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The Paradigm of Design Science Research: A Tool-Supported Literature Review

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Abstract. In this paper, a review of the state of the art of theory associated with the young and quickly evolving Design Science Research (DSR) paradigm is presented. The core of the review consists of a structured literature search covering the senior scholars' basket of eight from 1977 until the end of 2016, which resulted in data set of 196 sources. An iterative, selective coding of the title and abstracts revealed four major grounded clusters (138 papers). Three clusters (93 papers) were selected for co-citation analysis and augmented with additional forward and backward searches. The co-citation analysis affords an objective look at the current state of theory use in DSR and allows for the systematic identification of research opportunities. Altogether, the paper presents a multi-grounded DSR approach to literature reviews and contributes a reliable platform for further analysis and development of the DSR paradigm.

Keywords: Design Science Research · Literature Review · Co-Citation Analysis · Network Analysis

1 Introduction

One core idea of scientific enquiry is the generation of reliable abstract knowledge about phenomena that is applicable in a variety of contexts. Recognizing the importance of the design of artifacts, Simon [1] lay the foundations for a new kind of science, explicitly focused on design: the sciences of the artificial. Since then, research and design has been thoroughly entangled with many different perspectives regarding their relationship [2, 3]. Through the concerted effort of scholars providing evidence for the view that design is a valid form of scientific enquiry [4-7], design science research (DSR) has been emerging as a recognized research approach. During this process a key difference between traditional forms of scientific enquiry and DSR has become evident: whereas traditional forms of scientific enquiry are often focused on a specific aspect of a phenomenon (e.g., market transactions) investigated via a specific research method (e.g., qualitative or quantitative research) from the perspective of a specific discipline (e.g., economics), DSR is emerging as a generally boundary spanning and multi-paradigmatic research activity focused on the design of ever more complex artifacts, which shape and are reshaped by associated disciplines [8]. A central question that arises in

this context is *how does DSR deal with this complex entanglement of research areas and activities on a paradigm level?*

To start answering this question, this research-in-progress paper contributes a new perspective on the emerging DSR paradigm. It provides an up to date overview of the theories and opinions associated with DSR as presented in the IS senior scholars' basket. The analysis builds on a keyword search, which identified 196 article records in total. This data set was investigated with an inductive-deductive coding procedure, which lead to the identification of four major clusters representing qualitatively grounded themes in the data. Moreover, to gain deeper insight into the intellectual structure of the research, three clusters were selected for co-citation analysis [9]. The co-citation analysis suggests that the core concept at the center of research about DSR is the design theory. Furthermore, the co-citation analysis also supports the notion that DSR is still an emerging paradigm with research about DSR developing relatively isolated from other research areas and their knowledge bases.

This research makes two main contributions to the DSR knowledge base. First, the literature review provides several insights that may provide a platform for future research. For example, the co-citation analysis suggests that the relationships between research about DSR and other research areas are not yet well defined and may be fruitfully developed by future research. Second, an existing literature review method is refined and appropriated to the DSR paradigm. The resulting approach is useful in that it is conceptually simple, generic and, thus, easily tailorable to a specific context. As such, it can act as a framework for the analysis of the literature review process and support literature reviews that employ novel forms of analysis.

The rest of the paper is structured as follows. First, the general approach of literature review is described in detail. Second, the specific analyses and results are presented. Third, the findings are discussed and evaluated in terms of their contribution to the DSR paradigm. Fourth, a short summary and conclusion are given.

2 Literature Review

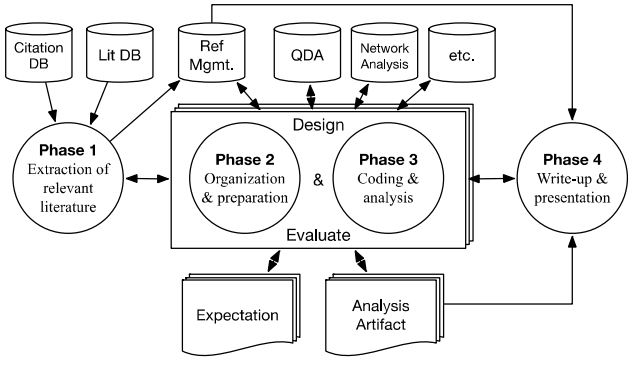


Fig. 1. Adapted tool-support literature review approach. Based on [10]

The literature review followed a version of the four-phase tool-supported literature review approach proposed by Bandara et al. [10] adapted to the DSR paradigm (see Fig. 1). The core idea of the approach is to increase the rigor of the literature review with comprehensive tool support. Tools such as reference managers, qualitative data analysis (QDA), or network analysis tools are used to extend the analyses that can be done based on the literature and associated metadata.

The approach can be summarized as follows. In phase 1, the relevant literature was extracted from the knowledge base. This phase corresponds to a multi-staged search process for journals, databases, and finally literature based on keywords, references or citations [11] utilizing tools such as literature databases or citation analysis tools [10]. Table 1 summarizes the initial keyword search that the rest of the review is based upon. The literature search was supported by LitSonar.com [12] an online tool which can generate appropriate search queries for a variety of literature databases (i.e., it converts a generic search query as shown in Table 1 into queries tailored for selected databases). The exact queries used for the literature search, the resulting data set and other supplementary data can be found at [13].

Based on a search of the IS senior scholar's basket covering the years from 1977-2016, a representative sample of 196 records from high quality research outlets was identified. A reference manager was used to consolidate the literature and associated meta data. Phase 1 was also revisited in a later stage when the Web of Science [14] was used to conduct a forward (a search for articles that reference a given article) and backward search (a search for the references of a given article) for selected articles.

Table 1. Overview of keyword search

Search (title, keywords, abstract)	("design science" OR "design theory" OR "design research" OR DSR OR artifact OR artefact) AND (framework OR theor* OR ontolog* OR paradigm OR concept OR model OR discipline)			
Journal	Coverage	Database	Records	
JAIS	2000-2016	AISeL	53	27%
MISQ	1977-2016	EBSCO BSC	41	21%
JMIS	1984-2016	EBSCO BSC	23	12%
EJIS	1991-2016	ProQuest	21	11%
ISR	1990-2016	EBSCO BSC	18	9%
JIT	1986-2016	ProQuest	17	9%
JSIS	1991-2016	ScienceDirect	11	6%
ISJ	1998-2016	EBSCO BSC	10	5%
		Total	**196**	**100%**

Afterwards, and extending Bandara et al. [10], the literature *processing* was realized in a multi-instance *Design & Evaluate cycle* with two main phases of *organization & preparation* as well as *coding & analysis*. The general goal or outcome of the literature processing are *analysis artifacts* (e.g., a concept matrix as described in [15] or illustrations and data based on co-citation analysis [16]) that are "worth-while" to present to the scientific audience. "Worth-while" in this context relates to the subjective *expectations* of the scholars that are engaged in the processing. Expectations mainly emerge in

the organization & preparation phase and set the boundaries for the coding & analysis of the literature. The processing of the literature may be paused and continued until the expectations of the involved scholars are met (e.g., reviewers might request additional processing).

In general, this literature review aims to *integrate* a *neutral representation* of DSR as a developing paradigm and its associated *central issues* for a *general scientific audience* by covering a *representative* sample of high quality research. Towards this goal, multiple analysis artifacts were constructed as presented in this paper.

3 Analysis and Results

3.1 Initial Classification of Major Themes in the Data Set

In an initial step, an inductive-deductive coding procedure was conducted by the first author utilizing a QDA environment. Inductive open-coding lead to the identification of *goals, kernel theories, research methods, thematic* as well as *theoretical focus* and *perspective* as core concepts that were used as a basis for further selective coding of the articles. This set the foundation for a thematic synthesis [17] which lead to the identification of four major themes (multi-classification possible), sic., *applied DSR*, *about DSR*, *about information system as an artifact,* and *about information systems as a discipline* in the data set. Table 3 details these themes with a coding example and includes a record count to help the reader gauge the prevalence of a given theme within the data set. 58 articles or around 30% of the data set could not be classified as relevant to the research question and were, thus, excluded from further analysis.

Table 2. Overview of identified themes

Theme	Coding example	Records	
Applied DSR	"Using a design science approach [...]" [18]	64	33%
About information system as an artifact	"[...] the nature of trust in technological artifacts is still an under-investigated and not well understood topic. [...] Consumers treat online recommendation agents as 'social actors' and perceive human characteristics (e.g., benevolence and integrity) in computerized agents." [19]	44	22%
About DSR	"Our primary objective is to propose a methodology for theory-driven design. We enhance Walls et al.'s (1992) IS Design Theory by introducing the notion of "applied behavioral theory," as a means of better linking theory and system design." [20]	36	18%
About information systems as a discipline	"We present an alternative set of heuristics that can be used to assess what lies within the domain of IS scholarship." [21]	35	18%
	Total (distinct)	**138**	**70%**

Based on this emersion in and parallel classification of the literature the goal of the review was refined into more specific research question: *how does DSR deal with the complex entanglement of associated research areas and activities on a paradigm level?*

To answer this question, a co-citation analysis of the three (meta-)research clusters was undertaken to gain insight into the intellectual structure of (meta)-research about DSR and how it has interacted with the rest of the research in the IS discipline [9, 16].

3.2 Co-Citation Analysis

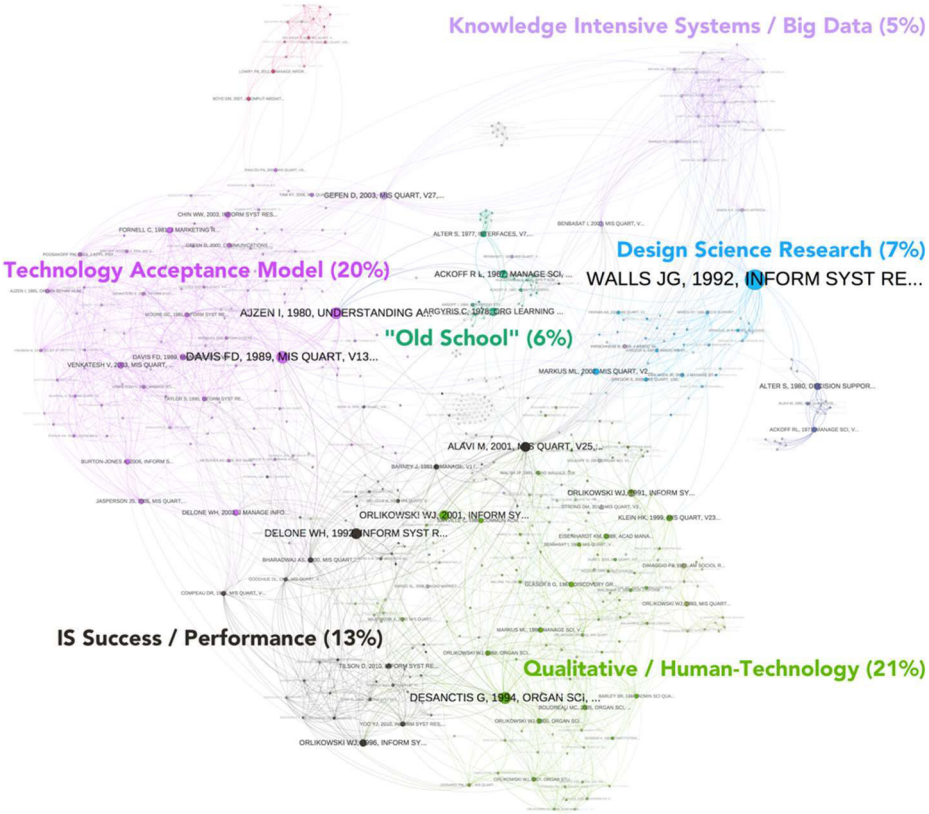


Fig. 2. Co-citation network (nodes: 512; links: 2156; diameter: 9; average path length: 3,741; modularity: 0,709) based on forward and backward searches of the articles in all three selected literature themes (2470 records).

Co-citation is a measure of the frequency with which two papers are cited together in a third paper [9]. Strong co-citation relationships have been argued to be associated with subject similarity or association of ideas and are, therefore, generally useful to identify and evaluate the intellectual structure of scientific literature [9, 16, 22]. In this view, a reference is seen as a symbol for a specific concept - it acts as a concept marker [23] - and if multiple authors cite the same references together, it reflects consensus in the co-usage of concepts [22]. In simpler terms, a co-citation analysis explicates the relationships that the general research community sees between a set of articles.

The goal of this specific co-citation analysis was to get a broad overview of how (meta-)research about DSR has interacted with the rest of the research in the IS discipline. Towards this end, the previously identified themes *about DSR*, *about information system as an artifact,* and *about information systems as a discipline* were selected as the core data set for further analysis. The Web of Science[1] (WoS) was utilized to perform forward and backward searches for every record in the data set.[2] In total 2470 records were identified. The co-citation analysis was conducted using CiteSpace [16] and Gephi [24]. CiteSpace was used for the construction of the co-citation network (configuration: time slicing: 1977-2016 in 1 year intervals; link retaining factor: 2; look back years: unlimited; selection criteria: g-index with k = 10; otherwise standard settings). Gephi was used for visualization and network analysis. As co-citation networks are just unimodal undirected graphs, the standard algorithms for the calculation of betweenness-centrality[3] [25] and community detection [26] were used to facilitate the meaningful visualization and interpretation of the networks.

Fig. 2 shows the co-citation network of the core data set with node size reflecting betweenness-centrality (i.e., more central nodes are larger) and node color community affiliation. Six major communities (each greater than 5% coverage, together about 72% of all nodes) were identified by a community detection algorithm and are annotated in the figure.

4 Discussion

The co-citation network suggests that the core concept at the center of research about DSR is the design theory. Walls et al. [27] seminal paper about design theories acts as the central hub and "point of origin" for the DSR cluster and is also a major hub in the network connecting DSR to other established research areas. As can be seen from Fig. 2, research about DSR seems to be focused on developing this core concept of DSR and has not been co-cited with other research areas in a broad way. This is evidence for the notion that DSR is still an emerging paradigm with research about DSR being relatively isolated from other research areas so far – including the integration of existing knowledge bases from other IS research areas. This view is further supported by the small size of the DSR cluster, which only covers about seven percent of the entire network - even though the underlying data set is biased towards literature about DSR. The co-citation network also allows for a comparison between the clusters DSR and Knowledge-Intensive Systems / Big Data just above it. While both clusters consist of relatively new literature, Knowledge-Intensive Systems / Big Data is connected to several older research areas whereas DSR remains largely isolated. This demonstrates that DSR is indeed seen by the community as a unique and emerging paradigm that is only in the process of being tied to the more established research areas.

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1 http://apps.webofknowledge.com/

2 Six records could not be found in the WoS citation index.

3 A general-purpose measure for the centrality of a node in a network. Defined as the number of shortest paths that pass through a node.

While this is somewhat to be expected as research about DSR is a rather new area, it leads to some interesting considerations regarding the way that the DSR community deals with the complex entanglement with associated research areas and activities. The clear separation indicates that the DSR community seems to pursue a defensive approach to the problem, with meta-research on DSR focused on defending the existence, identity and scientific rigor of DSR and prescriptive knowledge [5, 7, 27-29]. Research focused on integrating DSR with other research approaches has clearly not found its way into the mainstream, yet. This is somewhat surprising, as DSR is generally thought to encompass a diverse set of research activities [30] that resemble those found in established research approaches [4]. For example, *problem identification* is strongly related to qualitative research methods for *observation* (e.g., case studies) and *technology evaluation* is linked to *experimental* research methods. Some researchers even go as far as to argue that any research is always an act of design [31]. Thus, research focused on integrating DSR with established research methods and paradigms seems promising. Interesting research questions that come to mind are, for example: How does DSR relate to qualitative research? How does DSR relate to experimental research? Can DSR inform or support these established research areas? What is the role of DSR for the field? What is the best strategy to establish DSR as a core integrator for the IS field?

Future research should investigate the research question targeted in this paper in more detail. While the presented co-citation analysis allows for a rather unbiased view on the co-usage of concepts by the IS community, it necessarily lags cutting edge research and emphasizes only the most recognized articles. An in-depth analysis and classification of the articles in the core data set is, therefore, already planned.

While not the core focus of this paper, the presented literature review method is also viewed as a useful contribution to the knowledgebase. The existing literature review method by Bandara et al. [10] was refined and appropriated to the DSR paradigm. The resulting approach is useful in that it is conceptually simple, generic, extensible and, thus, easily tailorable to a specific context. It highlights that during a literature review many different types of analysis may be carried out (e.g., co-citation) and emphasizes the important coordinating and organizing role of reference management in this process. As such, it can act as a framework for the analysis of the literature review process and may inspire meta-research targeted at improvement of literature reviews. For example, reference management software vendors may use it to improve the coordination features (e.g., data storage, transformation and export capabilities) of their offerings.

5 Conclusion

This research-in-progress project set out to investigate the research question: *how does a generally multi-paradigmatic and boundary-spanning research areas such as DSR deal with the complex entanglement of associated research areas and activities on a paradigm level?* Towards this goal, a broad keyword search of high quality journals was performed. The resulting data set was qualitatively analyzed and segmented into a core data set of 93 article records. Additional forward and backward searches were then

conducted to augment the data set for a comprehensive co-citation analysis. The presented co-citation analysis affords a grounded view at the intellectual structure of research about DSR and highlights the focus (in mainstream research) on differentiation of DSR against other research methods. This finding provides a valuable contribution for DSR researchers who may want to push the integration of DSR with established research methods (e.g., [32]) and the development of DSR as an integrative methodology for the IS field (e.g., [33]) into the mainstream. The co-citation analysis highlights ample opportunities for future research into the integration of DSR into the IS-field.

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