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Design Principles Exposition: A Framework for Problematizing Knowledge and Practice in DSR

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Abstract. Design principles (DPs) have been recognized as a central contribution in Design Science Research and the research community has begun acknowledging their importance. Much of this work implicitly assumes that design principles are natural components of contributions that can easily be derived by researchers without a need for criteria for their proposal, application or evaluation. In this paper we infer a framework for how to expose the conceptual structure of DPs as both components and sole contributions. We find a danger in assuming that design principles alone are contributions as they are very broadly used to propose utility yet the specific target audience or the explicit use of them as components of design theory occur less frequent. Furthermore, by applying our framework to a set of DPs, we offer four parts of their conceptual structure that can be used to convey the nature of design principle contributions and further identify potential areas for improvement or further research. We derive 8 questions that offer a guiding hand to researchers who attempt to embed DPs as components of their contribution either to research or to practice.

Keywords: Design Principles, Practical knowledge, Technological rules, Design Theory Components

1 Introduction

Allow us to preface the initial sentence of this introduction with a bold and, perhaps provocative, statement: "*The current state of design science research on design principles has a serious utilization problem*". Why? Because the conceptualization of Design Principles (DPs) as a highly attainable DSR contribution is in a weird spot.

15 years ago, van Aken [1] wrote that "*Academic management research has a serious utilization problem*." [1, p. 219] in a call for more prescriptive research to *"open up the incestuous, closed loop of the Academy's conferences*" [1, p. 219]. The main point of the paper was to include prescriptive, research-oriented 'technological rules' to close the researcher-practitioner gap that had kept widening. While we do not dare call the state of DPs in DSR 'incestuous', we see several fundamental issues with how the field has evolved, specifically the continuous publication of "*design principles*" as prescriptive DSR contributions.

Design principles are considered to be an essential and guiding part of design theories [2–4]. The concept of "design principles" was initially proposed as a way to 1) close the gap between researchers and practitioners" and 2) provide more theoretical prescriptive research to the field of management of information systems. Seminal models and methods of DSR position design principles as a prominent set of outcomes [5, 6]. Chandra Kruse et al. [7] characterize DPs as "*knowledge about the creation of other instances of artifacts belonging to the same class*" (p. 39). Design principles should have their value assessed based on both practical and theoretical value, much in line with "principles of form and function", and "principles of implementation" as proposed by Gregor and Jones [8]. Often design principles are framed in a logical order from theoretical and/or empirical grounding but can also be elicited post-hoc from after an instantiation has been built or evaluated [4]. Recently, the area has garnered attention in terms of the meaning and usefulness to practice and guidelines on how to formulate DPs [7, 9], making it difficult to assess their usefulness to either practice or theory based on their current formulation.

The conundrum of where to place and how to propose design principles infer a thorough investigation into the different conceptual structures of design principles. As such, the paper proposes the following research question: *How to expose design principles so that their potential can be revealed on a practical and theoretical level?*

We have structured the paper the following way. First, we present the seminal works that conceptualize design principles or similar and consolidate the differences and commonalities on a conceptual level. Second, we infer a framework that can be used to expose the structure of DPs and apply this framework to a range of recent DSR journal publications that contribute with DPs and expose their underlying structure, origin and implications. We suggest a series of central questions that include the potential for future design-related work based on the DPs. Finally, we discuss the impact of having different knowledge contribution spaces as well as aims and criteria that can indicate how and why design principles can be viewed as both true and effective, as well as the potential for further research on an ontological and epistemological level.

2 The Conceptual Space of Design Principles

The origin of 'design principles' as a concept is somewhat difficult to historically pinpoint. In 'The Sciences of the Artificial', Simon [10] makes little to no mention of such a thing as design principles, and even the works of Hevner et al. [11] also do not mention the concept. Conceptually, *principles* have been defined as being a central part of 'Design Theory' [8] and are both *prescriptive* in nature and considered as new *generalized* or *abstract knowledge* through either *improvement* (applying new design solutions to old problems) or *exaptation* (applying old design knowledge to new problems) [4]. Despite rigorous ontologies for DSR concepts and being epistemologically rooted in *realism* [4, 8], the ontological definitions of DPs have not shared a similar inception.

In the following we present a dissemination of the conceptual space of the seminal works that have proposed structures of the DP concept in one form or another. The seminal works that are drawn on are the results of those papers that have been cited as

DP origins by newer DSR DP papers (identified after the 'selection' phase of the literature review methodology on page 5).

2.1 Different Application Levels

Design principles can be viewed on three different levels of application; technology, domain and formal level. The term is primarily defined as a matter of abstraction, from a concrete product and artefact-focused level (class of artefacts, systems or methods) to more general areas and contexts up to the highest level and spanning various technologies and domains (see **Table 1**).

Formal level: As early as 1966, Bunge [12] proposed prescriptive statements as normative rules that can be derived from laws. On the formal level, laws are defined as overall explanations of world phenomena that science will uncover and rules of conduct or action, utilized in practice are then (often) inferred from these laws. Distinct from laws. Van Aken [1] exemplified this distinction as *organization theory* that consists of describing, understanding and predicting phenomena.

Walls et al. [2] pioneered the notion of *product and process kernel theories* (used as seminal works of the foundation of DSR [8, 11]); various theories used to explain phenomena of the world used to derive and test prescriptive statements.

One example is that of the design features of relational databases [13] that over time has been applied to so many domains and technologies that the principles behind can be argued to be on the formal level. Another example is the Gestalt Principles from Psychology [14], also widely adopted and taught in other domains, including interaction design [15], all of which have been referenced, utilized, applied and evaluated so thoroughly that they can be considered "laws" of organization.

Domain level: On the domain level resides technological rules. These type of rules are directly inferred from laws and tested out in practice to both evaluate their usefulness but also to provide more knowledge about the existing laws from where they were derived [12, 16]. Bunge and van Aken provide the following example of a technological rule: *if wanting to provide outcome X, in context Z, then something like Y can help.*

Van Aken [1] proposes this level as *management theory* that provides prescriptive technological rules to guide practitioners in solving problems that can be applied to *classes* of domains. The level is can be considered similar to that of Walls et al. [2] and Gregor and Jones [8] who identify *meta-requirements* as: "[...] the class of goals to which the theory applies." (Walls et al. [2], p. 43).

Technological level: This level has a concrete focus on a specific, tangible technology or class of technologies to which prescriptive statements are applied. As domain level is not always specific enough, an application instance that can show the result of the application has been denoted a *design exemplar* [1], *expository instantiation* [8, 11] or the *meta-design* [2].

Table 1. Seminal works supporting the different application levels of design principles

		Bunge [16]	**van Aken** [1]	**Walls et al.** [2]	**Gregor and Jones** [8]
Application level	**Formal**	Laws Rules	"Organization theory"	Process and product kernel theories	Justificatory knowledge as kernel theories
	Domain	Technological rules	"Management theory"	Meta-requirements	~
	Technology	~	Design exemplar	Meta-design	Expository instantiation

2.2 Types of Design Principles

We identify DPs into two types; **concrete attribute principles** (CAPs) of a type of design that is needed to attain a certain goal, and **process action principles** (PAPs) that explicates how designers, developers or other actors should perform actions to attain the design or its use (see **Table 2**). The CAPs have been proposed as *algorithms* [1] (specific and concrete specifications that are required), *meta-design* [2] (defined as a generalized artefact that should correspond to the requirements), and principles of form and function [8] (the essence of an artefact; its *causa formalis*).

On the other side are the PAPs, proposed as *heuristics* [1] (qualitative and interpretative), the *design method* [2] (actions needed to attain the finalized design), or as *principles of implementation* [8] (*causa efficiens*; producing or using the material artefact).

Table 2. Seminal works supporting the design principle types

		Bunge [16]	**van Aken** [1]	**Walls et al.** [2]	**Gregor and Jones** [8]
Principle types	**Concrete attributes**	~	Algorithmic	Meta design	Of form and function
	Process actions	~	Heuristics	Design method	Of implementation

2.3 Utility Interest

We also find that DPs have a proposed utility in terms of the final recipient, either as **abstract knowledge** in which researchers would have an interest, or as **practical action** in which practitioners could benefit from applying the principles (see **Table 3**).

Bunge [16] and Van Aken [1] explicitly note that technological rules are used to solve practical problems and hence utilized by either practitioners and managers respectively. Hence, it is not necessary practitioners to know the underlying laws behind the rules as long as they use them effectively. Walls et al. [2] and Gregor and Jones [8] see focus more on components of prescriptive design theory with a stronger focus on the abstract knowledge.

Table 3. Seminal works supporting varieties of utility interest

		Bunge [16]	**van Aken** [1]	**Walls et al.** [2]	**Gregor and Jones** [8]
Utility interest	**Abstract knowledge**	Solution fit to domains, testing laws	Solution fit to domains	Prescriptive design theory	Prescriptive design theory
	Practical action	Practical, general solutions	Practical, managerial solutions	~	~

2.4 Criteria for Evaluation and Aim

The final part of our framework is that of *criteria*, including the **evaluation** of the principles, or at very least the proposed design (which is considered an important activity in DSR [11]) as well as the **aim** of the DPs, defined as the overall motivation. Note the potential overlap between utility interest and aim, though distinguished in terms of the onset (aim) and the end product (utility) (see **Table 4**).

Evaluation: As the technological rules are being utilized by researchers to either learn more of existing laws or about the effectiveness of the rules, Bunge [16] suggests thorough *empirical* testing. Van Aken denotes this *beta testing* [1]. Interestingly enough, neither Walls et al. [2] or Gregor and Jones [8] mention that the components of principles should be tested but rather the whole prescriptive design theory where principles take part should be evaluated through either *testable hypotheses* [2] or *testable propositions* [8] (note the difference in nomenclature as a silent acknowledgment that not all design theories reside in the objective domain where hypotheses are possible).

Aim: Bunge [16] proposes the importance of technological rules being used to test the fit to domains as well as the laws they were derived from. Van Aken [1] acknowledges that technological rules can be motivated by producing *practice-oriented, middle - range theories* through *transferability* between domains. On the other hand, Gregor and Jones [8] both see aim of principles as the components of producing prescriptive design theory (adopted from Walls et al. [2] who do not use the term *principles*).

Table 4. Seminal works supporting criteria of design principles

		Bunge [16]	**van Aken** [1]	**Walls et al.** [2]	**Gregor and Jones** [8]
Criteria	**Evaluating**	Empirical	Beta testing (empirically)	Testable hypotheses	Testable propositions
	Aim	Domain fit	Transferability	~	Design theory components

3 Methodology

In order to fulfil the research purpose of this study and to answer the proposed research question, we performed a literature review of past and present knowledge about design

principles in DSR. Our performed literature review was undertaken through an 'author-centric' approach [17] in order to present a summary of the relevant literature on a topic. Consequently, the review process into three distinct steps: (i) search and identification of literature (e.g. journal articles, conference papers), (ii) selecting relevant literature, and (iii) analyzing the selected literature. We explain each of the steps as follows.

Identification: The first step of the review process emphasized a search and find activity. Here, we performed an initial search via Ebscohost, looking for papers that included design principles as their main contribution. Consequently, we used the concatenated search queries for papers proposing design principles as part of their abstract: 'ab "design principles" AND ("Information Systems" OR "Information Technology")'. The search returned 122 hits and included CAIS, JMIS, MISQ, ISJ, JAIS, ISR, EJIS and JIS. A similar query was made on JIT (journal's own library) and SIS (using Science Direct) with 25 hits and 12 hits respectively, making a total of 159 hits. Finally, we also drew on references from previous papers on design principles [e.g. 6, 8, 16] that already focused on finding design principles papers.

Selection: The second step of the review process focused a selection of 14 papers. We systematically emphasized papers that explicitly focused and mentioned design principles as their main research contribution. As a consequence, we excluded meta-papers, theoretical papers, papers about design guidelines, or papers that used design principles without contributing to design theory, DSR, or evaluation of artifacts.

Analysis: The third and final step of the review process included an analysis of the 13 selected papers. Here, we divided the analysis process between the two authors by coding a number of crucial aspects such as: explicating the design principles of each paper and highlighting how the authors of each paper propose the utility of their design principles (e.g. principles for practice, theory), deriving the abstraction level of the principles (e.g. principles for technology, domain), and more.

Throughout the analysis process, we specifically noted where conflicts of interpretation were present and used the conflicts as areas of problematization for the results. We are thus aware that some may prefer to resolve conflicts, whereas for this specific paper, we addressed conflicts as essential elements of the results. The criteria for each illustration of our framework in the findings were a weighting based on whether the conflicts were unique to each finding or general for several of them.

4 Results

No papers contributed with DPs on the formal level (strange but not entirely surprising), though 3 papers contributed to DPs on both domain level and technology level. 4 papers drew on both CAPs and PAPs, and one of the papers introduced the notion that the two types of DPs were interdependent. 2 papers were found to be potentially utilized by both researchers and practitioners. Of most interest was the concept of criteria as this contained the most papers that fell into more than one category. As a result, we had to distinguish between evaluating through theoretical grounding; 9 papers where DPs

were derived from justificatory theory and discussed through the same, and evaluating through empirical grounding; also 9 papers that derived DPs from practice and/or evaluated them through practice. Another distinction of criteria was the aim. Here, 5 papers were found to have an explicit theoretical aim (contribution of DPs as components of a design theory), and 9 papers were found to have an explicit practical aim (contributing to practical knowledge or middle-range theory). **Table 5** illustrates these findings. In the following sections, we reveal our findings of the analysis through a set of *propositions*.

Table 5. Using the framework to expose the DPs of articles into different streams

		References
Application level	**To domain**	[19–23]
	To technology	[24–29]
	To technology and domain	[30–32]
Principle types	**Concrete attributes**	[20, 21, 24, 26–28]
	Process actions	[19, 22, 23, 25]
	Interdependent	[29–32]
Utility	**To Research knowledge**	[21, 29]
	To Practical action	[19, 20, 22–24, 26–28, 30, 31]
	To Knowledge and action	[25, 32]
Criteria	**Evaluating through grounding**	[20–23, 25–27, 29, 31, 32]
	Evaluating empirically	[20, 24–28, 30–32]
	Theoretical Aim	[25–27, 29, 32]
	Practical Aim	[20–25, 28, 30–32]

4.1 Application level combination as knowledge potential

We found a rough, even split between domain (5 papers) and technology (6 papers) application, while 3 papers focused on both technology and domain. No principles were found to be applied to the formal level (most likely because of the contemporariness of the identified papers, since formal level design principles need to be utilized in many domains and through many technologies). The principles that focused specifically on the technology application levels were written as requirement specifications with close to testable hypothesis connected to it. One paper [28] had so specific requirements of the principles that they could be read almost down to an interaction scenario level:

"DP1: The user interface should provide a mechanism for customizing the vocabulary of terms used by the system in its communication to the user, the composition of business transactions, and the content of the system's informational output to match the practices of the organization." ([28], p. 195)

The detailed nature of the principle above reveals a highly detailed specification of how the artefact should act and what criteria should be evaluated against, and thus implicitly aids any designer or developer in developing the artefact. For example, Hustad and Olsen [19] propose 8 DPs that can be applied to teaching users about systems, in this context enterprise systems. Yet the application domain remains within user teaching as the DPs are so abstract that they could also be tested on other technologies and across domains. The wording of the principles shows how sticking to a single application level, and also abstracting principles, can reveal a high potential in further knowledge potential either across domains or to other specific technologies. Yang et al. [28] who propose 5 design principles for designing an integrated information platform for an emergency response system and hence focus on both applying principles from technology (integrated information platforms) and applying these to the domain of emergency response through both CAPs and PAPs. The principles reveal a large potential for further knowledge creation by further coupling the two application levels: how well can the CAPs integrate into other emergency response domains, and into which other technologies can PAPs be applied to?

4.2 Phrasing of design principles influence the design principle type

While the principle of DPs might seem straightforward, many areas remain unclear. Areas such as the specific phrasing of a principle based on which type of knowledge one wants to convey, the context of the principle as well as the application level. For the papers analyzed, this was represented through a somewhat unclear distinction between CAPs and PAPs (also mentioned previously).

Some principles were clearly CAPs and others were clearly PAPs but other principles could be interpreted in a way that either included or excluded actual actors, or actors acting on a system and somewhat implying a certain functionality. In other cases, such as the one we mentioned in the previous section in regards to [30], we found a huge potential for further inquiry that could lead to even more design principles to be named, somewhat hinting that the list of relevant DPs is still incomplete.

The finding can be condensed into two main areas: (i) the dialectically causal nature between certain kinds of CAPs and PAPs, and (ii) the inclusion of implicit or explicit actors. The first finding implied that certain PAPs had to be performed prior or after other CAPs, or that certain CAPs were a baseline for PAPs to even occur. The second finding implied that to categorize a DP one should look into whether the actor was the artefact or product itself or actions taken by or on human actors. Examples include Gregor et al. [22] who contribute a list of PAPs for finding sweet spot change strategies, yet implicitly focused on actions that some actor needs to or should perform:

"Principle 1: Identify and act on the sweet spot(s) - Undertake a thorough analysis to identify the primary underlying inhibitor(s) for a desired outcome and target the initial intervention activity to address and overcome the primary inhibitor(s)" ([22], p. 664).

The implicitly phrased DPs thus hold a high potential in identifying specific actors that, in finding a challenge in identifying change strategies, could work together or act on the problem.

Another example included the potential to identify further CAPs from PAPs by

Markus et al. [25] who contribute with 5 DPs for designing systems that support emergent knowledge process. DP2 through DP5 are all explained as actions that should lead to specific functionality of the final system. In this sense, designers' actions precede the functionality of the system but in such and open way that the DPs can still not be used as either requirements, use cases or as actual testable propositions.

4.3 Knowledge contribution through instantiation and evaluation

The findings of the papers revealed that it is not always easy to explicitly identify a knowledge contribution of the principles themselves. Many of the papers showed that certain aspects of the principles were not entirely new, though the knowledge contribution came from the unique context that the principles resided in. Classical papers revealed how DPs were identified from literature, applied to an instantiation of an artefact and then evaluated and/or refined, showing the contribution as knowledge to practical application [22, 24, 26–30]. Other papers revealed a more theoretical proposal for DPs [19–21, 25].

For the latter referenced papers, DPs were identified or created based on meta-requirements, and then evaluated or inferred through literature. The following two vignettes illustrate the two mentioned issues further:

Two papers explicitly mentioned an intended *audience* for the DPs [22, 28] and greatly helped identify to *whom* the DPs can be targeted at. Identifying the target audience was not trivial, however, and heavily relied on interpreting the current state of the contribution. For example, Lee et al. [24] present 5 design principles (CAPs) proposed to be fundamental to achieve "Bright Internet", meaning the potential for a more secure and privacy-oriented use of the internet. The principles are derived from other theories across the formal domain of "internet security". The contribution is theoretical but could have the potential to be tested and evaluated through an artifact that supports the proposed "Bright Internet", hence showing evidence for the usefulness in practice and then grounded on the technological application level.

5 Concluding Remarks

In this paper, we contribute to DSR in IS with a framework for design principles that expose where potential and further design knowledge can be uncovered. We extend existing research on the matter by proposing a higher level framework than e.g. Cronholm and Göbel [9] (who primarily focused on structural aspects of the phrasings of DPs) that can be used to identify potential application levels that can be used to further the knowledge contribution and explain how to end up on DPs on a formal level. Similar to Chandra Kruse et al. [7], we also identified similar issues in regards to who the recipient of DPs are. One additional contribution of our framework included the fact that the utility and criteria can sometimes be confused but can be important to distinguish; simply because a DP is meant for practical action does not mean that the aim of the DP in itself is a theoretical one. If a principle is purely evaluated through theory with no instantiation, the DP might still be useful for practice though can certainly have

the potential to add to a theoretical knowledge base. We also have to acknowledge the essentiality of design principles as the factor that spans application domains, either in existing research or future research. It is interesting that design principles that reach the formal level will be easier applicable to practice through formal education (e.g. Gestalt Psychology that can be considered a cookbook within many design-oriented fields) than more nascently oriented DPs that still cling to their specificity of either domain or technology application level.

Our results also include criticism toward the content of principles as being a valid form of DSR contributions. However, our work delineates from establishing a heavy-handed criticism and instead withholds a central trademark of science and research in general, namely to question the current state of what the concept of design principles really means for making a theoretical and practical contribution to DSR. Through the development of the framework, we can identify a certain theoretical fuzziness initially that should be solved as theoretical problem areas.

For example, if one ontologically assumes that 'principles' as a term, is more abstract and spans different technologies or domains than for instance, 'guidelines', which implicitly infers a choice (e.g. a guideline is only valid after testing it to reality), then the implications for evaluating principles would be that principles should be evaluated 'upwards' (e.g. towards a universal claim or high-level theory), whereas a specific instantiation of guidelines should be evaluated 'downwards' (e.g. toward a practice by testing the guideline). In light of such line of argumentation, together with our findings, it can be necessary to suggest the following distinction: the target audience of design principles are first and foremost academics and researchers as the level of abstraction and general utility is oriented towards a higher type of contribution (e.g. design theory), whereas the target audience of design guidelines are first and foremost practitioners because practitioners follow guidelines that other practitioners create and propose based on a cumulative process of utility and evaluation of in situ artifacts that are created by professional designers and developers, not researchers.

The above is only one example of fleshing out entangled views on the concept of design principles, whereas in reality, we could problematize other aspects that concern the differentiation between principles and 'laws', 'procedures', and/or 'rules'. Finally, we argue that the DSR community would benefit from critical inquiries that questions the distinction between such interrelated concepts and differentiates their meaning by encompassing how they differ, what role or function do they have in a larger DSR project, and why principles are usually accepted as great outputs of rigorous DSR projects. Hence, we identify a need for further research on DPs and how they can be derived in the DSR process. As a help, we also propose that researchers should consider carefully the following questions when DPs are derived from the research process:

- ***Q1:*** *Which design principles have been used from other application levels?*
- ***Q2:*** *To which application level are the set of design principles applied?*
- ***Q3:*** *Wherein lies the potential if the set of design principles are applied to another application level?*
- ***Q4:*** *Assuming the principles belong to a single type; what would the complementary corresponding CAP or PAP be for each design principle proposed?*

- ***Q5:*** *Which actors will specifically have to perform the corresponding PAPs?*
- ***Q6****: How can design principles that are derived purely from theory be concretely instantiated into an artifact (e.g. with attributes or actions proposed by the principles)?*
- ***Q7****:How can design principles derived from an instantiated artefact be validated (e.g. to solve a similar specific or class of problems) by a 3rd party?*
- ***Q8****: How unique are the principles in isolation and how unique is the total set of principles?*

We also consider the formulated questions above as questions for further discussion and research, which could contribute to a genre theory as a possible solution area. As a genre, loosely structured design principle contributions could find both an ontological and epistemological linkage that assist practitioners and academics in producing and consuming DSR publications.

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