The Imprint of Design Science in Information Systems Research: An Empirical Analysis of the AIS Senior Scholars' Basket

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Completed Research Paper

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Abstract

Design Science (DS) has become an established research paradigm in Information Systems (IS) research. However, existing research still considers it as a challenge to publish DS contributions in top IS journals, due to the rather strict guidelines that DS publications are expected to follow. Against this backdrop, we intend to emphasize the myriad of configurations and empirically describe the status-quo of DS publications in IS. Based on a Systematic Literature Review (SLR) and a conceptually derived analysis frame, we empirically analyze DS papers published in the AIS Senior Scholars' Basket. Thereby, we intend to contribute conceptually and descriptively to the knowledge base of DS, by providing insights based on empirical evidence to aid and guide the discussion towards the advancement of the field. Overall, this shall lay the descriptive foundation for creating prescriptive knowledge on DS in IS by proposing and opening future research avenues.

Keywords: Design Science, Literature Review, Design Science Configurations

Introduction

With a long and lively history in our discipline, Design Science (DS) has become an established and widely used research method in the field of Information Systems (IS) research. As it has been shown in various research projects, DS is a suitable research method, for example, for the construction of socio-technical artifacts (Gregor and Hevner 2013). Consequently, the top journals of our discipline (i.e., the AIS Senior Scholars' Basket) publish a steadily growing number of DS-related articles. Despite this positive trend, renowned researchers in the field of DS still see some serious hurdles in the publication of DS contributions (Conboy et al. 2012; Goes 2014; Gregor and Hevner 2013). In search for possible explanations for this circumstance, one finds different views in the scientific discussion as to why it is still relatively difficult to publish DS contributions within the top journals of our discipline. For example, it is argued that DS is a relatively new research approach compared to the applied social sciences (Winter

2008), or that top journals in our discipline do not value practice-oriented research enough (Baskerville et al. 2011; Lyytinen et al. 2007). In response to this situation, a number of guidelines have been published in recent years that deal with how DS can be applied (Hevner et al. 2004; Peffers et al. 2007) and how the research contributions of a DS project can be presented and positioned as precisely as possible (Gregor and Hevner 2013). However, such guidelines imply the risk of being interpreted too strictly, thereby making DS a rather unattractive paradigm, as the many guidelines and objectives published in journals and conferences make it difficult and costly to carry out DS projects (Österle et al. 2011). In addition to that, according to Peffers et al. (2018), the published guidelines not only pose potential problems for authors but also pose risks for reviewers and editors. The reviewers may follow the published guidelines and use them without reflection as a reason for rejecting a contribution that deviates from these guidelines (Peffers et al. 2018). In order to counter this situation, we would like to illustrate the variety of DS contributions that have been published in the top journals of our discipline since the emergence of this research paradigm. To achieve this goal, we apply a Systematic Literature Review (SLR) to empirically examine the various studies that have been published within the Association for Information Systems (AIS) Senior Scholars' Basket of Journals since the advent of the DS approach. Thus, we intend to paint a picture of the status quo of the field of Design Science in the AIS Senior Scholars' Basket and also show the plethora of different configurations a DS paper can exhibit. Thus, we pose the following research question (RQ) that shall be answered in this paper:

RQ: *What are the characteristics of Design Science papers that have been published in the AIS Senior Scholars' Basket?*

By answering this research question, we intend to contribute to a more diversified descriptive knowledge base of research in Design Science, as it continues to develop. We hope to foster and contribute to the ongoing vivid discussion in the IS community by providing empirical evidence on the imprint of Design Science in IS research to aid and guide the discussion towards advancing the field of Design Science in Information Systems. Overall, this work shall lay the descriptive foundation for the future creation of prescriptive knowledge in Design Science in IS. The remainder of the paper is structured as follows. First, we provide a brief overview of the developments of Design Science in IS and conceptually develop a multidimensional analysis frame for characterizing Design Science papers. Subsequently, the method regarding the Systematic Literature Review and the analysis using a coding approach along the analysis frame as well as the data analysis techniques are described. Furthermore, we present our descriptive findings and insights into the status quo of Design Science papers in the AIS Senior Scholars' Basket. Based on this, we discuss our results, lay out the imminent limitations of our work and provide a structured overview of avenues for further research, before we close the paper in the conclusion section.

Conceptual Background

Before diving deeper into the analysis of the status quo of the field, we first want to clarify the terminology used in this paper. Design Science (DS), Design Science Research (DSR), Design Research or other derivatives such as Action Design Research (ADR) are well known as scientific approaches, aiming at developing socio-technical artifacts within the IS domain (Dinter and Krawatzeck 2015). For this paper, we use *Design Science* as the general term for research that is design-oriented and aims to produce an artifact with a practical and theoretical value-seeking utility. In this section, we further provide a brief overview of the historical developments of the field and lay out our conceptual foundation by presenting a frame for analysis, specifically tailored to characterizing the specific properties of Design Science publications. We conceptually develop this frame for analysis, based on a combination of theoretical frameworks theorizing about Design Science per se, to characterize successfully published Design Science papers both comprehensively and concisely.

Historical Developments of Design Science

The beginnings of Design Science in IS can be traced back to Nunamaker et al. (1991), who proposed systems development as a viable research strategy in IS research. While this is generally regarded as a valuable first step, it lacks clear methodological or scientific outputs (Baskerville et al. 2018). To address this issue, March and Smith (1995) proposed the use of kernel theories in theory testing and building in constructive research. Subsequently, Design Science in IS has grown significantly, distinct from the building approaches of computer science, which originated in the natural sciences. A major step for

Design Science in IS came in 2004, when Hevner et al. (2004) defined a set of principles for a canonical Design Science Research process. Since then, further methodological papers have been published that outline processes and approaches to conduct Design Science (e.g., Peffers et al. 2007). These papers focus on codified processes and propose ways for developing an artifact solving a relevant problem in a rigorous manner. Building on that, a research stream developed, in which the emphasis was on the elaboration of the practical contribution through introducing design interventions (that are equivalent to action research cycles from Action Research into the DS process) (Sein et al. 2011). These methodical contributions do not dictate the expected DSR outputs, since DSR is a very open and multi-faceted research strategy that can be applied to deliver all sorts of outcomes. In order to provide guidance for structuring the different kinds of design science studies, Gregor and Hevner (2013) provide guidelines for planning, reporting, evaluating and communicating outcomes of DSR projects.

Design Science is still discussed very intensely in the IS community. There has been a lively debate about the use of the method (Peffers et al. 2018), as well as the introduction of new design science research models like ADR (Mullarkey and Hevner 2019), but also about the contributions and their balancing between artifact and theory contribution (Baskerville et al. 2018). Between all these advances of the discipline, there is still a heavy debate about the theoretical contributions and the value of DS for the IS discipline and the possibilities to publish DS papers in top journals such as the AIS Senior Scholars' Basket (Baskerville et al. 2018). In order to shed light on that issue and to identify the characteristics of successfully published papers in the AIS Senior Scholars' Basket, we conceptualize theory-based characteristics of Design Science papers in a multidimensional analysis frame that is described in the next section.

Conceptualizing Characteristics of Design Science Publications

We aim at providing an overview of the characteristics of successfully published papers in high quality IS journals. In doing so, we intend to generate a unified frame of analysis, which allows for the comparability of the papers and a unified analysis of the state-of-the-art of the Design Science field in IS journals. We are motivated and inspired by Popper's perception of theories, which "are nets cast to catch what we call 'the world': to rationalize, to explain, to master it." (Popper 1972, p. 59). Therefore, we draw on existing theoretical frameworks methodologically theorizing about Design Science. We conceptually derive a consolidated theoretical frame of analysis derived from frameworks theorizing about Design Science. The conceptual steps taken to create this frame for analysis and the particular reasoning behind the steps shall be explained in this methodical subsection. When developing the analysis frame, we draw on the following qualitative attributes that originally stem from the field of taxonomy development. On the one hand, we aim for comprehensiveness (Bowker and Star 2000) and, on the other hand, for the conciseness of our analysis frame (Bailey 1994). Consequently, it needs to be extensive enough regarding its number of analytical dimensions to provide a comprehensive picture, characterizing why and how a single journal article used Design Science for reaching a knowledge contribution and what the particular outcome in terms of design artifacts is. Simultaneously, the frame of analysis needs to be concise enough to provide a crisp and graspable overview of the particular papers, which is motivated by dimensionality and complexity reduction. It shall be noted here that we develop this analysis frame for the specific purpose of this paper. We are aware that all dimensions, which are derived in the following, are debatable and that one might argue that the frame could be extended or narrowed down. In line with the philosophy of design as a search process seeking utility (Hevner et al. 2004), we argue that there is no right or wrong in creating a frame of analysis but we hope that we can transport our reasoning for creating the analysis frame in a cognitively understandable and practically reproducible manner. As a starting point for our conceptual derivation, we choose the work of Gregor and Hevner (2013) to assure the comprehensibility of our frame for analysis. The article investigates in a theory-based manner how to position and present design science research for maximum impact. Two reasons make this an appealing paper to start our conceptual journey for deriving an analysis frame for this paper. First, they theorize on a Design Science paper level as they are motivated by the intention to provide guidance for concrete paper-based research. This goes along neatly with our level of abstraction as we aim to set the scope of our research on published papers as units of analysis. Second, Gregor and Hevner (2013) provide a publication scheme as guidance for Design Science studies consisting of seven components starting with the introduction and ending with the conclusion of Design Science papers. Thus, we argue that the authors achieve a high level of comprehensibility in their theorizing endeavor, which serves as a starting point for deriving a frame of

analysis that is likely to fulfill the comprehensibility property described above. Taking Gregor's and Hevner's (2013) publication components on a higher level of abstraction, we identify two "complementary phases" of Design Science, which constitute major prerequisites to present a valuable contribution in high quality IS outlets, namely "build" and "evaluate" (Hevner et al. 2004, p.79). In addition to that, we draw on Gregor and Hevner (2013) and conclude that the particular Design Science "outcome" needs to be adequately presented as well. Thus, we structure our frame for analysis along these three layers. Within these layers, we conceptually derive the analysis dimensions from literature. Table 1 provides an overview of the conceptually derived frame for analysis that was developed by combining conceptually identified theories aiming to both comprehensively and concisely describe Design Science papers as a unit of analysis.

Table 1. Frame for Analysis of Design Science Papers

		Dimensions of Analysis	**Characteristics**
Build	Baskerville et al. (2018)	Knowledge Creation Strategy	Deductive
			Inductive
			Mix
		Design Science Theorizing Mode	Interior Mode
			Exterior Mode
Evaluate	Venable et al. (2016)	Evaluation Strategy	Naturalistic
			Artificial
			Formative
			Summative
Outcome	Gregor and Hevner (2013)	Situated Implementation of an Artifact (Level 1)	Instantiation
		Nascent Design Theory (Level 2)	Construct
			Model
			Method
		Mid-Range and Grand Theory (Level 3)	Design Theory
		Knowledge Contribution	Improvement
			Exaptation
			Invention
			Routine Design

The single dimensions of the conceptually developed frame for analysis shall be briefly described here to establish a profound knowledge base for the remainder of this paper.

Build: We draw on Baskerville et al.'s (2018) recent theoretical contributions to knowledge creation and theorizing modes in Design Science to derive dimensions for characterizing the "build layer" of our analysis frame. We first identify the dimension "Knowledge Creation Strategy" from Baskerville et al. (2018), which has a procedural perspective on the knowledge creation journey of a Design Science paper. The authors differentiate between deductive, inductive and hybrid knowledge creation strategies. While deduction refers to what is widely known as "theory-based design" using kernel theories (Kuechler and Vaishnavi 2008) – that is, first produce descriptive knowledge then prescriptive knowledge – induction builds on prescriptive knowledge creation from artifact design leading triggering the creation of descriptive knowledge (Baskerville et al. 2018). As potential research projects can also combine the two strategies, the dimension "Mix" is also included in our analysis frame. In their endeavor of describing distinct theorizing modes in Design Science, Baskerville et al. (2018) use the scope of analysis as a differentiating criterion. As this complements the process-based perspective described above very well, we include this as a dimension into our analytical frame. The authors differentiate two modes: an "Interior

Mode" where researchers "theorize prescriptively for artifact construction" and an "Exterior Mode" where researchers "theorize about artifacts in use" (Baskerville et al. 2018, p. 363).

Evaluate: We use the well-known FEDS framework ("Framework for Evaluation in Design Science Research") developed by Venable et al. (2016), as its multidimensional approach of describing evaluation strategies, tailored to the field of Design Science, allows for a mutually exclusive and collectively exhaustive characterization of evaluation endeavors in a concise but yet comprehensive manner. According to Venable et al. (2016), who investigated the multitude of evaluation possibilities in Design Science, the evaluation within a DS research project can be clustered into either evaluating in naturalistic or artificial settings, thereby using formative or summative functions. Regarding the evaluation paradigm, in naturalistic evaluation settings, outcomes are evaluated under real environmental conditions such as in organizations, while artificial evaluation settings comprise laboratory experiments, simulations, theoretical or mathematical arguments or proofs. In the dimension describing the functional purpose of evaluation, "formative" and "summative" evaluations can be compactly described as follows: "[W]hen formative functions are paramount, meanings are validated by their consequences" (William and Black 1996, p.545) and "when summative functions are paramount, consequences are validated by meanings" (William and Black 1996, p.545).

Outcome: The dimensions for characterizing the outcomes of particular Design Science articles are derived from Gregor's and Hevner's (2013) extensive efforts in conceptualizing contributions of Design Science. As one of the main contributions of their article, Gregor and Hevner (2013) provide a three-level conceptualization of contributions to theory in Design Science. On level 1, they refer to the situated implementation of a particular artifact, which goes along with the artifact type "Instantiation" as suggested by March and Smith (1995). "An instantiation is the realization of an artifact in its environment. IT research instantiates both specific information systems and tools that address various aspect of designing information systems. Instantiations operationalize constructs, models, and methods" (March and Smith 1995, p. 258). Gregor and Hevner (2013) further categorize the design artifacts constructs, models and methods, as suggested by March and Smith (1995), as nascent level 2-design theories. Hereby, "constructs or concepts form the vocabulary of a domain. They constitute a conceptualization used to describe problems within the domain and to specify their solutions" (March and Smith 1995, p. 256). "A model is a set of propositions or statements expressing relationships among constructs. In design activities, models represent situations as problem and solution statements" (March and Smith 1995, p. 256). "A method is a set of steps (an algorithm or guideline) used to perform a task. Methods are based on a set of underlying constructs (language) and a representation (model) of the solution space" (March and Smith 1995, p. 257). Level 3-design theories refer to so-called mid-range and grand theories, which comprise well-developed knowledge on the particular phenomena of interest on a more complete, abstract and mature level (Gregor and Hevner 2013).

In addition to that, Gregor and Hevner (2013) conceptualize the particular knowledge contribution of a Design Science paper using a 2x2 matrix spanned by high and low solution maturity and high and low application domain maturity. The dimension "Improvement" refers to developing new solutions for known problems. "Exaptation" refers to extending known solutions to new problems, such as applying solutions from other fields. "Invention" refers to inventing new solutions for new problems, and "Routine Design" is about applying known solutions to known problems, which poses no major knowledge contribution (Gregor and Hevner 2013, p. 345).

Method

In this section, we describe our literature search process that provides the empirical basis for successful journal articles, on which our analysis frame is subsequently applied in a coding process. Furthermore, we elaborate on the data analysis techniques applied in this paper to exploratively create descriptive insights about our topic area of interest in the manner of the knowledge discovery process.

Systematic Literature Review within the AIS Senior Scholars' Basket

In order to gather a representative coverage of Design Science literature, we conduct the literature search process according to the principles of Systematic Literature Reviews in line with Webster and Watson (2002) and vom Brocke et al. (2015). We define the search scope of the SLR along the dimensions of

process, source, coverage and techniques of the SLR (vom Brocke et al. 2015): We apply a *sequential search process* using the journal databases of the AIS Senior Scholars' Basket, which comprises eight top-level journals from the IS field. This serves as the *source* for identifying successfully published Design Science papers that reached top-ranked journal outlets. We aim for reaching a *representative coverage* of successfully published Design Science journal papers, which we intend to achieve by covering the whole AIS Senior Scholars' Basket and by applying full-text search as a *search technique*. To enable researchers to reproduce our search results, we aim for a high level of transparency in presenting the steps taken towards the final set of relevant literature for further analysis:

Step 1 - Selection of search strings: As we intend to reach a representative coverage of Design Science papers that reached a top-ranked journal outlet, we use one search string which is chosen to be broad. Therefore, we use "design science" as our only search string and put the search scope on a full-text search to find all papers that deal with Design Science in any way. By not restricting our search to title, abstract or keywords, we intend to make sure to not neglect relevant research papers, knowing that this makes the filtration and paper selection process more extensive and time-consuming.

Step 2 - Selection of databases: We choose the eight journal databases of the AIS Senior Scholars' Basket as a source for finding literature. The reasoning behind this approach can be summarized as follows. Our goal is set to identify a representative coverage of literature that uses Design Science as the guiding methodical approach for achieving a research contribution that successfully made its way to a high quality journal. As the AIS Senior Scholars' Basket is well known for its high quality research covering the most prominent and prestigious journal outlets, the choice to use it as a search foundation for gathering Design Science literature in IS falls in place logically. The following eight journals, with their particular abbreviations in brackets, are covered as part of the Senior Scholar Basket in the course of our literature search process: Management Information Systems Quarterly (MISQ), Journal of Management Information Systems (JMIS), Journal of the Association for Information Systems (JAIS), Information Systems Research (ISR), European Journal of Information Systems (EJIS), Information Systems Journal (ISJ), Journal of Strategic Information Systems (JSIS), Journal of Information Technology (JIT).

Step 3 - Refinement of search strings: To not neglect learning effects in search string selection when analyzing the retrieved papers, we kept the set of search strings open for extension during the search process. However, we found the initial search string "design science" to be sufficient for achieving our research goal, when applying full-text search. Originally, it was our concern that specific Design Science approaches such as Action Design Research as introduced by Sein et al. (2011) might not be covered in our search only using the search string "design science". However, we quickly found that by applying full-text search, papers pursuing derivative Design Science approaches are covered as well, as the search string "design science" occurs at a minimum in the theoretical background section of the particular papers. Searching in the full text of the papers, the journal-based search reveals 457 hits in the eight AIS Senior Scholars' Basket journals. This number still includes literature not relevant for the purpose of our study.

Step 4 - Selection of papers: Our key criterion for a paper to be included in the subsequent analysis using the analytical frame developed above is that the particular paper needs to directly apply Design Science methods as the guiding approach of knowledge creation. In an initial screening procedure, we scanned the hits from the AIS Senior Scholars' Basket regarding title, abstract, introduction and the research method section, as we suspected to find the selection criterion to either be fulfilled or not fulfilled in these sections. This led to an initial number of 120 papers that were screened in further detail regarding their full texts. This second filtration and selection step led to a further reduction of relevant papers that apply Design Science knowledge creation. Overall, 97 papers remain to be relevant for further content-wise analysis. For statistical reasons, we also tracked the number of papers that deal with Design Science in a methodological manner. This includes papers theorizing about Design Science without applying it to a certain research problem. Overall, we could identify 93 methodological studies on Design Science in the AIS Senior Scholars' Basket, which almost makes up a 50:50 ratio of applied Design Science studies and methodological studies. This can be seen as one of the first findings of this paper, which will be discussed in more detail in the results section. However, as we are interested in papers that apply Design Science for the creation of knowledge that solves a certain research problem, we only consider the 97 applied Design Science papers in our further analytical process. To enable scholars to reproduce the keyword search, Table 2 depicts the total and relevant search results per database and search string.

Table 2. Results of the Literature Search Process			
	Search String (Full-Text): *"Design Science"*		
	Total Hits	**Applied Design Science**	**Methodological Studies**
Management Information Systems Quarterly	89	15	15
Journal of Management Information Systems	62	23	5
Journal of the Association for Information Systems	76	24	17
Information Systems Research	37	4	6
European Journal of Information Systems	93	21	28
Journal of Information Technology	39	2	13
Information Systems Journal	39	5	7
Journal of Strategic Information Systems	22	3	2
Sum	**457**	**97**	**93**

Coding for Boolean Vectors and Data Analysis

We use the developed frame for analysis consisting of 18 dimensions depicted in Table 1 to characterize the 97 identified papers. This means that we create 18-dimensional Boolean vectors characterizing the particular finger prints of each of the 97 successfully published Design Science papers that were identified in the literature search described above.

A team of three researchers approaches the Boolean vector creation by applying closed coding on the full-texts of the 97 Design Science articles from the AIS Senior Scholars' Basket using the dimensions of the analysis frame developed in this paper. The coding process is rooted in the methodological field of Qualitative Content Analysis and conducted according to the guidelines suggested by Forman and Damschroder (2007). We pursue an iterative approach of characterizing the single papers individually by assigning "1" to a dimension of the analysis frame if a certain paper fulfills the particular characteristic and "0" if the paper does not fulfill the characteristic. After each iteration, we validate the results in research discussions among the three researchers. By applying this cross-validation approach, we intend to achieve reproducible, stable, and valid paper characterizations. However, it must be noted that assigning codes in Qualitative Content Analysis always requires intellectual and individual human judgement. Thus, a subjective bias can never be fully eliminated, which we discuss in the limitations section of this paper.

Formally represented, the Boolean vectors of papers can be defined as follows:

Characteristics of the analysis frame $C = \{c_1, c_2, \dots c_j \dots c_{m-1}, c_m\},\ j \in J = \{1, \dots, m\}$

Paper instances $S = \{s_1, s_2, \dots s_i \dots s_{n-1}, s_n\},\ i \in I = \{1, \dots, n\}$

Occurrence (1 or 0) $x_{ij} \in X : I \times J \rightarrow \{0,1\}$

The 97 instances s_i of Design Science articles successfully published in the AIS Senior Scholars' Basket are characterized along the 18 characteristics c_j of the developed frame for analysis. Each instance s_i either fulfills a characteristic c_j or not. This occurrence is represented by respective matrix entries, which either take values of 1 if an instance si fulfills a characteristic c_j or 0 if an instance s_i does not fulfill a characteristic c_j. Consequently, all 97 papers can be represented by their particular Boolean vectors consisting of 18 dimensions. The transformation of the textual papers to a binary data set makes the observed Design Science papers comparable, and thus analyzable with statistical techniques. As it is our designated research goal to reach a contribution for the descriptive knowledge base of Design Science, we focus our data analysis on gathering insights about "the what" of Design Science. Consequently, we apply techniques from descriptive statistics on the created set of 97 Boolean vectors analyzing both the variable space and the object space. We also analyze the respective papers from different analytical angles comprising a time-based, an outlet-based and an outcome-based view.

Results

This section first elaborates on the descriptive findings that emerged through the coding of the 97 papers from the AIS Senior Scholars' Basket using the analysis frame that has been conceptually derived in this paper. Diving deeper into the analysis of the object and variable space of the 97 Boolean vectors derived from the coding, we present the main insights into the status quo of Design Science in the AIS Senior Scholars' Basket.

Descriptive Findings

Overall, we analyzed 97 publications in the AIS Senior Scholars' Basket that apply Design Science methodologies for problem-solving in IS. Figure 1 depicts how the field of Design Science emerged in the AIS Senior Scholars' Basket regarding the number of publications on a timeline. The youngest paper is from 2019 and the oldest paper from 2004. We can observe an increasing trend in publications, which seems to happen in waves over time. This reflects the increasing adoption and emancipation of Design Science in top IS journal outlets. One of the factors leading to the wave-shaped publication curve are particular special issues of the journal outlets published at certain points in time. A deeper root cause analysis of other factors leading to the publication curve as displayed here is a promising avenue for future research but not in the scope of this paper.

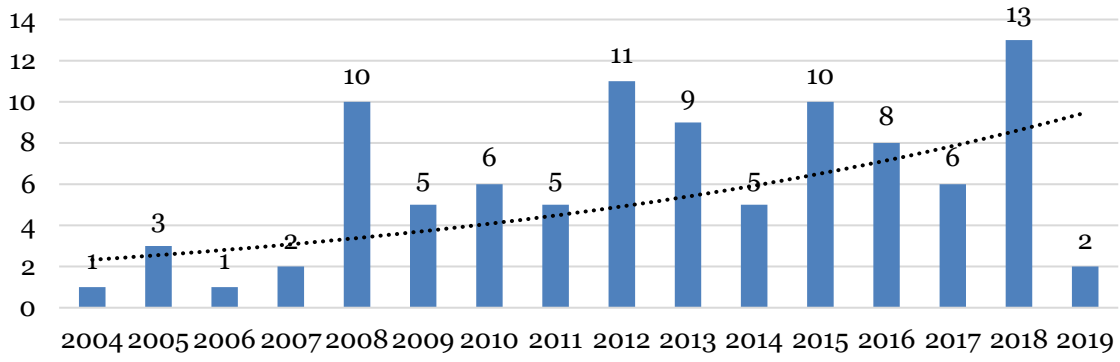

Figure 1. Timeline of Design Science Publications in the AIS Senior Scholars' Basket

Furthermore, a high level of heterogeneity in application domains of Design Science is reflected by our results, as we found Design Science to be applied in the following domains: Manufacturing, virtual worlds, financial industry, software development, education, energy supply and green IS, eGovernment, enterprise integration, cyber-physical systems, digital services, cybersecurity, social networks, cloud computing, Internet-of-things, decision support systems, data warehousing, digital platforms, business models, healthcare, and many more. This underlines the matter-of-fact of an increasing adoption and diffusion of Design Science in IS research. In Table 3, we provide a high-level overview of our coding results. In particular, we included the number of occurrences (#) of characteristics in the distinct dimensions of our analysis frame and provide exemplary statements from individual papers that lead us to the specific coding decisions to foster the transparency of our presented results. Diving deeper into the analysis of the coding results, we present our main insights in the next subsection.

Table 3. Numeric Coding Results and Exemplary Statements from Journal Articles

			#	Exemplary Statements from Journal Articles
Build (Baskerville et al. 2018)	Knowledge Creation Strategy	Deductive	41	*"A **deductive** approach, based on the **kernel theory** of CJ, allowed us to identify design features to address the design requirements."* (Coenen et al. 2018, p.252)
		Inductive	23	*"The proposed approach and vast majority of features **identified through supervised feature engineering** are applicable across brands"* (Ghiassi et al. 2016, p. 1034)
		Mix	33	*"[…] developing a conceptual modeling grammar **based on activity theory and grounded in an analysis** of more than 1000 […] reports […]"* (Valecha et al. 2019, p. 48)
	Design Science Theorizing Mode	Interior Mode	63	*"We describe **an implementable solution** […]"* (Datta et al. 2012, p. 507)
		Exterior Mode	52	*"[…]a model that relates design of collaboration technologies to **team performance**."* (Zhang et al. 2011, p. 572)
Evaluate (Venable et al. 2016)	Evaluation Strategy	Naturalistic	51	*"A **case study** based on a financial services Web site is used to provide a preliminary validation and d**esign evaluation** of our approach."* (Albert et al. 2004, p. 161)
		Artificial	59	*"To evaluate the proposed framework, **a series of experiments** are conducted on a test bed […]"* (Abbasi et al. 2012, p. 1293)
		Formative	44	*"Evaluation of the earlier version of our BMDT was **formative** and contributed to its refinement."* (Ebel et al. 2016, p. 536)
		Summative	78	*"We have designed two laboratory experiments and one expert user study as part of a **summative evaluation** of the developed artifacts."* (Babaian et al. 2018, p. 198)
Outcome (Gregor and Hevner, 2013)	Situated Implementation (Level 1)	Instantiation	7	*"An interviewing system design using facial rigidity analysis **was implemented** and experimentally evaluated […]"* (Pentland et al. 2017, p. 971)
	Nascent Design Theory (Level 2)	Construct	14	*"The results shed light on the relative strength and robustness of various **types of deception indicators** within this new context."* (Twyman et al. 2015, p. 216)
		Model	39	*"[…] We are able to generalise our insights and interpretations to more general **models** […]"* (Chatterjee et al. 2018, p. 684)
		Method	47	*"From a design science perspective, the catalog and its use can be considered as a **method artifact**."* (Soffer et al. 2015, p. 378)
	Mid-Range and Grand Theory (Level 3)	Design Theory	12	*"This research proposes and validates a **design theory** for digital platforms […]"* (Spagnoletti et al. 2015, p. 364)
	Knowledge Contribution	Improvement	83	*"[…] help **create an improved method** of creating Digital Signature Policies (DSPs)."* (Papas et al. 2012, p.151)
		Exaptation	12	*"In this **exaptation research**, we set out to design, implement, and evaluate the first decision support system that aids decision-makers in the automobile industry […]"* (Kloör et al. 2018, p. 171)
		Invention	3	*"In terms of the knowledge contributions of design science research (Gregor & Hevner, 2013), one may categorize Brownie as an **invention** […]."* (Hariharan et al. 2017, p. 283)
		Routine Design	0	-

Insights

This section provides a set of insights that we gained when analyzing the results of our coding procedure. We structure our results along the descriptive insights we derived from analyzing the object and variable space of the 97 Boolean vectors that emerged through the coding procedure using the developed analysis frame. Overall, seven descriptive insights into the status quo of Design Science in the AIS Senior Scholars' Basket are presented and illustrated with the respective statistical charts. We were able to identify insights along all dimensions of the developed analysis frame. It shall be noted here that in this paper we do not intend to provide any normative prescription. However, we view and interpret the insights from the analysis of the 97 Design Science journal articles in the light and context of papers that normatively theorize about the desired properties of the Design Science field and describe the spotted deltas between the status quo and the plethora of possible configurations that Design Science publications can exhibit.

Methodological studies are a prevalent phenomenon of Design Science in IS journal outlets: While conducting the Systematic Literature Review for retrieving Design Science papers from the AIS Senior Scholars' Basket that contain the search "design science" in their full texts, we quickly realized that we were about to encounter a disproportionate amount of papers theorizing about Design Science itself. Even though, these papers are not part of the focus of our analysis, we tracked them for statistical reasons. Figure 2 shows that, in the AIS Senior Scholars' Basket, almost 50 percent of Design Science papers talk about Design Science but do not actually apply it for problem-solving in the IS discipline.

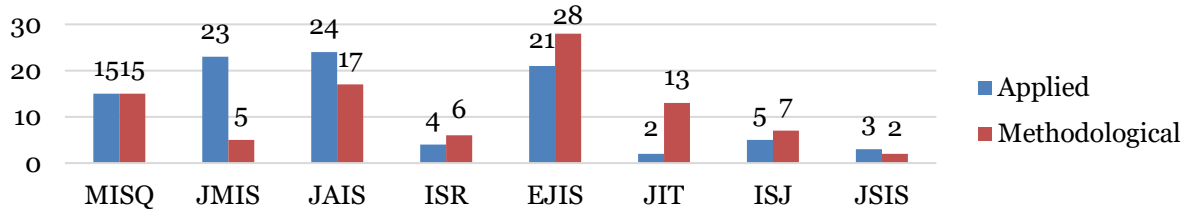

Figure 2. Applied and Methodological Design Science Papers in Distinct Journal Outlets

We found 93 methodological papers compared to 97 papers that apply Design Science as the guiding methodology for solving a specific IS problem. We find this disproportionate occurrence of methodological Design Science studies to be a noteworthy insight into the status quo of the field of Design Science in IS. On an outlet-level, for instance, in the European Journal of Information Systems (EJIS), we find a higher share (28) of Design Science papers theorizing about Design Science itself than articles applying Design Science for problem-solving (21). Management Information Systems Quarterly (MISQ) also shows a 50:50 ratio of applied and methodological Design Science papers and, in the Journal of Information Technology (JIT), 13 papers theorize about Design Science compared to two that apply it as a method. We hypothesize that this fact has its roots in the vivid scientific discourse that has been conducted in the field of IS during the emergence of Design Science as a utility-seeking mindset of research. However, we leave a deeper sense-making process and root-cause analysis for further research and discussion.

Despite many methodological papers on Design Science, there exist methods in Design Science that find disproportionate levels of application in the IS community: During our analysis of articles that apply Design Science for problem-solving in IS, we kept track of the particular methods researchers use to structure their Design Science endeavors. Among the multitude of cited approaches, we found two approaches to be the by far most cited. With 60 mentions, the three-cycle-view on Design Science suggested by Hevner et al. (2004) is the most wide-spread approach from a bibliographic point of view. The DS approach suggested by Peffers et al. (2007) is referred to 21 times. We aggregated all the other derivatives, extensions and alternative approaches, as none of them reached a citation count of above six or more in our retrieved set of applied Design Science articles in the AIS Senior Scholars' Basket. Overall, these approaches are referred to 48 times in aggregation in the AIS Senior Scholars' Basket.

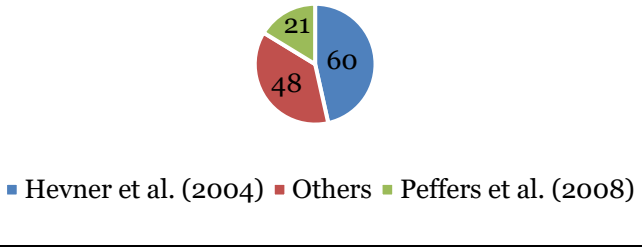

Figure 3. Applied Design Science Methodologies

Summing up the numbers in Figure 3 shows that 129 times researchers cited approaches in their papers, which makes more than one approach per paper (129/97 ≈ 1.33). Also the two approaches suggested by Hevner et al. (2004) and Peffers et al. (2007), which are applied most often, are sometimes referred to in combination. While Hevner et al. (2004) present a quite open framework that provides researchers with a lot of freedom in the single steps towards finishing their Design Science projects, Peffers et al. (2007) provide a tightly guided approach that serves researchers with a higher level of structure. Referring to both approaches poses an interesting hybrid view on approaching Design Science challenges, which might be worth further investigation. A first deep dive into the papers shows that some papers refer to the approach suggested by Hevner et al. (2004) in a manner that tends to be a research paradigm used for macroscopic framing of the research endeavor but not for further methodological guidance. However, in no way do we intend to make any statements about the quality of the approaches here, as they both find justification in distinct Design Science contexts, as the observations from the AIS Senior Scholars' Basket show.

Deductive theory-based and hybrid knowledge creation strategies make up for a larger proportion than merely inductive approaches: Our analysis shows that, in Design Science, deduction is the dominant strategy for contributing to the IS knowledge base. Researchers in the field of Design Science in IS call this type of knowledge creation strategy "theory-based design" (Kuechler and Vaishnavi 2008). We find this to be an interesting observation as one of the fundamental properties of Design Science that differentiates it from truth-seeking sciences is the knowledge stemming from the learning process in designing particular artifacts (Hevner et al. 2004). This approach to science is inherently inductive but underrepresented in top IS journals as our analysis results show. As Figure 4 shows, we can also observe a high level of hybrid approaches conducting both inductive and deductive knowledge creation phases.

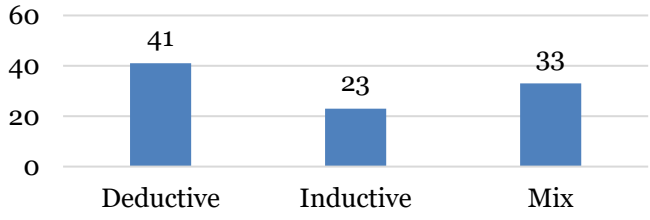

Figure 4. Knowledge Creation Strategies

In their endeavor to find a balance between artifact and theory, Baskerville et al. (2018) extensively elaborate on the interplay of science that has the goal "to grow the descriptive knowledge base of the natural world and human behavior" (Baskerville et al. 2018, p. 360) and of technology that aims to "grow the prescriptive knowledge base of purposefully designed artifacts to improve human capabilities both physically (e.g., tool use) and mentally (e.g., decision-making)" (Baskerville et al. 2018, p. 360). The authors call this the "science-technology dualism" (Baskerville et al. 2018, p. 361) and argue for a rigorous grounding of design endeavors in descriptive theories, such as kernel theories. In this light, the share of

hybrid approaches is in line with Baskerville et al. (2018) However, future research should investigate why merely inductive approaches are still underrepresented in top IS journals.

Among the distinct journals, there are significant differences in the share of articles that pursue an interior mode vs. an exterior mode of theorizing: Between the modes of theorizing suggested by Baskerville et al. (2018), there does exist a quite balanced number of occurrences on a global scale in the AIS Senior Scholars' Basket with the interior mode (63 occurrences) being used for theorizing slightly more often than the exterior mode (52 occurrences). The numbers in Figure 5 show that there is also a certain share of papers (18.6 percent) that uses both modes of theorizing. These papers are both supposed to "theorize prescriptively for artifact construction" (interior mode) and to "theorize about artifacts in use"(exterior mode) (Baskerville et al. 2018, p. 363).

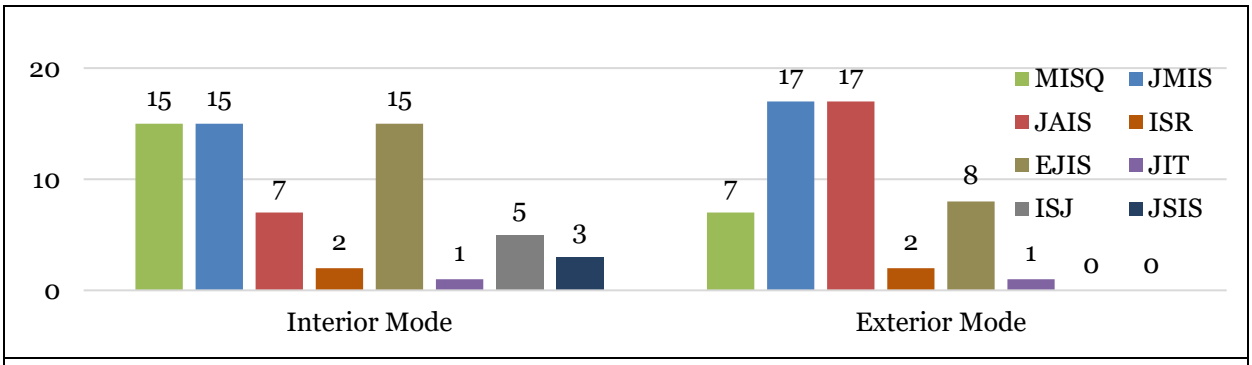

Figure 5. Theorizing Modes

However, we can observe quite contrasting numbers when interpreting the results on a journal-outlet level. In the MISQ journal, we find 15 articles pursuing an interior mode of theorizing and 7 articles pursuing an exterior mode of theorizing. The proportion in EJIS is quite similar to MISQ. Comparing this to JAIS, Figure 5 visualizes that this relation is twisted around. In JAIS, there are 7 articles conducting an interior mode of theorizing and 17 conducting an exterior mode of theorizing. This difference between IS journals in their modes of theorizing are worth further investigation, as our findings indicate structural differences in IS journal outlets – some predominantly producing theoretical insights about the artifact design itself, such as EJIS or MISQ, some focusing on theorizing about the use of artifacts, such as JAIS.

Summative evaluation strategies are the predominant evaluation strategy in Design Science publications in the AIS Senior Scholar's Basket: As the evaluation phase is a key component of Design Science endeavors (Hevner et al. 2004; March and Smith 1995; Vaishnavi and Kuechler 2004; Venable et al. 2016), frameworks providing guidance towards the latter have been developed, such as the FEDS framework by Venable et al. (2016), which is uniquely tailored to the use in Design Science that we included in our frame for analysis. On the axis of the evaluation paradigm (naturalistic vs. artificial) of the FEDS framework, we could not observe any significant shifts implying tendencies into the directions of naturalistic or artificial evaluation strategies – neither on an overarching level in the AIS Senior Scholars' Basket nor on a specific outlet-level.

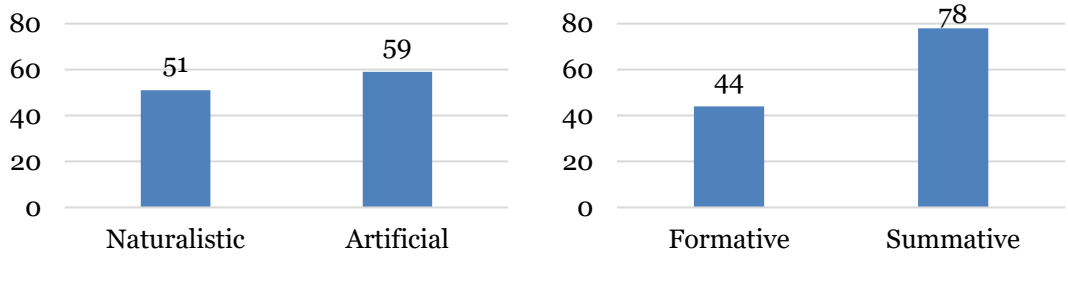

Figure 6. Paradigms (left) and Functional Purpose (right) of Evaluation Strategies

Instead, as depicted in Figure 6, there are observable imbalances in the dimension describing the functional purpose of the evaluation, namely between the frequency in which formative and summative evaluation is applied by IS researchers in the AIS Senior Scholars' Basket. We find a substantially higher amount of evaluations conducted summatively (78) in the analyzed Design Science papers than formative evaluation approaches (44). While Venable et al. (2016) argue that formative evaluation strategies reduce risks by enabling early and stepwise testing and evaluation in the design process, and summative strategies enable a closer proximity to reality, we want to stress an additional facet. Referring to what Nunamaker et al. (2015) call the last research mile, we pose the question of if a tendency of the Design Science field in IS towards merely summative evaluations hinders the development of mid-range and grand theories according to Gregor and Hevner (2013) as the stepwise formative learning that enables causality through transparency is not leveraged to its full extent. As we will show in the next paragraph, mid-range and grand theories still only make up for a small number of Design Science outcomes in the AIS Senior Scholars' Basket. Thus, combining both formative and summative evaluation might be the strategy bringing researchers closest to bridging the last research mile, moving from proof-of-concept over proof-of-value towards proof-of-use (Nunamaker et al. 2015).

Nascent design theories are the predominant theoretical contribution of Design Science in the AIS Senior Scholars' Basket: On a Design Science outcome level, we differentiated between distinct artifact types (March and Smith 1995) and three levels of theory (Gregor and Hevner 2013). As shown in Figure 7, there is a clearly observable peak in outcomes that fall into the category of nascent design theories (level 2) with 100 artifacts. Compared to seven situated implementations of artifacts and twelve mid-range and grand theories the number of nascent theories consisting of constructs, models and methods, is quite significant. The numbers need to be interpreted with the awareness that one journal article can "produce" multiple theoretical contributions or combinations of artifacts.

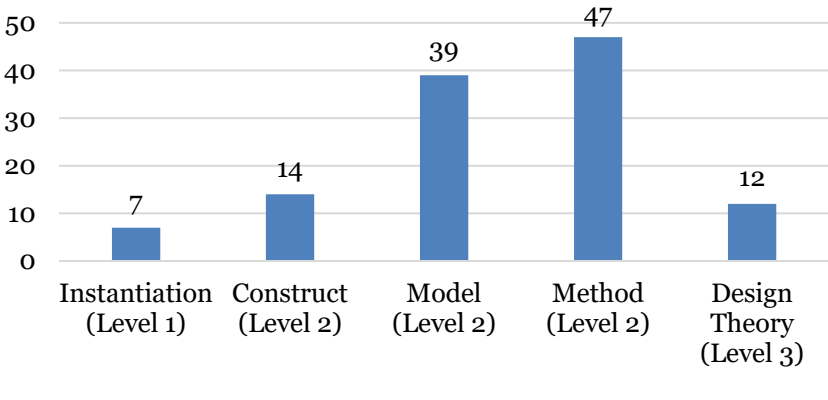

Figure 7. Outcome Types of Design Science Endeavors

This reflects the ongoing discourse in the IS community that is about the theoretical contribution of Design Science per se and its scientific justification in seeking for utility rather than truth as a first priority motivation. We also hypothesize that publishing mere instantiations of artifacts as level 1 theories might be hard in the AIS Senior Scholars' Basket due to a comparably low level of theoretical contribution perceived by IS scholars. This goes along with the comparably low number of papers that conducted the knowledge creation process merely inductively, as shown above. Also publishing mid-range and grand theories, which is the long-term goal of Design Science endeavors, seems to pose serious challenges in Design Science. This is worth further investigating on if the root cause lies in publishing or producing these kinds of outcomes with Design Science methodologies.

Most Design Science outcomes reach a knowledge contribution by posing a new solution for a known problem (i.e., improvement), while exaptations and inventions are still rare: As we move to the last insight generated in our analysis of the AIS Senior Scholars' Basket, we focus on the knowledge contribution achieved by the analyzed journal articles. As Figure 8 shows, we find an overwhelming number of 83 knowledge contributions falling in the area of improvements compared to 12 exaptations and 3 inventions.

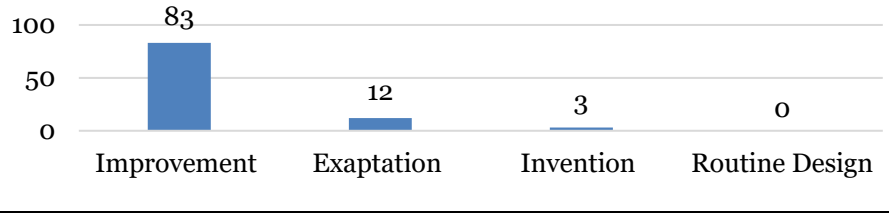

Figure 8. Knowledge Contribution Types of Design Science Papers

Routine design does not pose any new contribution to the IS knowledge base and no occurrences could be observed in the AIS Senior Scholars' Basket. The number of inventions being quite low was an expected outcome during our research process and held true in the outcomes of our analysis as true inventions that incorporate new solutions for new problems are rare. However, what is an interesting insight to us is that our analysis shows that exaptations, which use known solutions from other disciplines for solving new problems, reach such a significantly lower number than improvements in the IS Senior Scholar Basket. From our interpretation, this shows a certain degree of isolation of the Design Science community. We argue for a higher degree of integration of knowledge from other disciplines as the benefit from learning from the latter could be a fruitful seed for Design Science and Information Systems in their entirety.

Discussion and Outlook

In this work, we contribute conceptually and descriptively to the knowledge base of Design Science in the Information Systems community. We provide seven insights based on empirical evidence to aid and guide the discussion towards the advancement of the field of Design Science in Information Systems research. In this research project, the scope was set to be descriptive, non-normatively elaborating on the status quo of Design Science publications in the AIS Senior Scholars' Basket. This shall provide IS researchers with a clearer picture of the myriad of distinct configurations of characteristics that Design Science publications can exhibit, thereby outlining the imprint of DS in IS top-journals. We intended to both emphasize the distinct configurations and empirically describe the status quo of Design Science in IS from a numerical point of view, thus contributing to "the what" of Design Science in IS. In this context, our conceptually derived analysis frame served as the guiding structure for characterizing successfully published Design Science papers retrieved from the AIS Senior Scholars' Basket. We argue that it can be used to provide a unified theoretical lens for characterizing Design Science papers, and thereby provides a valuable contribution to the methodological knowledge base of Design Science in IS. Furthermore, the analysis frame can be applied by other scholars extending or enriching our results, or to structure their own research endeavors in Design Science, which poses another contribution to Design Science in IS research. For instance, future research could investigate journal review processes to explore the reasoning behind using particular Design Science methods, e.g. in the context of research framing or the establishment of "quasi-industry standards". Regarding the observed underrepresentation of merely inductive knowledge creation and the differences in modes of theorizing between top-IS journals, further analysis of potential paper survival bias and research investigating the mission statements of IS journals in relation to the general maturation of the Design Science field could extend our research. Additionally, the root causes of the scarcity of mid-range and grand theories of Design Science in IS journals should be investigated, potentially in relation to the tendency of Design Science in IS towards merely summative evaluations, which hinders learning-based theorizing.

Overall, this work shall lay the descriptive foundation for future creations of prescriptive knowledge on Design Science in IS by suggesting and opening a multitude of avenues worth further investigating. We are aware that the dimensions derived while creating our frame for analysis are debatable and that one might argue that the frame could be extended or narrowed down. In line with the philosophy of "design as a search process" seeking utility (Hevner et al. 2004), we argue that there is no right or wrong in creating a frame of analysis but we hope that we could transport our reasoning for creating the analysis frame in a cognitively understandable and practically reproducible manner. Even though, we intended to conduct the retrieval and analysis of successfully published Design Science papers as rigorously and reproducibly as possible, the Systematic Literature Review (SLR) comes with several limitations. First, the search scope

of the SLR is not fully exhaustive as we limited it to the AIS Senior Scholars' Basket. However, as we were interested in Design Science papers successfully published in the top-outlets of the IS discipline, we view the AIS Senior Scholars' Basket to encompass a representative spectrum of papers that still allows for the creation of more generalizable descriptive insights. Furthermore, it needs to be noted that the selection and coding of papers is a process that inherently is dependent on subjective human judgement. To minimize potential subjective biases as far as possible, we defined and followed unified and concise selection criteria in an iterative process guided by discussions among three IS researchers (Forman and Damschroder 2007). However, a certain residuum of subjective bias always remains. On a data analysis level, we see limitations in the set of applied data analysis techniques as they are quite simple and merely descriptive so far. As we did not intend to derive either normative prescription or causalities in this step of our research, this does not hinder our knowledge contribution to be based on a clean methodical basis, but we see the limitations in the power of suggested hypotheses, when discussing our derived insights. Thus, we intend to open the spectrum of data analysis techniques in future research. For instance, we aim to apply cluster analysis to eventually identify archetypes of publications that can serve as a foundation for conducting further root-cause analysis of the status quo of Design Science, which has been displayed in this paper. Furthermore, future work building up on our results could enrich them with additional bibliographic information, such as citation networks investigating the relations within the field of Design Science in IS in a more detailed manner. Another limitation of this paper simultaneously offers extensive future research opportunities. We see our results confronted with publication or survival bias, as only successfully published journal papers are part of the scope of analysis. Even though, this was the goal of our research in this paper, we argue that a clearer picture of the status quo of Design Science in IS could be painted by considering research that, so far, did not make it to the top-outlets of our discipline, or earlier versions of the successfully published papers. This opens an avenue for future research as it has the potential to allow for a more concise characterization of the Design Science field in general and its publications in particular by offering opportunities for identifying delimitations between successfully published and unpublished papers and their respective life cycles. By pursuing the methodological pathways outlined above, we intend to bridge the gap between the conceptual and descriptive insights derived in this paper and future research opportunities based on our insights.

Conclusion

The research goal of this work was to empirically identify and conceptualize characteristics of Design Science (DS) papers that apply Design Science methods and have been published in the AIS Senior Scholars' Basket. In pursuing this goal, we intended to illustrate the variety of DS contributions that have been published in the top journals of our discipline since the emergence of DS as a research paradigm. We applied a Systematic Literature Review followed by a coding process among three researchers to empirically examine the various studies that have been published within the AIS Senior Scholars' Basket since the advent of the DS approach, thus intending to contribute to a more diversified knowledge base of research in DS. On the foundation of a brief overview of the developments of DS in IS, we conceptually derived a multidimensional analysis frame for characterizing DS papers and conducted a coding approach along the analysis frame to characterize the 97 DS papers that were retrieved from the AIS Senior Scholars' Basket and actually apply DS methodologies for solving a designated problem in IS. Applying data analysis techniques on the object and variable space of the 18-dimensional Boolean vectors of paper characterizations that resulted from our coding procedure, we derived descriptive findings and insights into the status quo of successfully published DS papers in the AIS Senior Scholars' Basket: (1) We found that methodological studies are a prevalent phenomenon of DS in IS journal outlets. (2) Despite many methodological papers on DS, there exist methods in DS that find disproportionate levels of application in the IS community. (3) Deductive theory-based and hybrid knowledge creation strategies make up for a larger proportion than merely inductive approaches. (4) Among the distinct journals there are significant differences in the share of articles that pursue an interior mode vs. an exterior mode of theorizing. (5) Summative evaluation strategies are the predominant evaluation strategy of DS in IS journal publications. (6) Nascent design theories are the predominant theoretical contribution of DS in IS Journals. (7) Most DS outcomes reach a knowledge contribution by posing a new solution for a known problem (i.e., improvement), while exaptations and inventions are still rare. Based on these insights, we hope to foster and contribute to the ongoing vivid discussion in the IS community by providing empirical evidence on the imprint of DS in IS research to aid and guide the discussion towards advancing the field of DS in IS.

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