere, Gregor, Hevner, & Rossi, 2018). Our experiences suggest that researchers do not adequately recognize or understand this difference. Thus, we pose the following research question to guide our work:

> **RQ**: How can we categorize design contributions in IS research?

With this paper, we contribute to the ongoing discussion by suggesting a design research activities (DRA) framework with four categories. We apply the framework to papers that the *Journal of the Association for Information Systems (JAIS)* published from 2007 to 2019 and demonstrate that one can find design research examples from each category in the academic literature. We selected *JAIS* to demonstrate the DRA framework because it publishes design research and focuses on theory. Furthermore, *JAIS* is the flagship journal among the AIS journal family and represents the international IS community. Based on our findings, we draw inferences about the nature of research in each category. We also use the framework to show how one can map progress in a specific research field in terms of activity across the quadrants.

This paper proceeds as follows: in Section 2, we summarize related work. In Section 3, we describe the research approach we followed in order to derive the DRA framework. In Section 4, we introduce the DRA framework with its two key dimensions and the resulting four quadrants. In Section 5, we summarize the results from analyzing *JAIS* design contributions and classifying them into the DRA framework. In Section 6, we illustrate the significance of the DRA framework by drawing additional inferences and providing guidance for publishing design contributions. In Section 7, we demonstrate how the DRA framework can help one analyze existing research streams. Finally, in Section 8, we summarize the paper and highlight topics for future research.

2 Related Work

We use the term design research in a general sense to refer to research that develops design knowledge about how people can construct and use an artifact to achieve a desired goal: that is, artifact-centric or design-oriented research. Thus, the way we use the term concurs with Kuechler and Vaishnavi's (2008) view that this terminology follows practice in most other design-based fields. Design research differs from design in that the former focuses on knowledge about new or improved means for solving important problems, while the latter focuses more on routine design using existing knowledge (Kuechler & Vaishnavi, 2008; Gregor & Hevner, 2013).

IS researchers have used various labels to describe research approaches falling under the broad design research umbrella. For example, Ilvari (1991) referred to constructive work, while Nunamaker, Chen, and Purdin (1990) discussed an engineering or systems development approach. In Gregor's (2006) taxonomy of theory types, formalizing design knowledge as theory yields theory for design and action. Researchers have also proposed different views on how one should formulate design theory (e.g. Baskerville & Pries-Heje, 2010; Gregor & Jones, 2007; Walls, Widmayer, & El Sawy 1992). Authors such as Iivari (2007), Kuechler and Vaishnavi (2008), and March and Storey (2008) have presented design research's history in the IS field. Cole, Purao, Rossi, and Sein (2005) used the term design research to refer to artifact-based research as we do, but also say that many researchers treat it as equivalent to "design science" (p. 326).

March and Smith (1995) and Hevner, March, Park, and Ram (2004) have supported the design science research (DSR) approach in information systems. Buckminster Fuller introduced the term "design science" in the 1960s (Fuller, 1983) to refer to a combination of technology, science, and rationalism. Since that time, researchers have developed research methods for DSR (e.g., Bider, Johannesson, & Perjons, 2012; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008) and action design research (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011) and written DSR textbooks (e.g., Johannesson & Perjons, 2014).

Walls, Widmayer, and el Sawy (1992) defined the concept of IS design theory and emphasized "prototype construction" as a major aspect of design theory research. In doing so, they set the scene for DSR's later focus on construction. March and Smith (1995) provided an early and influential description of DSR in relation to information technology (IT). They saw design science as "attempts to create things that serve human purpose" (p. 253). In their view, scientific interest in IT comes in two forms: 1) descriptive research that focuses on understanding IT's nature and 2) prescriptive research that focuses on improving IT's performance (p. 252). They saw this dichotomy as potentially harmful and proposed a framework for IT research that reconciles the conflicting viewpoints. Their framework places research activity related to IT on a continuum from building and evaluating, which have design science intent, to theorizing and justifying, which have natural science intent. Although the March and Smith framework has been extremely valuable, subsequent work in the IS field indicates that it may lack sufficient detail to accommodate the variety that current research exhibits. It does not, for example, consider situations where researchers who follow a behavioral science paradigm (modeled on natural science) partly engage in "features" work with artifact building in order to develop an experimental vehicle to test natural-science type hypotheses that can yield design knowledge.

In a recent editorial from a special issue on exemplars and criteria for applicable design science in the *European Journal of Information Systems* (*EJIS*), Peffers, Tuunanen, and Niehaves (2018) proposed five genres of IS DSR that have different characteristics, standards, and values and that represent a different research methodological tradition: IS design theory, design science research methodology, design-oriented IS research, explanatory design theory, and action design research. They identified the genres from an interpretive review of papers published in the AIS basket of eight journals from 2004 to 2018. The depiction of these prototype genres is useful, as it results from a bottom-up, data driven categorization of relevant work. It serves as a counterpoint for the top-down classification of design research activities we propose, which we base on a priori classificatory dimensions drawn from the philosophy of science, work on the sciences of the artificial, and observations of research practice.

From this brief review, we conclude that existing work on classifying design research in the IS field lacks consensus about what research contributes to the design knowledge base and how one may contribute. As a result, researchers faced with choosing a research approach lack guidance and face difficulty in attempting to analyze and review design research and development in a field over time. Accordingly, we focus on providing greater clarity to researchers and reviewers in positioning their contributions in a design space.

3 Research Approach

We begin by deriving a framework that comprised two important dimensions along which design-focused research can vary; namely, the type of statements that researchers use to express knowledge contributions and the researcher role with respect to the artifact. As a result, we propose four design research contribution categories. We then examine whether the framework can accommodate prior research by applying it to research that *JAIS* has published over a 13-year period. Subsequently, we use a classification approach to understand how the framework's four quadrants differ in terms of research motivation, research evaluation, and research communication. Finally, we apply the framework to a research stream on explanations to show how work can progress through the quadrants over time.

4 A Design Research Activities (DRA) Classification Framework

To organize discussions about the nature of design knowledge contributions and, thus, guide research toward a shared understanding, one can usefully categorize research along relevant dimensions that capture the researcher's role and the form of design contributions that results from a research project. We propose the DRA framework based on these dimensions as we show in Figure 1. The horizontal axis (form of design knowledge contribution) distinguishes whether researchers use descriptive or prescriptive statements to express design-relevant knowledge. The vertical axis (the researcher role) indicates the extent to which researchers "create" (i.e., construct) artifacts or their variants or whether they "observe" (i.e., examine existing) artifacts. On the left-hand side, the framework represents what researchers more traditionally recognize as design science research (DSR); in contrast, on the right-hand side, the figure shows work that we term design-oriented behavioral research.

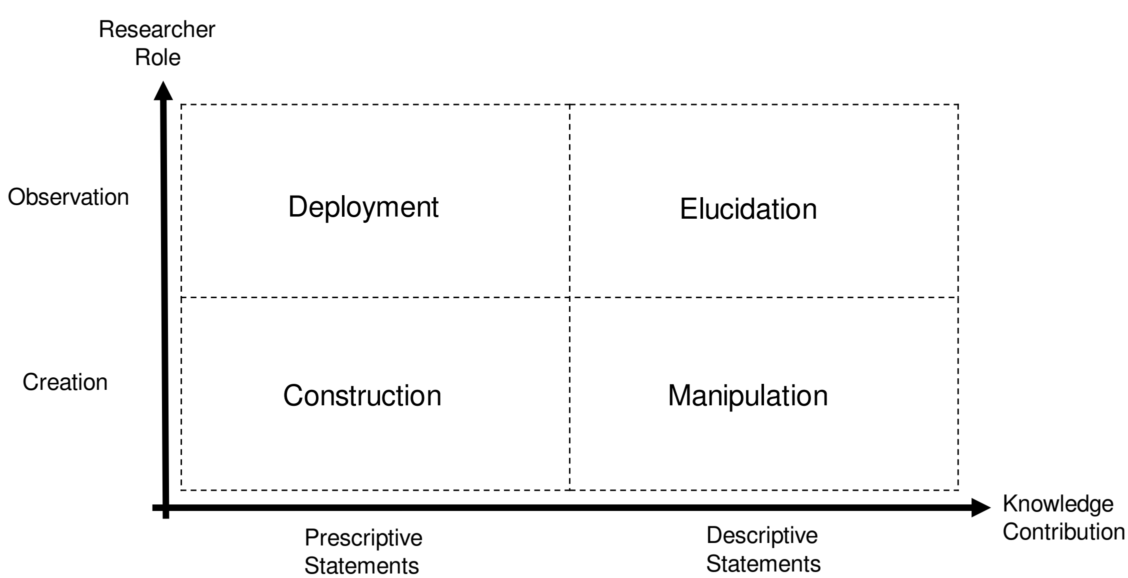

Figure 1. Design Research Activities Classification Framework

In some cases, a single journal paper might report more than one type of knowledge contribution. From our observation, however, authors commonly highlight one form of contribution more than another and the language they use in making knowledge claims reflects what they claim as their primary contribution. For example, Wang and Benbasat (2007) studied the effect that explanation facilities had on trusting beliefs with recommendation agents (RAs). They constructed an experimental prototype that they designed to simulate well-known RAs and that had different types of explanations. They used a pilot test to assess whether each type of explanation provided matched the general definition of its type in the literature before they conducted an experiment. They did not claim that they developed new knowledge about how to construct explanations. They presented hypotheses that expressed relationships between explanation types and outcomes such as consumer trust. They concluded: “The main contribution to IS research is a fine-grained understanding of the impact of explanation facilities on consumers’ trust building in RAs” (p. 239, emphasis added). Thus, their paper exemplifies the “manipulation” quadrant in Figure 1. Next we discuss the two dimensions (i.e., the knowledge contribution dimension and the researcher role dimension).

4.1 The Knowledge Contribution Dimension

We draw a distinction between prescriptive knowledge (how-to) and descriptive knowledge (what-is). Niiniluoto (1993) argued that technological rules constitute the logical form of knowledge structures in design science (prescriptive statements) and that descriptive statements constitute the logical form of knowledge structures in other branches of science (see also Bunge 1966, 1979; van Aken, Chandrasekaran, & Halman, 2016). van Aken (2005) and others in management research saw this dimension as a difference between two research modes that correspond to producing descriptive or prescriptive knowledge. Niiniluoto also showed how behavioral research can help researchers develop design knowledge when they observe relationships between causes and an effect. If one can manipulate a cause (e.g., as in feature X of an artifact), then one can convert the relationship into a technological rule of the form: “If we want to achieve the aim A, and the situation is of type B, then we should bring about the cause X” (p. 13). However, IS researchers generally couch propositions in probabilistic terms rather than as laws that apply universally. Further, the prescriptive statement does not necessarily follow from the inverted descriptive statement: other ways to achieve the desired goal may exist. Thus, the design knowledge that arises from this inversion process constitutes something that researchers suggest for consideration as an option to achieve a goal rather than a definitive prescription. van Aken (2005) captured this idea well in saying that some “technological rules” (design principles) have an algorithmic nature and that one can follow them directly, while others have a more heuristic nature as in: “if you want to achieve Y in situation Z, then perform something like action X” (p. 21).

A central question about design contributions arises in studies that investigate one or more specific capabilities or “features” of an information system (e.g., by conducting an experiment that uses a purposely constructed experimental prototype or that adapts an operational information system to determine the effect the feature(s) has on some outcomes of interest). A typical study in this genre may contain a hypothesis, such as “A system with feature X will result in more of outcome O than will one without X”, that researchers might frame as traditional behavioral IS research. In this framing, a research model might hypothesize a relationship between two constructs (e.g., the level of construct X is positively associated with the level of construct Y). To test such a hypothesis, researchers would vary one or more system features (or observe alternative real systems that manifest the feature in different ways) to instantiate levels of the construct(s) of interest and measure their effect on some outcomes of interest. However, one can turn the hypothesis (if supported) around to provide evidence for design knowledge such as “If you aim for more of outcome O, then include feature X in your system” (see Niiniluoto, 1993; Gregor, 2009). Such work includes Komiak and Benbasat’s (2006) study on the effect that personalizing recommendation agents has on trust. In their experimental study, they used different commercial recommendation agents and found support for the hypothesis that perceived personalization increases customers’ adoption intentions by increasing cognitive trust and emotional trust. One can invert this finding to provide prescriptive knowledge in the form: if you want to increase the degree to which customers adopt recommendation agents, then consider using personalization. A lack of consensus on whether this type of work contributes to design knowledge, the implications that arise from considering such work as making a design knowledge contribution, and, more generally, the ways in which researchers can contribute to design knowledge still manifests in discussions at scholarly venues despite a wide range of work that considers the nature and value of design science.

The knowledge contribution dimension corresponds to the interior-exterior distinction that Simon (1996, pp. 6-13) identified. In the interior mode, concern focuses on the details of the organization and functioning of an artifact to allow it to achieve some goal(s) in a range of environments. In the exterior mode, concern focuses on how well the capabilities of the artifact allow it to accomplish goals in specific environments. However, Simon did not stress that, for design knowledge, one cannot treat an artifact's interior workings completely as a black box even in the exterior mode (see Gregor, 2009). Researchers must carefully identify the independent variable when testing hypotheses in this mode, which represents an artifact or one of its features, so that they can clearly identify and reproduce its distinctiveness (from alternatives) as in medicine where researchers need to describe precisely the chemical formula for a specific vaccine they used in a randomized control trial. In their paper, Wang and Benbasat (2007) exemplify this practice in the IS literature well as they pretested users' perceptions about the manipulated feature against its definition in the design literature.

Researchers have studied the distinction between descriptive and prescriptive knowledge in terms of different forms of logic in the field of knowledge representation (e.g., see Russell, Norvig, Davis, & Edwards, 2016). One can represent descriptive knowledge in propositional logic forms (e.g., if X then Y). One can consider prescriptive knowledge in terms of "the logic of action" (Segerberg, Meyer, & Kracht, 2016). In design science research, a design principle constitutes a general form for expressing prescriptive knowledge. Gregor, Chandra Kruse, and Seidel (2020) synthesized the existing ways in which researchers have defined design principles to give a general form: "For Implementer I to achieve or allow Aim A for User U in Context C employ Mechanisms M1, M2, M3…. involving Enactors E1, E2, E3, … because of Rationale R" (p. 1633).

Researchers can describe the mechanisms they employ to achieve aims using representation tools such as flowcharts, pseudocode, algorithms, architectural diagrams, modeling tools, narrative descriptions of methods and screen layouts individually or in combination.

4.2 The Researcher Role Dimension

On the vertical axis, we distinguish between 1) research in which researchers develop artifacts (creation) and 2) research in which researchers/practitioners develop artifacts and then different researchers/practitioners observe the artifacts in use either in further research or in industry (field) settings (observation). Researchers can develop design knowledge (both prescriptive and descriptive) in both cases. In the observation role, they can analyze and synthesize findings from one or more cases or studies. They can use single case studies to identify critical insights or to disprove a generalization. In addition, in the observation role researchers can synthesize findings across a range of studies, as in multiple case studies, literature reviews, or theory-development studies. In some instances, the distinction between creation and observation may be fuzzy, as when researchers use participant observation. We suggest this approach belongs more to the "observe" category considering its description in texts on research methods (e.g., Cooper & Schindler, 2014). The way in which researchers should position action design research is also ambiguous, although we suggest that researchers consider it as more belonging to the "create" category, consistent with its description in the DSR literature (e.g., Sein at el., 2011).

4.3 The Design Research Classification Framework

The classification framework that uses these two dimensions comprises four quadrants:

- **Construction**: in this quadrant, researchers use creativity to construct an artifact and derive prescriptive knowledge from their first-hand experience. Research activities in this quadrant constitute quintessential DSR and have existed for many years. We would now categorize the concept and model for the first decision support system developed by Scott Morton in 1967 into this quadrant given his work constituted "a pioneering implementation, definition and research test of a model-driven decision support system" (Power, 2003). A more recent example is Marten and Provost's (2014) work on data-driven document classification. Their primary knowledge contribution is a "new sort of explanation" for this type of application (p. 73). As one would expect in DSR, researchers need to conduct some evaluation to demonstrate credibility. In this case, the authors conducted an "empirical analysis" (p. 82) in which they ran the models they developed on test data. Prat, Comyn-Wattiau, and Akoka's (2015) review provides many further examples of work in the construction quadrant. Researchers can justify claims that they contributed knowledge in this quadrant in terms of whether the contribution constitutes an invention, improvement, or exaptation as Gregor and Hevner (2013) depict.

- **Deployment**: in this quadrant, researchers derive prescriptive knowledge from observing and analyzing existing artifacts in use outside their original development environment. For example, Müller, Junglas, Debortoli, and vom Brocke (2016) derived "lessons learned" on how organizations can use text analytics effectively from studying usage in three organizations. In this quadrant, researchers can also develop a full design theory. For instance, Moody (2009) developed a design theory for visual notations by synthesizing theory and empirical evidence. Some work in this quadrant can show limitations of systems deployed and suggest that designs put controls on their use. For example, studies that have examined machine learning systems in operation have shown them leading to unexpected and even harmful outcomes that designers did not anticipate (see Knight 2017). This situation has led to a specific prescriptive (and normative) guideline in the Association for Computing Machinery's (2018) code of ethics: "Extraordinary care should be taken to identify and mitigate potential risks in machine learning systems" (p. 8). Following Denyer, Tranfield and Van Aken (2008), research activities in evidence-based management derive "design propositions" (principles) through "research synthesis", an approach that researchers have also used to some extent in the IS field as in Pilbeam, Alverez, and Wilson's (2012) systematic literature review. Van Aken (2004) discusses the approaches that researchers can use in this quadrant in organizational studies in some detail. He sees the deployment quadrant as including work in which third parties beta test technological rules whose original creators first developed and alpha tested in construction work. Researchers still express the knowledge contribution in this quadrant in a prescriptive form, such as lessons learned, guidelines, and design principles or design theories. Researchers can again justify that they contributed knowledge in this quadrant in terms of whether the contribution constitutes an improvement, exaptation, and, in some cases, exploitation (claims for inventions will more likely belong to the create quadrant as Gregor and Hevner (2013) depict).
- **Manipulation**: in this quadrant, researchers exhibit some creativity in designing a study that includes an artifact (e.g., an experimental vehicle with a manipulable design feature) that yields descriptive knowledge. Wang and Benbasat's (2007) study exemplifies work in this quadrant: they examined the effect explanation facilities have on trusting beliefs in recommendation agents using an experimental platform with three types of explanations. This quadrant also includes work in which researchers creatively adapt an artifact that others developed to their own experimental context to investigate a system feature with an empirical study. One example includes Komiak and Benbasat's (2006) experiment on personalization levels in commercial recommendation mentioned above in Section 4.1. In some experiments, the manipulation (treatment) is rather minor with respect to the degree to which researchers creatively design an artifact or one of its features. For example, Wang, Zhao, Qiu, and Zhu (2014) investigated the effect that emoticons have on the degree to which users accept negative feedback in computer-mediated communication. In their experiment, they used emoticons—artifacts they did not design themselves—as the treatment. Other experiments might involve a simulated interface with no operational system behind it. Such experiments can require considerable ingenuity in experimental design and can be valuable in studying the effect of one design feature in isolation. Thus, we suggest placing them in the manipulate category. Similarly, the placement of research designs using natural experiments or time series analysis is not clear cut. Again, we suggest placing them in the manipulate quadrant, as they can involve creativity and ingenuity in imagining how the treatment variable/design feature can be envisaged.
- **Elucidation**: in this quadrant, researchers derive descriptive knowledge relating to manipulable design characteristics from observing and analyzing existing artifacts and their use. Deployment and elucidation primarily differ in that deployment focuses on investigating specific artefact's consequences and producing prescriptive knowledge, whereas elucidation focuses more on aggregating knowledge from observing and analyzing existing artifacts and descriptively recounting their use in depth. A paper that analyzes multiple case studies, conducts a literature review, or engages in theory development could bring together findings from several studies to derive descriptive propositions about artifact characteristics and outcomes of their use. Morana, Schacht, Scherp, and Maedche's (2017) study exemplifies work in this category: the authors integrated the existing body of work on the nature and effects of guidance design features by reviewing existing empirical studies and linking them to three

existing research streams. In doing so, they developed an integrated taxonomy on guidance design features and an overview on effects and outcomes of guidance design features. Similarly, Feine, Gnewuch, Morana, and Maedche (2019) extracted and aggregated existing knowledge about social cues in conversational agents and their impacts from existing research in this field. The authors presented the knowledge via a taxonomy that classified social cues into four top-level categories (verbal, visual, auditory, invisible). Some work in this quadrant could also arise from large scale surveys or studies of systems in use that express knowledge in a descriptive form. For example, in industry-focused work on an IT-governance framework, Weill and Ross (2005) derived the generalization that high IT governance performance in an organization correlates with desired success measures. In more technical fields, Denning and Martell (2015) have ambitiously focused on deriving very general laws that describe repeatable cause-effect relationships such as "every communication system can be modelled as a noisy channel carrying encoded signals representing messages from a source" (p. 56).

Looking at a specific research topic such as recommender systems in e-commerce, one can trace design research activities through all four quadrants. First, in the construction quadrant, one can address the "how to build" question by designing artifacts with various capabilities, such as data management, algorithms, and the user interface, as well as their interdependencies and integration. Second, in the manipulation quadrant, one can investigate the effects of a specific recommender system's capabilities, such as a textual explanation capability in the user interface. Thus, one can ask: "What effects does a specific capability have on outcomes of interest?" Third, in the deployment quadrant, one focuses on answering the "in-use" questions. Here, one can observe one or more recommender systems in use outside the development environment and develop further prescriptive knowledge related to their design (e.g., high-level principles). Finally, in the elucidation quadrant, one can focus on the question "How we can account for the nature of recommender systems and the outcomes resulting from their use?" Here, one generates descriptive statements about the outcomes of using recommender systems and their capabilities.

Our framework contributes to the literature by characterizing research we term design-oriented behavioral research in which descriptive statements that researchers derive through observation or creation that follow a behavioral science paradigm also contribute to design knowledge. Such studies would follow generally accepted guidelines for behavioral research (e.g., see Shadish, Cook, & Campbell (2002; Cooper & Schindler, 2014). Design-oriented behavioral research includes manipulable causes (i.e., designed IT artifacts) in its descriptive knowledge claims, which distinguishes it from other forms of behavioral research that focus on naturally occurring explanatory factors that one cannot manipulate (e.g., human cognitive capacity). As Niiniluoto (1993) and others show, design-oriented behavioral research can provide an important source of design knowledge as it serves as a base for technological rules or design principles.

Our framework concurs with the original continuum that March and Smith (1995) proposed between design science and natural science type research in relation to artifacts, which could be represented by a trajectory from the construction quadrant to the elucidation quadrant. However, our framework recognizes other research activities that one can observe in research practice and that also contribute to design knowledge; namely, the deployment quadrant in which one obtains prescriptive knowledge second-hand from prior DSR studies or field use studies and the manipulation quadrant in which one gains descriptive knowledge first-hand by manipulating features or similar in purpose-built or existing artifacts.

In Sections 5, we use the DRA framework to categorize research with design components that *JAIS* has published over a 13-year period to demonstrate that one can use it to better understand research contributions' design element. In Section 6, we consider the value of the categories in the framework in drawing inferences about research activities and outcomes. In Section 7, we demonstrate how one can use the DRA framework to map research's maturity in a specific research area.

5 A Review of *JAIS* Design Contributions

We analyzed publications in *JAIS* from 2007 to 2019. We began by selecting one year in this period (2017 / volume 17). For each paper that the journal published in that year, we each independently determined 1) if it contained a design element and, 2) if so, classified it into one quadrant in our framework. After we conducted this activity for the 2017 papers, we met and reviewed our classifications, discussed the differences (most differences centered on whether a paper contained design elements), and refined our criteria for assigning papers to the four quadrants. Subsequently, we divided the remaining papers (from 2008 to 2019) among ourselves and each coded one-third.

In a few cases, we disagreed on the coding. In some cases, researchers used existing design features in operational systems as their independent variable or had used a simulated interface rather than constructing a prototype system that instantiated a design feature. Such cases did not involve much design creativity from the researcher but still involved creativity in how they designed the experiment to represent a design feature. Thus, we classified them in the manipulate quadrant. Other cases involved papers that discussed the relationship between artifact features and some dependent variable(s) of interest and used secondary data (e.g., online posts that contains emoticons) and statistical association tests. Due to the difficulty in providing strong evidence that such design features lead to (or cause) the outcome(s) of interest in these cases, the design implications might not be clear. However, in the end, we determined that finding relationships between design features and outcomes of interest can provide a foundation for subsequent causal studies to test design variants and their impact (such as a controlled experiment) and decided to code these examples as belonging to the manipulate quadrant.

Table 1 summarizes the results. Overall, we identified 97 papers containing design contributions in *JAIS* over the 13-year period. These constituted 26 percent of all published *JAIS* papers from 2007 to 2019 (the Appendix lists each study and its category). The two quadrants construction and manipulation together accounted 68 percent of the design contributions in *JAIS* during the period examined followed by the elucidation quadrant (21%) and the deployment quadrant (11%).

Table 1. Design Research Contributions in JAIS (2007-2019)

Number of papers	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Sum	%
Number of *JAIS* publications overall	35	39	45	33	31	38	29	36	31	27	26	33	55	370	
Number of *JAIS* design research publications	5	7	9	7	11	6	7	6	12	7	7	5	8	97	26%
Construction	2	3	4	4	4	3	1	2	3	2	1		6	35	36%
Deployment	1		1	1	3		2		1		2			11	11%
Manipulation	1	4	1	1	2		2	4	4	3	3	4	2	31	32%
Elucidation	1		3	1	2	3	2		4	2	1	1		20	21%

Our analysis shows that *JAIS* has published research from all four quadrants in our DRA framework, which demonstrates that one can practically use these distinctions to classify design-oriented research. The distribution of papers across all four quadrants is evidence of the journal's broad scope and inclusiveness. We further identified an increase in the number of papers in the manipulation category over time, which demonstrates that researchers have paid growing attention to design-oriented behavioral research that endeavors to justify design choices using existing theories and to evaluate the impact (typically in an experimental setting) that design choices have on traditional attitudinal and behavioral constructs of interest in IS research. We speculate that this trend reflects calls from the IS research community for researchers to pay greater attention to the IT artifact (e.g., Benbasat & Zmud 2003). In contrast, the number of publications in the artifact construction category remained relatively constant during the period covered in our analysis. We find this result somewhat surprising as we covered the period during and after the publication of high-profile papers that articulated the design science research approach (Hevner et al., 2004), presented methodology for conducing design science research (Peffers et al., 2008), and showed how to position design science research for publication and impact (Gregor & Hevner, 2013). Finally, we identified more research that created artifacts than research that observed artifacts in use.

6 Significance of the DRA Framework

We developed the DRA framework to better understand IS research that studies artifact design features by identifying research categories based on variations in two relevant dimensions: 1) whether the research created or observed artifacts and 2) whether research expressed the design knowledge as prescriptive or descriptive statements. The framework extends traditional design research notions in the IS field that emphasize prescriptive statements about using design features to reach some goal by considering also descriptive statements about the relationship between design features and some dependent variable(s) of interest. From our analysis, we produced research categories that we term design-oriented behavioral research, which we have shown to encompass a substantial proportion of IS research that studies the IT artifact. The framework also distinguishes between research that creates artifacts (or adds features to existing artifacts) and research that observes artifacts in use.

These two dimensions produce four design research categories in the IS field. However, we need to examine whether the four categories that this two-dimension framework creates constitute more than a simple way to subdivide research according to whether the research activity involves creation versus observation and whether research output comprises prescriptive versus descriptive statements. In Table 2, we summarize the key properties of exemplary *JAIS* publications in each quadrant.

Table 2. Properties of the Four Categories and Selected Examples

Category	Construction	Deployment	Manipulation	Elucidation
JAIS paper from class	Chou, Sinha, & Zhao (2010)	Day, Junglas, & Silva (2009)	Wang et al. (2014)	Chua & Yeow (2010)
Nature of the problem	Text classification depends on the methods one uses to select attributes. Existing methods come with trade-offs about efficiency and effectiveness.	Forming supply chains in catastrophic disasters is a complex task. Need to better understand information flows in managing disaster relief supply chains.	Delivering negative feedback through computer-mediated communication can have negative consequences on recipients. Emoticons used to send social and emotional signals.	In free/libre open source software (FLOSS), multiple projects work on a single piece of software. Cross-project coordination in such an environment involves considerable challenges and remains under-researched.
Role of theory (as input)	Authors used no dedicated theory but provided an overview of existing attribute-selection methods.	Authors used no dedicated theory but did refer to related work on supply chain in disasters.	Authors leveraged feedback process model and dissonance reduction theory to derive hypotheses.	Authors built on existing behavioral coordination theories with task decomposition and coordination practice perspective.
Research methods	Performance evaluation with experimental data	Qualitative study with single, critical instance case (extreme case) following grounded theory approach.	Laboratory experiment.	Inductive, theory-building case study that involved three representative cross-project cases.
Type/form of design knowledge created	Concrete instantiation in the form of an artifact ("text-mining approach") that they described with a flowchart, narrative, and formulae.	A set of *design principles* for IS to alleviate the impacts that arise from the information impediments of future disasters and provide improved resource flow throughout the disaster relief supply chain.	Authors tested their hypotheses on the effects of liking emoticons used in specific and unspecific feedback They provided specific guidelines on using emoticons in feedback delivery.	Authors derived *propositions* expressed as descriptive statements. They stated that others can transform the statements into prescriptive knowledge for cross-project coordination.

Each category in our framework has two properties that take on different values. Artifact construction research produces 1) new artifacts accompanied by 2) prescriptive statements about design features intended to accomplish specific objectives. Artifact deployment research 1) observes artifacts in use to derive 2) prescriptive statements about design features intended to accomplish specific objectives. Artifact manipulation research examines the effect that 1) manipulating artifact features has on specific outcomes (e.g., the behavior of artifact users) via 2) descriptive statements. Finally, artifact elucidation research 1) observes artifacts in use to describe 2) specific outcomes via descriptive statements.

Following Parsons and Wand (2012), we suggest it is useful to think about whether these divisions constitute classes, rather than simply categories. In the DRA framework, the phenomena are research studies. Whereas a category groups phenomena such that category members share common properties, a class also carries inferential capability, which means that one can draw inferences about the characteristics that members in the same category share in addition to the characteristics that one would need to observe to place them in the category. In other words, our framework proposes that one can categorize research papers into one of four quadrants based on whether they involve artifact creation or artifact observation and whether they express the design knowledge in prescriptive or descriptive statements. These distinctions become useful when the quadrants differ in ways beyond these characteristics.

Observe that one can draw additional inferences about each category's instances. To illustrate, consider how research from each quadrant can differ with respect to core steps of the research. In particular, we consider the three dimensions from Peffers et al.'s (2008) research methodology (i.e., research motivation, evaluation, and communication) to indicate how the type of design research can influence aspects of the research process. In their methodology, Peffers et al. (2008) define motivation with respect to specifying the problem and the value of solving it. They define evaluation with respect to measuring how well an artifact solves the identified problem. Finally, they define communication with respect to whether one expresses all stages of the research process in a way that the relevant audience (e.g., other researchers or practitioners) would find appropriate.

6.1 Research Motivation

Artifact construction research is typically motivated by an unsolved problem that the artifact is intended to address. Such research might emphasize how an artifact's design features address specific aspects of the problem and make specific effort to justify how various design choices contribute to solving the problem. An opportunity to observe an artifact in use to more fully assess its effectiveness outside the development environment and develop design knowledge for its improvement or to yield more general design knowledge only apparent across various instances of use may motivate researchers to conduct artifact deployment research. A desire to improve an artifact's effectiveness can also motivate artifact manipulation research. Such work might entail mapping an artifact's specific design features to theoretical constructs that causally relate to other constructs. These mappings, in turn, can provide guidance for manipulating design features to improve an artifact's effectiveness (Lukyanenko & Parsons, 2020). Finally, a desire to fully account for the relationships between design features and outcomes of interest can motivate researchers to conduct artifact elucidation research. Such work involves observing systems in use or reviewing other studies to develop general explanatory descriptive statements that hypothesize theoretical relationships among design features and outcomes of interest.

6.2 Research Evaluation

Different forms of evaluation are appropriate in each of the four quadrants. In artifact construction research, one often conducts multiple build-evaluate cycles to determine whether an artifact faithfully enacts the prescriptive statements that guide its design (or that one derives from the design process) to achieve instantiation validity (Lukyanenko, Evermann, & Parsons, 2014). One can conduct such work by iterating through various design changes (artifact versions) and obtaining feedback on the extent to which the design features concur with the prescriptive statements from which they were derived. In this case, one often performs formative rather than summative evaluation (alpha testing), and one may conduct summative evaluation with relatively small samples or test data. In conducting such evaluations, one often seeks only to ensure that the artifact functions as required without detectable errors. Designers may also white-box test software algorithms in cases where they know about critical paths in the software and ensure that they adequately test them—something that may not occur in any other quadrant.

Artifact deployment research can involve drawing conclusions (prescriptive statements) inductively from observing how users use an artifact in practice and relating design attributes to outcomes. To do so, one can observe users' experiences in working with the artifact to achieve the desired objectives (or not). Deployment research studies preexisting artifacts. Accordingly, researchers might not derive their design features from predetermined design principles or prescriptive statements.

Artifact manipulation research can involve hypothetico-deductive work in which one derives descriptive statements about the effect that design features have on variables of interest from prior theory and express them via a research model with empirically testable propositions. To do so, one can compare user behavior and performance with and without the target design features. Unlike artifact deployment research, studies in this quadrant typically examine the effect that absence or presence of specific design features on outcomes of interest.

In artifact elucidation research, one may also test descriptive statements about the effect that design features have on variables of interest using, for example, surveys, multiple case studies, or behavioral trace data. Alternatively, one could inductively develop descriptive statements from work that reviews different sources of evidence (see last column of Table 2).

6.3 Research Communication

Artifact construction research creates an artifact as its primary research contribution and provides evidence that it solves the original problem. Therefore, communication approaches in such work might include describing the artifact design and construction in a sufficient detail that allows others to replicate it and articulating evidence that design features faithfully accord with stated design principles or prescriptive statements. A key issue in communicating artifact deployment research contributions concerns articulating the logic underlying the derivation of design principles extracted from observing and reasoning about the artifact in use. To do so, researchers might need to richly describe the artifact in use and make clear arguments that justify how one derived the design principles. They could develop design theory to show high-level principles and justify them (as in Gregor & Jones, 2007). Researchers can communicate artifact manipulation research by both justifying the features that they choose for manipulation (e.g., by showing how these features causally associate with outcomes of interest) and articulating how they manipulate features in a way that remains faithful to the underlying constructs they reflect. As in artifact deployment research, artifact elucidation research could involve rich descriptions of artifacts based on observing their use or on referring to work that reviews multiple evidence sources and connects causal mechanisms or artifact capabilities with outcomes. However, artifact elucidation research should situate an artifact with respect to its design features and outcomes by abstracting from observations to develop a justified theoretical model of relationships among constructs.

7 Mapping Design Knowledge with the DRA Framework: The Explanations from Intelligent Systems Research Stream

One can also use the DRA framework we propose to analyze a research stream to determine its maturity and whether researchers should conduct further work with specific approaches (i.e., in different quadrants). To demonstrate how one might use the framework for this purpose, we consider the research on explanations from intelligent systems. We analyze this research stream given its importance, relatively bounded nature, and ongoing nature. Furthermore, work in this stream has occurred in waves that correspond to new technology developments, and review papers have examined the two main waves (e.g., Gregor & Benbasat, 1999; Mueller, Hoffman, Clancey, Emrey, & Klein, 2019). We conduct our analysis here for illustration only as even this relatively narrow research area contains much work and we cannot cover it in its entirety.

Explanations from intelligent systems are capabilities that explain or justify the reasoning that the systems employ to arrive at conclusions or recommendations. We can discern two “waves” of work—the first for logic-based intelligent systems and the second for machine learning. The logic-based wave began after the initial creation of the first expert system, Dendral, in 1965 (see Zwass, 2016) and “inadequacies of the first generation of expert systems gave birth to the first generation of explanation systems, including MYCIN and its related system” (Mueller et al., 2019 p. 45). Based on Gregor and Hevner’s (2013) taxonomy, one could say that the first explanation system was an “invention”. A second wave of explanation research arose with increasing work on machine learning, where the provision of explanations can be difficult. Mueller et al. (2019) analyzed publications per year related to “explanation in intelligent systems” (p. 61) and identified no more than five publications per year up to 1997 (the first wave), an “explainability winter” until 2015, and then an increase in publications afterwards with 15 or more per year (the second wave). We use the DRA framework to examine the papers in each main wave and illustrate how research has progressed.

7.1 First Wave: Explanations from Logic-based Intelligent System

In their review, Gregor and Benbasat (1999) focused on "knowledge-based systems" (e.g., expert systems, decision support systems). They examined empirical studies available to that date and proposed a new theoretical framework. Since the framework has propositions, it is primarily descriptive, although the propositions have design implications since they link system capabilities with outcomes. The review included 18 "empirical" studies. The authors included studies that "involve[d] actual use of an intelligent system of some type, whether prototype or operational, by human users" (p. 500). One such study, Wognum's (1990) doctoral thesis, contained three different types of design work, which the authors considered separately, so the sample that we analyze below comprised 20 studies. In analyzing the studies with the DRA framework, we found:

- Construction quadrant: we classified only two studies as "create"; that is, studies in which researchers developed new forms of explanations (improvement) and provided prescriptive knowledge. In some cases, they subjected their system to evaluation with users. Wognum (1990) showed how one could produce an understandable proof (a tree-form algorithmic explanation) for a theorem-proving system. De Greef and Neerincx (1995) developed a method for designing "aiding functions" (which include explanations) in general. They developed an aiding interface for a statistical package and tested its efficacy in an experiment. They discussed how testing these interfaces forms part of the development (creation) process. The work includes design principles such as that the aiding function should take the initiative by providing information at the right time.
- Deploy quadrant: we classified no studies in this quadrant.
- Manipulation quadrant: we classified 17 studies in this quadrant. Researchers described most as experiments (primarily in the laboratory) and some as field studies. They described the intelligent systems they used as purpose built and simulated. In other cases, they adapted an operational system. Many studies in this quadrant used student participants.
- Elucidation quadrant: one of Wognum's (1990) studies was a "retrospective" study in which she examined nine operational systems to determine whether users wanted or used explanations in practice. Interestingly, she found that users demanded a certain explanation type (a terminological or which-function), something that other researchers had not previously observed in non-field settings. One can describe Gregor and Benbasat's (1999) review itself as fitting in this quadrant. It provides descriptive knowledge based on observing and analyzing other studies. The descriptive knowledge is in the form of general propositions such as: "explanations conforming to Toulmin's model (justification) explanations will give rise to more positive user perceptions of a KBS than other explanations (trace and strategic explanations)" (p. 514).

This analysis indicates that most activity in this stream belonged to the manipulate quadrant. We find it potentially concerning that the deploy quadrant contained few studies (i.e., studies that examined systems in operational use that yields prescriptive knowledge), and that no studies in this quadrant produced any overarching design principles or design theory. However, the fact that Gregor and Benbasat (1999) could produce their theoretical framework indicates some level of design knowledge maturity.

Mueller et al. (2019) indicate that, from about 1997 (i.e., in the "explainability winter"), researchers conducted little new research on explanations, although some researchers translated earlier methods to new applications (exaptation). During this period, practitioners deployed expert systems and decision support systems in industry as operational systems. In such cases, the knowledge generated from relatively routine application cases (exploitation) was not suitable for publication in research journals and likely appeared in industry reports or specialist outlets. For instance, Pisano, Stern, and Mahoney (2004) report on a decision support system used in Iowa in winter to help keep clear ice and snow off roads.

7.2 Second Wave: Machine Learning

Since the mid-2010s, a new wave of work began as, with machine learning and neural network technologies, the need for explanations reawakened. Mueller at al. (2019) produced their review as part of the DARPA XAI program. In this review, they extensively covered the importance of explainable artificial intelligence (XAI), disciplinary perspectives, history, psychological theories and models, and studies that evaluate XAI systems with human participants. Their appendix lists 37 studies that involve "evaluations…using human participants" (p. 170). Of these, 17 studies concerned machine learning, while others concerned older logic-based forms of AI. We used the DRA framework to analyze the 17 studies that concerned machine learning and found:

- Construction quadrant: we classified eight of the 17 studies as belonging to this quadrant. In these cases, researchers conducted evaluation with human participants to demonstrate that a new algorithm or method had some validity. These studies tended to use small sample sizes and student participants or participants from Mechanical Turk. Part of the history section in the Mueller et al. (2019) review shows how the technologies for producing explanations had evolved and expanded since the explainability winter (p. 62).
- Deploy quadrant: we classified no study as belonging to this quadrant.
- Manipulate quadrant: we classified nine studies as belonging to this quadrant. Some used simulated interfaces. Eight used student participants or participants from Mechanical Turk.
- Elucidate quadrant: we could classify no study as belonging to the elucidation quadrant. In their review, Mueller et al. (2019) present some psychological (behavioral) explanation theories/models and say "strictly speaking there no comprehensive theories of explanation in psychology, in the sense of well-formed theories that make strong predictions" (p. 70). However, the authors go on to say, that researchers have demonstrated many separate hypotheses in experiments. For example, they state: "explanations are good if they make sense in terms of the context or the enabling conditions of cause-effect relations" (p. 75). Mueller et al. (2019) also present the DARPA XAI "evaluation framework" that relates explanations and their use to various user outcomes, such as trust, comprehension, and performance—a model that has some congruence with Gregor and Benbasat's (1999) framework.

In conclusion, we found that the explanations field in machine learning systems lacks maturity. Specifically, the field lacks work in the deploy quadrant with field studies and general design principles. We can further observe this poor maturity via the several studies in journals with a general readership that express concerns about deploying machine learning without adequate explanations. For example, in talking about "the dark secret at the heart of AI", Knight (2017) points to several problems that arise with medical diagnosis tools that cannot explain their predictions.

Using the DRA framework in this way has some parallels with evidence-based medicine (EBM) whereby one assesses knowledge (evidence) from various sources in making decisions about knowledge maturity and the best current knowledge available for treating patients (see Sackett, 1997). Approximating terms from EBM to our framework, knowledge sources in EBM can include laboratory research to develop the vaccine and test it on test animals or a small group of human volunteers (construction), randomized controlled trials (manipulation), use of the vaccine on larger groups of the target population (deployment), and systematic reviews of studies (elucidation). These evidence sources form a hierarchy from laboratory research to systematic reviews. Our essay indicates something similar would be useful for design research in information systems as Wainwright, Oates, Edwards, and Childs (2018) have also proposed.

8 Conclusion

Design research has an important role in research given that information-technology-based artifacts pervade our everyday lives. Questions remain, however, as to how we should understand its nature and boundaries. In this paper, we view design research in broad terms as some early approaches to the topic have done but do not see it as equivalent to design science research (DSR), which we portray as something that primarily concerns artifact construction. In this wider view, design science has two activity subsets: one that generates prescriptive knowledge akin to how many portray DSR and one that generates descriptive knowledge, which we term design-oriented behavioral research. In both cases, researchers and/or practitioners undertake artifact-centric research.

Congruent with this encompassing view, we developed the design research activity (DRA) framework to categorize design contributions based on based on the type of statements that researchers use to express knowledge contributions (prescriptive or descriptive) and the nature of the researcher role (creation or observation). The framework contains four quadrants: construction, manipulation, deployment, and elucidation.

To demonstrate that one can use the framework to categorize research, we first analyzed the 97 papers we classed as design research that *JAIS* published from 2007 to 2019. We found that the journal has published valuable and high-quality research in each quadrant. Complementing the design science research mode, which focuses on contributing prescriptive statements, the research mode we term design-oriented behavioral research represents a substantial proportion of artifact-centric research that *JAIS* has published. This mode emphasizes descriptive statements about the relationship between design features and some dependent variable(s) of interest and delivers valuable design research contributions. Future research may extend our analysis beyond *JAIS* by classifying design research contributions from other journals in the IS senior scholars' basket and beyond.

We also show the framework's significance in representing classes of research, in the sense that inferences could be drawn about the shared attributes of members of each class providing guidance for publishing design contributions. In a final step, we demonstrate that one can use the DRA framework to map a research stream's research activities to its four quadrants. For demonstration purposes, we considered how work on explanations from intelligent systems has evolved from a first wave that contained work with logic-based systems through to a second wave that contained work with machine learning systems. In our analysis, we found that the first wave reached a stage of relative maturity while the second wave has yet to reach such maturity and requires ongoing research. In both analyses, we found a relative lack of work in the deployment quadrant, though outlets with a more general readership or specialist journals rather than mainstream academic journals may be more likely to contain work in this quadrant.

In analyzing *JAIS* design research publications, we found a clear tendency towards the "creation" researcher role with a balanced focus on delivering knowledge as both prescriptive and descriptive statements. In general, we believe that, in the future, design research should emphasize the "observation" researcher role more strongly. This perspective aligns with recent work that has emphasized the need to accumulate knowledge in the design research field (vom Brocke, Winter, Hevner, & Maedche, 2020). Furthermore, we also argue that design research should be considered as a journey through the four quadrants. We do not see the quadrants as independent research strategies; thus, researchers should leverage knowledge produced in one quadrant in the other quadrants. Depending on a specific design challenge's context and characteristics, the journey through the four quadrants may look quite different.

With this paper, we help better explain design-oriented research by developing the DRA framework, which addresses tensions that have been evident for some time between the perspective that views design research in broad terms (i.e., as involving activities that generate prescriptive knowledge and activities that generate descriptive knowledge) and the perspective that views it more narrowly as equivalent to design science research (i.e., something that primarily concerns artifact construction). The new framework should help researchers position their own work, justify the type of contribution they wish to make, and identify fruitful areas for further work in a research stream.

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Wang, W., Zhao, Y., Qiu, L., & Zhu, Y. (2014). Effects of emoticons on the acceptance of negative feedback in computer-mediated communication. *Journal of the Association for Information Systems*, *15*(8), 454-483.

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Appendix

Table A1. *JAIS* Papers with Design Research Contributions

Paper	Quadrant
Germonprez, M., Hovorka, D., & Collopy, F. (2007). A theory of tailorable technology design. *Journal of the Association for Information Systems*, *8*(6), 351-367.	Deployment
Mark, G., Lyytinen, K., & Berman, M. (2007). Boundary objects in design: An ecological view of design artifacts. *Journal of the Association for Information Systems, 8*(11), 546-568.	Elucidation
Xu, J., Wang, G. A., Li, J., & Chau, M. (2007). Complex problem solving: Identity matching based on social contextual information. *Journal of the Association for Information Systems, 8*(10), 525-545.	Manipulation
Soffer, P., & Wand, Y. (2007). Goal-driven multi-process analysis. *Journal of the Association for Information Systems, 8*(3), 175-202.	Construction
Wales, R. C., Shalin, V. L., & Bass, D. S. (2007). Requesting distant robotic action: An ontology for naming and action identification for planning on the mars exploration rover mission. *Journal of the Association for Information Systems, 8*(2), 75-104.	Construction
Iyer, L., D'Aubeterre, F., & Singh, R.(2008). A semantic approach to secure collaborative inter-organizational ebusiness processes (SSCIOBP). *Journal of the Association for Information Systems, 9*(3), 231-266.	Construction
Roussinob, D., & Chau, M. (2008). Combining information seeking services into a meta supply chain of facts. *Journal of the Association for Information Systems, 9*(3), 175-199.	Construction
Chen, R., Sharman, R., Chakravarti, N., Rao, H. R., & Upadhyaya, S. J. (2008). Emergency response information system interoperability: Development of chemical incident response data model. *Journal of the Association for Information Systems, 9*(3), 200-230.	Construction
Niederman, F., Briggs, R. O., van de Vreede, G., & Kolfschoten, G. L. (2008). Extending the contextual and organizational elements of adaptive structuration theory in GSS research. *Journal of the Association for Information Systems, 9*(10), 633-652.	Manipulation
Goswami, S., Chan, H. C., & Kim, H. W. (2008). The role of visualization tools in spreadsheet error correction from a cognitive fit perspective. *Journal of the Association for Information Systems, 9*(6), 321-343.	Manipulation
Keith, M., Shao, B., & Steinbart, P. (2009). A behavioral analysis of passphrase design and effectiveness. *Journal of the Association for Information Systems, 10*(2), 63-89.	Elucidation
Chatterjee, S., Sarker, S., & Fuller, M. A. (2009). A deontological approach to designing ethical collaboration. *Journal of the Association for Information Systems, 10*(3), 138-169.	Construction
Druckenmiller, D. A., & Acar, W. (2009). An agent-based collaborative approach to graphing causal maps for situation formulation. *Journal of the Association for Information Systems, 10*(3), 221-251.	Construction
Davis, A., Murphy, J., Owens, D., Khazanchi, D., & Zigurs, I. (2009). Avatars, people, and virtual worlds: Foundations for research in metaverses. *Journal of the Association for Information Systems, 10*(2), 90-117.	Elucidation
Bragge, J., & Merisalo-Rantanen, H. (2009). Engineering e-collaboration processes to obtain innovative end-user feedback on advanced Web-based information systems. *Journal of the Association for Information Systems, 10*(3), 196-220.	Construction
Day, J. M., Junglas, I., & Silva, L. (2009). Information flow impediments in disaster relief supply Chains. *Journal of the Association for Information Systems, 10*(8), 637-660.	Deployment
Lowry, P. B., Roberts, T. L., Dean, D. L., & Marakas, G. (2009). Toward building self-sustaining groups in PCR-based tasks through implicit coordination: The case of heuristic evaluation. *Journal of the Association for Information Systems, 10*(3), 170-195.	Manipulation
Nan, N., & Johnston, E. W. (2009). Using multi-agent simulation to explore the contribution of facilitation to GSS transition. *Journal of the Association for Information Systems, 10*(3), 252-277.	Construction
Baker, J., Jones, D., & Burkman, J. (2009). Using visual representations of data to enhance sensemaking in data exploration tasks. *Journal of the Association for Information Systems, 10*(7), 535-559.	Elucidation

Paper	Quadrant
Chou, C.-H., Sinha, A. P., & Zhao, H. (2010). A hybrid attribute selection approach for text classification. *Journal of the Association for Information Systems, 11*(9), 491-518.	Construction
Levermore, D. M., Babin, G., & Hsu, C. (2010). A new design for open and scalable collaboration of independent databases in digitally connected enterprises. *Journal of the Association for Information Systems, 11*(7), 367-393.	Construction
Arazy, O., Kumar, N., & Shapira, B. (2010). A theory-driven design framework for social recommender systems. *Journal of the Association for Information Systems, 11*(9), 455-490.	Construction
Chua, C. E. H., & Yeow, A. Y. K. (2010). Artifacts, actors, and interactions in the cross-project coordination practices of open-source communities. *Journal of the Association for Information Systems, 11*(12), 838-867.	Elucidation
Jiang, Z., Chan, J., Tan, B. C. Y., & Chua, W. S. (2010). Effects of interactivity on website involvement and purchase intention. *Journal of the Association for Information Systems, 11*(1), 34-59.	Manipulation
Appan, R., & Browne, G. J. (2010). Investigating retrieval-induced forgetting during information requirements determination. *Journal of the Association for Information Systems, 11*(5), 250-275.	Deployment
Eriksson, O., & Åferfalk, P. J. (2010). Rethinking the meaning of identifiers in information infrastructures. *Journal of the Association for Information Systems, 11*(8), 433-454.	Construction
Torkar, R., Minoves, P., & Garrigos, J. (2011). Adopting free/libre/open source software practices, techniques and methods for industrial use. *Journal of the Association for Information Systems, 12*(1), 88-122.	Deployment
Parsons, J. (2011). An experimental study of the effects of representing property precedence on the comprehension of conceptual schemas. *Journal of the Association for Information Systems, 12*(6), 441-462.	Construction
Cheng, J., Sun, A., Hu, D., & Zeng, D. (2011). An information diffusion-based recommendation framework for micro-blogging. *Journal of the Association for Information Systems, 12*(7), 463-488.	Deployment
Zhang, X., Venkatesh, V., & Brown, S. A. (2011). Designing collaborative systems to enhance team performance. *Journal of the Association for Information Systems, 12*(8), 556-585.	Elucidation
Dunn, C. L., & Gerard, G. J., & Grabski, S. V. (2011). Diagrammatic attention management and the effect of conceptual model structure on cardinality validation. *Journal of the Association for Information Systems, 12*(8), 585-605.	Deployment
Kock, N., & Chatelain-Jardón, R. (2011). Four guiding principles for research on evolved information processing traits and technology-mediated task performance. *Journal of the Association for Information Systems, 12*(10), 684-713.	Construction
Müller-Wienbergen, F., Müller, O., Seidel, S., & Becker, J. (2011). Leaving the beaten tracks in creative work—a design theory for systems that support convergent and divergent thinking. *Journal of the Association for Information Systems, 12*(11), 714-740.	Construction
Germonprez, M., Hovorka, D., & Gal, U. (2011). Secondary design: A case of behavioral design science research. *Journal of the Association for Information Systems, 12*(10), 662-683.	Elucidation
Al-Natour, S., Benbasat, I., & Cenfetelli, R. (2011). The adoption of online shopping assistants: Perceived similarity as an antecedent to evaluative beliefs. *Journal of the Association for Information Systems, 12*(5), 347-374.	Manipulation
Kelley, H., Chiasson, M., Downey, A., & Pacaud, D. (2011). The clinical impact of ehealth on the self-management of diabetes: A double adoption perspective. *Journal of the Association for Information Systems, 12*(3), 208-234.	Manipulation
Price, R., & Shanks, G. (2011). The impact of data quality tags on decision-making outcomes and process. *Journal of the Association for Information Systems, 12*(4), 323-346.	Construction
Schmeil, A., Eppler, M. J., & de Freitas, S. (2012). A structured approach for designing collaboration experiences for virtual worlds. *Journal of the Association for Information Systems, 13*(10), 836-860.	Construction
Venkatesh, V., & Windeler, J. B. (2012). Hype or help? A longitudinal field study of virtual world use for team collaboration. *Journal of the Association for Information Systems, 13*(10), 735-771.	Elucidation

Paper	Quadrant
Cheung, C. M.-Y., Sia, C.-L., & Kuan, K. K. Y. (2012). Is this review believable? A study of factors affecting the credibility of online consumer reviews from an ELM perspective. *Journal of the Association for Information Systems, 13*(8), 618-635.	Elucidation
Milton, S. K., Rajapakse, J., & Weber, R. (2012). Ontological clarity, cognitive engagement, and conceptual model quality evaluation: An experimental investigation. *Journal of the Association for Information Systems, 13*(9), 657-694.	Construction
Li, L., & Zeng, D., & Zhao, H. (2012). Pure-strategy Nash equilibria of GSP keyword auction. *Journal of the Association for Information Systems, 13*(2), 57-87.	Construction
Nardon, L., & Aten, K. (2012). Valuing virtual worlds: The role of categorization in technology assessment. *Journal of the Association for Information Systems, 13*(10), 772-796.	Elucidation
Corbett, J. (2013). Designing and using carbon management systems to promote ecologically responsible behaviors. *Journal of the Association for Information Systems, 14*(7), 339-378.	Deployment
Parsons, J., & Wand, Y. (2013). Extending classification principles from information modeling to other disciplines. *Journal of the Association for Information Systems, 14*(5), 245-273.	Construction
Eryilmaz, E., Ryan, T., van der Pol, J., Kasemvilas, S., & Mary, J. (2013). Fostering quality and flow of online learning conversations by artifact-centered discourse systems. *Journal of the Association for Information Systems, 14*(1), 22-48.	Manipulation
de Corbière, F., & Rowe, F. (2013). From ideal data synchronization to hybrid forms of interconnections: Architectures, processes, and data. *Journal of the Association for Information Systems, 14*(10), 550-584.	Deployment
Sun, Y., Lim, K. H., & Peng, J. Z. (2013). Solving the distinctiveness-blindness debate: A unified model for understanding banner processing. *Journal of the Association for Information Systems, 14*(2), 49-71.	Elucidation
Javadi, E., Gebauer, J., & Mahoney, J. (2013). The impact of user interface design on idea integration in electronic brainstorming: An attention-based view. *Journal of the Association for Information Systems, 14*(1), 1-21.	Elucidation
Figl, K., Mendling, J., & Strembeck, M. (2013). The influence of notational deficiencies on process model comprehension. *Journal of the Association for Information Systems, 14*(6), 312-338.	Manipulation
Wang, W., Zhao, Y., Wiu, L., & Zhu, Y.(2014). Effects of emoticons on the acceptance of negative feedback in computer-mediated communication. *Journal of the Association for Information Systems, 15*(8), 454-483.	Manipulation
Goh, K.-Y., & Ping, J. W. (2014). Engaging consumers with advergames: An experimental evaluation of interactivity, fit and expectancy. *Journal of the Association for Information Systems, 15*(7), 388-421.	Manipulation
Parsons, J., & Ralph, P. (2014). Generating effective recommendations using viewing-time weighted preferences for attributes. *Journal of the Association for Information Systems, 15*(8), 484-513.	Construction
Silsand, L., & Ellingsen, G. (2014). Generification by translation: Designing generic systems in context of the local. *Journal of the Association for Information Systems, 15*(4), 177-196.	Construction
Léger, P.-M., Sénecal, S., Courtmanchhe, F., de Guinea, A. O., Titah, R., Fredette, M., & Labonte-LeMoyne, E., (2014). Precision is in the eye of the beholder: Application of eye fixation-related potentials to information systems research. *Journal of the Association for Information Systems, 15*(10), 651-678.	Manipulation
Vance, A., Anderson, B. B., Kirwan, C. B., & Eargle, D. (2014). Using measures of risk perception to predict information security behavior: Insights from electroencephalography (EEG). *Journal of the Association for Information Systems, 15*(10), 679-722.	Manipulation
Soffer, P., Wand, Y., & Kaner, M. (2015). Conceptualizing routing decisions in business processes: theoretical analysis and empirical testing. *Journal of the Association for Information Systems, 16*(5), 599-611.	Construction
Meth, H., Mueller, B., & Maedche, A. (2015). Designing a requirement mining system. *Journal of the Association for Information Systems, 16*(9), 799-837.	Construction

Paper	Quadrant
Windeler, J., Maruping, L. M., Robert, L. P., & Riemenschneider, C. K. (2015). E-profiles, conflict, and shared understanding in distributed teams. *Journal of the Association for Information Systems, 16*(7), 608-645.	Manipulation
Zahedi, F. M., Abbasi, A., & Chen, Y. (2015). Fake-website detection tools: Identifying elements that promote individuals' use and enhance their performance. *Journal of the Association for Information Systems, 16*(6), 448-484.	Construction
Galluch, P. S., Grover, V., & Thatcher, J. B. (2015). Interrupting the workplace: Examining stressors in an information technology context. *Journal of the Association for Information Systems, 16*(1), 1-47.	Manipulation
Li, S. S., & Karahanna, E. (2015). Online recommendation systems in a B2C e-commerce context: A review and future directions. *Journal of the Association for Information Systems, 16*(2), 72-107.	Elucidation
Andrade, A. D., Urquhart, C., & Arthanari, T. S. (2015). Seeing for understanding: Unlocking the potential of visual research in information systems. *Journal of the Association for Information Systems, 16*(8), 646-673.	Deployment
Goh, K.-Y., Tan, C.-H., & Teo, H.-H. (2015). Stated choice analysis of conditional purchase and information cue effects in online group purchase. *Journal of the Association for Information Systems, 16*(9), 738-765.	Manipulation
Lankton, N. K., McKnight, D. H., & Tripp, J. (2015). Technology, humanness, and trust: Rethinking trust in technology. *Journal of the Association for Information Systems, 16*(10), 880-918.	Elucidation
Teubner, T., Adam, M., & Riordan, R. (2015). The impact of computerized agents on immediate emotions, overall arousal and bidding behavior in electronic auctions. *Journal of the Association for Information Systems, 16*(10), 838-879.	Manipulation
Grgecic, D., Holten, R., & Rosenkranz, C. (2015). The impact of functional affordances and symbolic expressions on the formation of beliefs. *Journal of the Association for Information Systems, 16*(7), 580-607.	Elucidation
Kuan, K. K. Y., Hui, K.-L., Prasarnphanich, P., & Lai, H.-Y. (2015). What makes a review voted? An empirical investigation of review voting in online review systems. *Journal of the Association for Information Systems, 16*(1), 48-71.	Elucidation
Hong, Y., Huang, N., Burtch, G., & Li, C. (2016). Culture, conformity, and emotional suppression in online reviews. *Journal of the Association for Information Systems, 17*(11), 737-758.	Manipulation
Vitharana, P., Zahedi, F. M., & Jain, H. K. (2016). Enhancing analysts' mental models for improving requirements elicitation: A two-stage theoretical framework and empirical results. *Journal of the Association for Information Systems, 17*(12), 804-840.	Manipulation
John, B. M., Chua, A. Y. K., Goh, D. H. L., & Wickramasinghe, N. (2016). Graph-based cluster analysis to identify similar questions: A design science. *Journal of the Association for Information Systems, 17*(9), 614-647.	Construction
Brown, S., Fuller, R., & Thatcher, S. M. (2016). Impression formation and durability in mediated communication. *Journal of the Association for Information Systems, 17*(9),	Elucidation
Warkentin, M., Walden, E., Johnston, A. C., & Straub, D. W. (2016). Neural correlates of protection motivation for secure it behaviors: An fMRI examination. *Journal of the Association for Information Systems, 17*(3), 194-215.	Elucidation
Fridgen, G., Häfner, L., König, C., & Sachs, T. (2016). Providing utility to utilities: The value of information systems enabled flexibility in electricity consumption. *Journal of the Association for Information Systems, 17*(8), 537-563.	Construction
Vijayasarathy, L. R., & Casterella, G. I. (2016). The effects of information request language and template usage on query formulation. *Journal of the Association for Information Systems, 17*(10), 674-707.	Manipulation
Fehrenbacher, D. D. (2017). Affect infusion and detection through faces in computer-mediated knowledge-sharing decisions. *Journal of the Association for Information Systems, 18*(10), 703-726.	Elucidation

Paper	Quadrant
Hariharan, A., Adam, M. T. P., Dorner, V., Lux, E., Mueller, M. B., Pfeiffer, J., & Weinhardt, C. (2017). Brownie: A platform for conducting neuroIS experiments. *Journal of the Association for Information Systems, 18*(4), 264-296.	Construction
Cheung, M. Y. M., Hong, W., & Thong, J. (2017). Effects of animation on attentional resources of online consumers. *Journal of the Association for Information Systems, 18*(8), 605-632.	Manipulation
Van Looy, A., Poels, G., & Snoeck, M. (2017). Evaluating business process maturity models. *Journal of the Association for Information Systems, 18*(6), 461-486.	Deployment
Goel, S., Williams, K., & Dincelli, E. (2017). Got phished? Internet security and human vulnerability. *Journal of the Association for Information Systems, 18*(1), 22-44.	Manipulation
Lukyanenko, R., Parsons, J., Wiersma, Y., Wachinger, G., Huber, B., & Meldt, R. (2017). Representing crowd knowledge: Guidelines for conceptual modeling of user-generated content. *Journal of the Association for Information Systems, 18*(4), 297-339.	Deployment
Lee, Y., Chen, A. N. K., & Hess, T. (2017). The online waiting experience: Using temporal information and distractors to make online waits feel shorter. *Journal of the Association for Information Systems, 18*(3), 231-263.	Manipulation
Dadgar, M., & Joshi, K. D. (2018). The role of information and communication technology in self-management of chronic diseases: An empirical investigation through value sensitive design. *Journal of the Association for Information Systems, 19*(2), 86-112.	Elucidation
Suh, K.-S., Lee, S., Suh, E.-K., Lee, H., & Lee, J. (2018). Online comment moderation policies for deliberative discussion-seed comments and identifiability. *Journal of the Association for Information Systems, 19*(3), 182-208.	Manipulation
Huang, L., Tan, C.-H., Ke, W., & Wei, K. K. (2018). Helpfulness of online review content: The moderating effects of temporal and social cues. *Journal of the Association for Information Systems, 19*(6), 503-522.	Manipulation
Krancher, O., Dibbern, J., & Meyer, P. (2018). How social media-enabled communication awareness enhances project team performance. *Journal of the Association for Information Systems, 19*(9), 813-856.	Manipulation
Tams, S., Thatcher, J. B., & Grover, V. (2018). Concentration, competence, confidence, and capture: An experimental study of age, interruption-based technostress, and task performance. *Journal of the Association for Information Systems, 19*(9), 857-908.	Manipulation
Jenkins, J. L., Proudfoot, J., Valacich, J. S., Grimes, G. M., & Nunamaker, J. F., Jr. (2019). Sleight of hand: Identifying concealed information by monitoring mouse-cursor movements. *Journal of the Association for Information Systems, 20*(1), 1-32.	Manipulation
Valecha, R., Rao, R., Upadhyaya, S., & Sharman R. (2019). An activity theory approach to modeling dispatch-mediated emergency response. *Journal of the Association for Information Systems, 20*(1), 33-57.	Construction
Morana, S., Kroenung, J., Maedche, A., & Schacht, S. (2019). Designing process guidance systems. *Journal of the Association for Information Systems, 20*(5), 499-535.	Construction
Miah, S. J., Gammack, J. G., & McKay, J. (2019). A metadesign theory for tailorable decision support. *Journal of the Association for Information Systems, 20*(5), 570-603.	Construction
Wortmann, F., Thiesse, F., & Fleisch, E. (2019). The impact of goal-congruent feature additions on core is feature use: When more is less and less is more. *Journal of the Association for Information Systems, 20*(7), 953-985.	Manipulation
Ptaszynski, M., Lempa, P., Masui, F., Kimura, Y., Rzepka, R., Araki, K., Wrocynski, M., & Leliwa, G. (2019). Brute-force sentence pattern extortion from harmful messages for cyberbullying detection. *Journal of the Association for Information Systems, 20*(8), 1075-1128.	Construction
Chanson, M., Bogner, A., Bilgeri, D., Fleisch, E., & Wortmann, F. (2019). Blockchain for the IoT: Privacy-preserving protection of sensor data. *Journal of the Association for Information Systems, 20*(9), 1274-1309.	Construction
Dissanayake, I., Nerur, S., Singh, R., & Lee, Y. (2019). Medical crowdsourcing: Harnessing the “wisdom of the crowd” to solve medical mysteries. *Journal of the Association for Information Systems, 20*(11), 1589-1610.	Construction

About the Authors

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