“Designing” Design Science Research – A Taxonomy for Supporting Study Design Decisions

Hanlie Smuts[1[0000-0002-3142-0468]], Robert Winter[2[0000-0001-9383-2276]], Aurona Gerber [1,3[0000-0003-1743-8167]] and Alta van der Merwe[1[0000-0002-3652-7512]]

[1] Department of Informatics, University of Pretoria, Hatfield, Pretoria, South Africa
[2] Institute of Information Management, University of St. Gallen, Switzerland
[3] CAIR, Centre for AI Research, Pretoria, South Africa
hanlie.smuts@up.ac.za

Abstract. The Design Science Research (DSR) paradigm is highly relevant to the Information Systems (IS) discipline because DSR aims to improve the state of practice and contribute design knowledge through the systematic construction of useful artefacts. Since study designs can be understood as useful artefacts, DSR can also contribute to improving conceptualizing a research project. This study developed a taxonomy with relevant dimensions and characteristics for DSR research. Such a taxonomy is useful for analyzing existing DSR study designs and successful DSR study design patterns. In addition, the taxonomy is valuable for identifying DSR study design principles (dependencies among characteristics) and subsequently for systematically designing DSR studies. We constructed the DSR study taxonomy through a classification process following the taxonomy development approach of Nickerson et. al.

Keywords: DSR, Design Science Research, DSR Study Taxonomy, Research Study Design

1 Introduction

Even though the Design Science Research (DSR) paradigm is still relatively young within Information Systems (IS), it is highly relevant to the Information Systems (IS) discipline [1]. For the last two decades there has been an interest to establish DSR within IS as a way of creating different forms of knowledge and improve the state of practice through the systematic construction of useful artefacts. In this way DSR aims to contribute to both theory-building and having value for practitioners [2]. Peffers et al. [3] emphasized that DSR scholars often find themselves confronted with an excess of advice, options, and different expectations and opinions on how to execute a DSR study.

It is a challenge for any researcher to understand the different options available during the design of a research project, especially for those researchers that are involved in supervision and the design of postgraduate studies. In descriptive IS research the study design usually follows guidelines of authors such as Orlikowski & Baroudi [4] to assist with choosing between study design alternatives. For example, a researcher might decide to do an empirical research study with qualitative data, the research strategy would typically be case study research with the data collection being done using interviews. Several choices among different alternatives must be made by researchers during the design of any research study.

DSR research studies are no exception, and there are several choices that a scholar is confronted with when designing a DSR study. However, there is a lack of published guidelines with regards to all the alternatives that the researcher could consider. Existing guidelines often only identify a set of important design characteristics (e.g. the DSR grid [5]) or suggest very general principles (e.g. consider a DSR project as a generic staged process, or choose among a small number of very generic artifact types). While some suggestions provide a basis for certain combination alternatives (e.g. Engel et al. [6]), they do only present a few or very basic choices.

To assist with choosing between alternatives, we constructed a taxonomy that organizes the alternatives for the study design of DSR into dimensions with characteristics. This taxonomy can be used to design or analyze DSR studies, and even identify design patterns (such as dominant combinations of certain characteristics in different dimensions). The taxonomy may also be used as a basis to ultimately propose design principles for DSR studies. These patterns and principles would be useful for designing a feasible DSR research study, i.e. for avoiding incoherent choices and for choosing a study design that matches certain research objectives or a certain research context. This research therefore seeks to answer the following research question: What are the dimensions and characteristics of a taxonomy that a researcher should consider in order to design DSR studies and identify DSR study design patterns? To answer the research question, we did a review of the literature focusing on DSR studies and used Nickerson et al.'s classification method for developing a taxonomy [7].

In this paper we first introduce DSR briefly in section 2 followed by a summary of Nickerson's method in section 3. Section 4 provides an overview of the research method followed by our taxonomy construction, while section 5 presents the resulting taxonomy. We conclude the paper in section 6.

2 Design Science research

Simon's Sciences of the Artificial [8] is widely accepted as the fundamental basis for DSR. Although there were many publications related to the value of the design of artefacts in the 90s and design-oriented research was well established in some research communities [9], the MISQ publication by Hevner et al. [10] had a big impact on legitimizing DSR as a research approach within the global Information Systems (IS) research community. Based on earlier work such as Nunamaker et al. [11], Walls et al. [12] and March and Smith [13], Hevner et al. [10] provided a conceptual framework for understanding, executing, and evaluating IS DSR research that emphasized the value of relevance and rigor during the design cycle. More or less in the same timeframe, Vaishnavi & Keuchler [14] started a web site focusing on DSR in IS. According to them, "DSR uses a set of synthetic and analytical techniques and perspectives for performing research in IS". They define "DSR as being involved in the creation of new knowledge, firstly through the development of artefacts and secondly through the study of the use of the artefact afterwards".

Within literature several studies concerned with the execution of DSR exist. The framework for understanding, executing and evaluating DSR provided by Hevner et al. [10] does not elaborate on the phases for executing a DSR project, but distinguishes between development and evaluation as two distinct phases. Vaishnavi et. al. [14] provide a DSR process model for DSR project execution that is based on work from Takeda et. al. [15]. Perhaps the mostly referenced approach is the DSR process model published by Peffers et. al. [16] that consolidates various process model proposals. For the evaluation of the artefact, the pioneers working in this field were Pries-Heje, Baskerville & Venable [17], who published a number of articles building up to a framework for evaluation in design science (FEDS) [17]. FEDS is intended to assist DSR researchers in better understanding evaluation options in DSR, suggesting evaluation as a sequence of episodes rather than a design afterthought, but does not provide (yet) concrete guidance how to design study-specific "evaluation journeys".

Van der Merwe et. al. [18] presented a set of guidelines for conducting DSR in IS [18]. The six guidelines included the contextualization of DSR in the IS field, as well as understanding the philosophical underpinning of research and the discourse on the nature of DSR. Other guidelines included the consideration of the role of the artefact in DSR, the selection of an appropriate DSR method for execution of the research study and ultimately strategizing on how research done in DSR should be communicated in a report [18].

Any scholar that needs to design a DSR study is therefore confronted with several perspectives and choices. The alternatives and subsequent consequences are however not always apparent [19]. In descriptive IS research, a researcher usually reflects on the philosophical underpinning of the research, the research strategy, data collection and data analysis. Several publications that guide the design of a descriptive research study exist, for example, the work by Saunders et al. [20] where they prescribe the research design to include the philosophy, approach, strategy, choices, time horizon and techniques and procedures (data collection and data analysis). However, guidance for designing descriptive IS research is only partially, if at all, applicable to DSR. Fundamental conceptual differences include the relevance and rigor cycles, the necessity of artefact construction, research contributions that include design knowledge, established evaluation practices etc. To address this lack of guidance in the design of DSR studies, this paper reports on a project that developed a taxonomy of DSR studies. The taxonomy with its dimensions and characteristics could be used to understand which alternatives are available as well as their implications when designing a DSR study.

3 Taxonomy Development Approach

Nickerson et al. studied classification in IS [4] and as main contribution of their work, they defined a taxonomy, as well as proposed a classification method for a taxonomy [4]. They formally define a taxonomy T as a set of n dimensions Di (i=1,…, n), each consisting of ki (ki≥2) mutually exclusive and collectively exhaustive characteristics Cij (j=1,…,ki) such that each object under consideration has one and only one Cij for each Di, or T= {Di, i=1,…,n | Di={Cij, j=1,…,ki; ki≥2}}. They specified additional characteristics of taxonomies that need to be adhered to, including that taxonomies should be mutually exclusive (no object can have two different characteristics in a dimension) and collectively exhaustive (each object must have one of the characteristics in a dimension). Together these conditions imply that each object has exactly one of the characteristics in a dimension.

The classification approach of Nickerson et al. [7] is iterative and commences with determining the meta-characteristics and the ending conditions of the taxonomy. The meta-characteristics should be determined by the overall purpose of the taxonomy, while the ending conditions are both objective and subjective. For the purpose of this paper we summarize the ending conditions in Table 1.

Table 1. Ending conditions for taxonomy development [7]

	Condition	Description
Objective	Comprehensive object sampling and identification	A representative sample of objects has been examined, and no object was merged or split in the last iteration of the taxonomy development approach.
Objective	Completion: taxonomy dimensions with characteristics.	No new dimensions or characteristics were added in the last iteration of the taxonomy development approach, and no dimensions or characteristics were merged or split. Furthermore, at least one object is classified under every characteristic of every dimension (no 'null' characteristics).
Objective	Uniqueness: Dimension, Characteristic and Cell	Every dimension is unique and not repeated, and every characteristic is unique within its dimension (i.e., there is no dimension duplication). Each cell (combination of characteristics) is unique and is not repeated (i.e., there is no cell duplication). (This condition follows from mutual exclusivity of characteristics)
Subjective	Conciseness	The number of dimensions allow the taxonomy to be meaningful without being unwieldy or overwhelming.
Subjective	Robustness	The dimensions and characteristics provide for differentiation among objects and allow for a description of sample objects.
Subjective	Comprehensiveness	All objects under consideration can be classified.
Subjective	Extendible	A new dimension or a new characteristic of an existing dimension can be easily added.
Subjective	Explanatory	The dimensions and characteristics can explain aspects of an object.

After the execution of the first two steps, a choice must be made on whether the iteration is empirical-to-conceptual (bottom-up) or conceptual-to-empirical (top-down). In a bottom-up iteration, the researcher identifies a subset of objects that should be classified, and from an investigation of the objects, characteristics are identified. These characteristics are then refined into the taxonomy dimensions. In a top-down iteration, the dimensions of the taxonomy are conceptualized in a deductive and often intuitive way that is based on the researcher's knowledge. These dimensions are then refined by adding characteristics that allow for the classification of objects. For the development of a taxonomy, both types of iterations may be adopted, for instance, the first iteration might be conceptual-to-empirical, and a next iteration that refines the taxonomy could be empirical-to-conceptual. The iterations are performed until the specified ending conditions as specified in Table 1 are met.

4 Research Method

The aim of this study is to develop a taxonomy of DSR studies with its associated dimensions and characteristics. While every single study would represent a distinct instantiation of that taxonomy, a set of studies would allow to identify patterns, i.e. recurring instantiations that constitute frequently chosen study designs [21]. If the dependencies between specific choices within the taxonomy are well understood, such patterns could be the basis for formulating study design principles. For example, the recurring combination of a certain evaluation technique choice with a certain artefact type choice could indicate that, for that artefact type, a particular evaluation technique is recommended.

To develop the taxonomy we collected relevant articles using a keyword search with different combinations of the terms "design-oriented research" and "information system" and ("practical" or "applied"). The keyword search was executed in common databases such as SpringerLink, ACM, AIS, EBSCO Host and Google Scholar. We selected 461 peer-reviewed journal and conference papers. Secondly, we screened the identified set of papers and extracted 72 papers that used DSR as a research method and that provide data necessary for the taxonomy. We excluded non-English papers, duplicates, and papers that did not contribute any DSR study design considerations. We concluded a detailed screening of abstracts and analysis of the full text of the prospective papers and created a dataset (Appendix 1 [22]) that was utilized for the systematic development of a taxonomy of DSR dimensions and characteristics based on Nickerson et al.'s [7] method. The taxonomy development process [23, 24] was executed through several steps as described in section 3. Firstly, we defined the meta-characteristics as the dimensions of design-oriented research with the assumption that all dimensions must describe the structural differences of design-oriented research. We adopted Hevner and Chatterjee's [19] fundamental dimensions of design-orientated research i.e. contribution, artefact type, and type of validation and framed our meta-characteristic within it. We proceeded through 4 iterations until all the extracted papers in our dataset were classified and the ending conditions were fulfilled as specified by Nickerson et. al. [7].

In terms of the iterations, we initially adopted a conceptual-to-empirical iteration and integrated taxonomy dimensions identified in the literature review. During this iteration, we added one dimension scientific contribution [10]. The second, third and fourth iterations were empirical-to-conceptual and led to the classification of all the extracted papers in our dataset guided by the set of guidelines for conducting DSR in IS (refer Section 2) [18]. In these iterations, additional dimensions were identified namely construction mode [25, 26], procedure [27], data collection technique [28, 29] and evaluation technique [30].

Lastly, we performed a thematic analysis for each dimension from the taxonomy to identify, analyze and report patterns or characteristics within the data [31]. The purpose of a thematic analysis is to interpret and make sense of data in order to identify patterns or themes, emphasizing both organization and rich description of the data set and theoretically inform interpretation of meaning [32, 33]. Towards this purpose we followed an iterative approach identifying patterns of themes until all characteristics in a particular taxonomy dimension were classified (Appendix 2 [22]).

5 Results: Taxonomy for Design Science Research Studies

The taxonomy resulting from analyzing 72 DSR studies is shown in Figure 1. It consists of seven dimensions, each with two to seven distinct characteristics.

In the context of IS research, the purpose of DSR is to study and find innovative solutions to problems and phenomena relevant to the domain. The aim of DSR studies is to inspect what is known and not known about the problem and solution set in order to find answers [19].

Dimensions	Characteristics						
Artefact Type	Construct	Model	Method	Instantiation	Design Theory		
Construction Mode	Build and evaluate	Theory-led construction					
Validation / Evaluation approach	Parallel with design	Only at the end					
Procedure	Specialize general solutions	Generalize specific solutions	Combine existing solution components in a novel way				
Contribution	Improvement	Invention	Exaptation	Routine design			
Data collection techniques	Scientific procedure	Observation	Facilitated discussion	Survey	Secondary sources		
Validation / valuation techniques	Experiment	Simulation	Prototype	Active participation	Formal proof	Case study	Empirical validation

Fig. 1. DSR Design Decision Taxonomy

An outcome of DSR is an artefact that solves a domain problem which must be assessed against criteria of value or utility. The artefact type dimension of the taxonomy considers: what artefact type will be the outcome of the DSR research study? DSR artefact outputs are concerned both with utility [13] and theory [34]. For the artefact type dimension we adopted the existing topologies defined by March and Smith [13]. However, the existing classification of artefact types is quite coarse, and characteristics are not well-defined yet e.g. what type of model, design theory or design principle, characteristics overlap i.e. a model is an instance of a meta model, etc.

IS construction is the process of creating meaningful, working software-reliant work systems through a combination of design, validation and testing [35]. The question that the construction mode dimension of the taxonomy addresses is: what drives design-evaluate iterations? The main driver may either be the (theory-agnostic) search for sufficiently useful designs based on solution creation, solution evaluation and backtracking

[8] - or the translation of descriptive knowledge and design theories into solution candidates and their subsequent iterative modification until a satisfactory solution is found [36].

Evaluation is the process of determining how well the designed artefact performs and the execution must be rigorously demonstrated via well-executed evaluation methods. The validation/evaluation approach dimension of the taxonomy aims to address the following question: when, during the DSR process, will the artefact be validated and/or evaluated? Due to the impact of evaluations on designer thinking, evaluation may be conducted parallel with design and thus inform design ("formative" or "concurrent" evaluation [37]). Evaluation may also only be conducted as an ex-post assessment of the value of the artefact ("summative" evaluation [38]).

The procedure dimension of the DSR taxonomy refers to the way the research outcomes were accomplished by following a series of ordered steps. These steps are typically concerned with answering the question: what specific steps guide the DSR process towards deriving a solution? A set of known, general solutions to the particular research problem may be considered as a starting point to derive a specific solution for the phenomenon under study. When the procedure of generalization of a specific solution is followed, the DSR study draws broad inferences from particular observations and applies them to the phenomenon under study. Alternatively, existing solutions may be applied in a novel manner to the phenomenon under study based on the characteristics and demands of the problem or the optimization the DSR study is attempting to deliver.

In DSR, knowledge is developed that enable the design of solutions for a particular problem domain. The contribution dimension intends to address the question: how does the DSR artefact contribute to the body of knowledge? The focus of DSR with an improvement contribution is to create better solutions by way of more efficient and effective products, processes, services, technologies, or ideas [39]. Invention points to radical breakthrough and entails research in new applications where little current understanding of the problem context exists and where no effective artefacts are available as solutions. DSR with an exaptation aim applies effective artefacts in a related problem area research situation to a field where effective artefacts are not available or are suboptimal. Design knowledge that already exists in one field is extended or refined so that it can be used in some new application area. Routine design ensues when existing knowledge for the problem area is well understood and when existing artefacts are used to address the opportunity or question – a characteristic that should usually not apply to design research [40].

Data-collection techniques allow us to systematically collect information about objects of study and about the settings in which they occur. The data collection technique dimension addresses the question: how will data be collected for the DSR study? Specific characteristics were classified in this instance namely scientific procedure, observation, facilitated discussion, survey and secondary sources. Scientific procedure uses the manipulation and controlled testing to understand causal processes e.g. an experiment in a lab, while observation refers to a technique involves systematically selecting, watching and recording behavior and characteristics of objects or phenomena. Facilitated discussion collects target audience opinions and attitudes about certain products, services or phenomena such as focus group discussion, and structured- and semi-structured interviews. The survey characteristic describes the opinion collection from a large population and includes hand-delivering questionnaires to respondents or using a web-based application to collect respondent opinion. Secondary sources refer to data that is collected by someone other than the user such as organizational records and data, manuals, and product specifications. Our characteristic classification set in this instance was based on the analysis of the papers extracted for the purpose of this study. It must be noted that, as many research studies use more than one of these techniques, a more comprehensive characteristics-set of data collection techniques will also include behavioral science data collection techniques such as one-on-one cognitive testing, debriefings, expert reviews, behavior coding, etc. [41, 42].

Evaluation in DSR is concerned with the evaluation of DSR outputs, such as theory and artefacts, and the validation / evaluation technique dimension answers the question: how (and not when) will the DSR artefact be evaluated/validated? In our classification we identified particular characteristics namely experiment (e.g. laboratory or field experiment), simulation (imitation of a situation or process e.g. computer simulation), prototype (preliminary version of application), active participation (e.g. action research), formal proof (using known facts and deduction rules of logic to reach conclusions), case study (investigates phenomenon within its real-life context), and empirical validation (e.g. statistical analysis) [38]. Similar to the data collection characteristic, many research studies use multiple data analysis techniques. Prat et. al. [43] developed a taxonomy of evaluation methods for IS artefacts. They identified seven typical evaluation patterns of which experiment, simulation, empirical validation and formal proof were also identified in this study. In addition, they reported additional patterns such as demonstration, practice-based evaluation of usefulness (in this study we defined it as case study), laboratory, and algorithmic complexity analysis.

6 Using the proposed taxonomy to identify patterns of DSR studies

The aim of this study was to develop a taxonomy of DSR studies with its associated dimensions and characteristics. The taxonomy could be used to design and analyze DSR projects, and subsequently identify DSR research patterns. Figure 2 shows how two exemplary DSR studies can be interpreted as “instantiations” of the general study design implied by the proposed taxonomy.

6.1 Example studies

Example 1 (the solid line in Fig. 2) presents new organizational and technological options of process management and illustrated the concept by a prototype platform for process management and real-world application scenarios in the construction industry [26]. The paper finally presents an evaluation of the design-oriented research approach.

The authors highlighted that the dynamic nature of an organization is observable based on the dynamics of corporate systems and the impact of new conditions on process management. They identified the applicability of Web 2.0 applications such as wikis, social networks, social bookmarks, RSS feeds etc., a key feature as it enables high speed reaction to events and spontaneously support actions adequately to ensure their success. However, Web 2.0 applications have primarily been designed for private and not for business users. Therefore, the problem that they wanted to resolve with their research was to establish whether the design principles of Web 2.0 can be efficiently deployed in the business environment, particularly for the control of dynamics in process management. In terms of the artefact type, they created a real instance to develop a clear picture of actual deficits and to define possible options for action. Their chosen construction mode was therefore to "build and evaluate". Evaluation was done at the end of the project after they concluded steps such as exploration, participation, iteration and evolution. They produced a prototype-oriented system development with the intention to improve process design and execution. Upon conclusion of their DSR process, the authors identified essential and encouraging options for process management organization and for the development of new tools for process management.

In example 2 (the dotted line in Fig. 2), the paper describes the design process toward a functional reference model for business rules management for practitioners evaluating software solutions [44]. From a scientific perspective, the model represents a theory for designing and developing information systems with the objective of managing business rules. The model was evaluated in a company (real-world scenario) by using a survey. At the end of their DSR process, the authors established that the functional reference model for business rule management was beneficial regarding the advancement of the state of the art both in practice and in science.

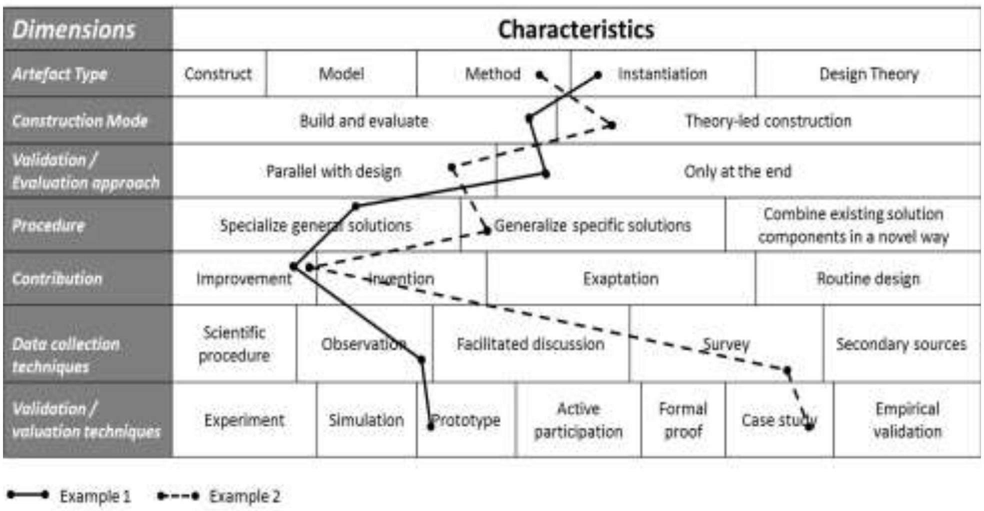

Fig. 2. Exemplary DSR studies as "instantiations" of the proposed taxonomy

6.2 DSR Research Patterns

The two studies shown in Figure 2 illustrate how the taxonomy may support identifying DSR research patterns in future research. If a large number of studies can be "classified" we expect that statistical analysis would yield clusters of dominant "paths" across the taxonomy, i.e. typical forms how study design decisions across different dimensions are linked in published studies. We assume that certain "paths" are dominant, and that not all combinations of characteristics may be observed, because not every characteristic can be combined with every other characteristic. For example, it apparently makes not much sense to use simulation as an evaluation technique for constructs. The consideration of research patterns references similar studies such as Houy, Fettke [21] aiming to identify "compositional styles" or "stylized facts" for a large set of study designs.

7 Conclusion

The DSR paradigm in IS is fundamentally a problem-solving paradigm and aims to provide solutions to important and relevant business problems. Research design decisions span the choices from broad assumptions to detailed methods of data collection and analysis. In this study we classified the dimensions and characteristics of DSR studies and presented a DSR taxonomy. The DSR taxonomy was developed through the application of Nickerson et. al's taxonomy development method [7]. The DSR taxonomy consists of seven dimensions, each with two to seven distinct characteristics. The DSR taxonomy should guide researchers with DSR choices when designing a DSR study by presenting available options. As a limitation, we acknowledge that researcher bias may be present in the dimensions and characteristics of the taxonomy, however, most classification artifacts include some form of bias, which is mediated by establishing consensus. Future research will aim to establish consensus in the IS DSR community for the taxonomy.

Future research will also aim to identify possible DSR research patterns (or "dominant study designs") using the taxonomy that could constitute a foundation to derive design principle candidates. In the domain of research study design, design principles would link research objectives (i.e., design requirements for research studies) to research features (i.e., characteristics of research study designs) on a generic level [45] and thus provide useful guidance for designing concrete and feasible DSR studies. Ultimately, the nature of DSR for IS research and IS practice may be considered in future research, as DSR in essence supports IS practice through the development of relevant and useful artifacts.

References

1. Goldkuhl, G., *Design Research in Search for a Paradigm: Pragmatism Is the Answer*, in *Practical Aspects of Design Science*, M. Helfert and B. Donnellan, Editors. 2012, Springer Berlin Heidelberg. p. 84–95.
2. Baskerville, R., et al., *Design Science Research Contributions: Finding a Balance between Artifact and Theory*. Journal of the Association for Information Systems, 2018. **19**(5): p. 358–376.

3. Peffers, K., T. Tuunanen, and B. Niehaves, *Design science research genres: introduction to the special issue on exemplars and criteria for applicable de-sign science research* European Journal of Information Systems, 2018. **27**(2): p. 129–139.
4. Olikowski, W. and J. Baroudi, *Studying Information Technology in Organizations : Research Approaches and Assumptions.* Information Systems Research, 1991. **2**(1): p. 1–28.
5. Vom Brocke, J. and A. Maedche, *The DSR grid: six core dimensions for effectively planning and communicating design science research projects.* Electron Markets, 2019. **29**: p. 379–385.
6. Engel, C., N. Leicht, and P. Ebel. *The Imprint of Design Science in Information Systems Research: An Empirical Analysis of the AIS Senior Scholar's Basket.* in *International Conference on Information Systems (ICIS)*. 2019. Munich, Germany.
7. Nickerson, R., U. Varshney, and J. Muntermann, *A method for taxonomy development and its application in IS.* European Journal of Information Systems, 2013. **22**: p. 336–359.
8. Simon, H.A., *The Sciences of the Artificial*. 1st Edition ed. 1969, Cambridge, MA: MIT Press.
9. Winter, R., *Design science research in Europe.* European Journal of Information Systems, 2008. **17**(5): p. 470–475.
10. Hevner, A., et al., *Design Science in Information Systems Research.* MIS Quarterly, 2004. **28**(1): p. 75-105.
11. Nunamaker, J., M. Chen, and T. Purdin, *Systems Development in Information Systems Research.* Journal of Management Information Systems, 1991. **7**(3): p. 89-106.
12. Walls, J.G., G.R. Widmeyer, and O.A. Sawy, *Building an Information System Design Theory for Vigilant EIS.* Journal Information Systems Research, 1992. **3**(1): p. 36-59
13. March, S.T. and G.F. Smith, *Design and natural science research on information technology.* Decision Support Systems, 1995. **15**: p. 251-266.
14. Vaishnavi, V. and B. Kuechler *Design Research in Information Systems. DSR in IS, [Online]. Available: http://desrist.org/design-research-in-information-systems/.* 2004.
15. Takeda, H., et al., *Modeling Design Processes.* AI Mag, 1990. **11**(4): p. 12.
16. Peffers, K., et al., *The Design Science Research Process: A Model for Producing and Presenting Information Systems Research*, in *DESRIST 2006* 2006: Claremont, CA.
17. Pries-Heje, J., R. Baskerville, and J. Venable. *Strategies for Design Science Research Evaluation*. in *16th European Conference on Information Systems (ECIS)*. 2008. Galway, Ireland.
18. Van der Merwe, A., A. Gerber, and H. Smuts, *Guidelines for Conducting Design Science Research in Information Systems*, in *Communications in Computer and Information Science: ICT Education*, B. Tait, J. Kroeze, and S. Gruner, Editors. 2020, Springer: Cham. p. 163-178.
19. Hevner, A. and S. Chatterjee, *Design Science Research in Information Systems*. Design Research in Information Systems. 2010: Springer Science+Business Media.
20. Saunders, M.N.K., P. Lewis, and A. Thornhill, *Research methods for business students*. 5th edition ed. 2009, New York: Prentice Hall.
21. Houy, C., P. Fettke, and P. Loos, *Stylized Facts as an Instrument for Literature Review and Cumulative Information Systems Research.* Communications of the Association for Information Systems, 2015. **37**.
22. Appendices. *https://www.researchgate.net/publication/358316570_Appendix_1_-Dataset_created_from_papers_identified_extract*. 2021.
23. Remane, G., et al., *The Business Model Pattern Database: A tool for systematic business model innovation.* International Journal of Innovation Management, 2017. **21**(1): p. 1-61.
24. Nakatsu, R.T., E.B. Grossman, and C.L. Iacovou, *A taxonomy of crowdsourcing based on task complexity.* Journal of Information Science, 2014. **40**(6): p. 823–834.
25. Mettler, T. and P. Rohner *Situational maturity models as instrumental artifacts for organizational design*. in *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology*. 2009.

26. Vanderhaeghen, D., P. Fettke, and P. Loos, *Organizational and Technological Options for Business Process Management from the Perspective of Web 2.0*, in *Business & Information Systems Engineering*. 2010, Springer: Cham. p. 15-28.
27. Kiesow, A., et al. *Managing Internal Control: Designing a Wiki based Information System for Continuous Process Assurance*. in *Thirty Sixth International Conference on Information Systems*. 2015. Fort Worth.
28. Österle, H. and B. Otto, *A Method for Researcher-Practitioner Collaboration in Design-Oriented IS Research.* Business & Information Systems Engineering, 2010. **5**(2010): p. 283-293.
29. Heger, O. *Value Sensitive Design in Design Science Research Projects: The Cases of Affective Technology and Healthcare Technology*. in *14th International Conference on Wirtschaftsinformatik*. 2009. Siegen, Germany.
30. Vogel, J., et al. *Design and Development of a Process Modelling Environment for Business Process Utilization within Smart Glasses*. in *9th International Workshop on Enterprise Modeling and Information Systems Architectures*. 2018. Rostock.
31. Vaismoradi, M., H. Turunen, and T. Bondas, *Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study.* Nursing & Health Sciences, 2013. **15**(3): p. 398-405.
32. Alhojailan, M.I., *Thematic Analysis: A Critical Review of its Process and Evaluation.* West East Journal of Social Sciences, 2012. **1**(1): p. 39-47.
33. Leedy, P.D. and J.E. Ormrod, *Practical Research: Planning and Design*. 12th Edition ed. 2018: Pearson.
34. Gregor, S. and D. Jones, *The Anatomy of a Design Theory.* Journal of the Association for Information Systems, 2007. **8**(5): p. 312-335.
35. Bollinger, T., Gabrini, P, and L. Martin, *Software Construction*. 2002, IEEE. p. 4-1 - 4-15.
36. Gregor, S., *Design Theory in Information Systems.* Australasian Journal of Information Systems, 2002. **Special Issue**(2002): p. 14-22.
37. Sonnenberg, C. and J. vom Brocke, *Evaluations in the Science of the Artificial – Reconsidering the Build-Evaluate Pattern in Design Science Research*, in *Design Science Research in Information Systems. Advances in Theory and Practice*, K. Peffers, M. Rothenberger, and B. Kuechler, Editors. 2012, Springer: Berlin, Heidelberg. p. 381-397.
38. Venable, J., J. Pries-Heje, and R. Baskerville, *FEDS: a Framework for Evaluation in Design Science Research.* European Journal of Information Systems, 2016. **25**: p. 77–89.
39. Vom Brocke, J., et al., *Special Issue Editorial – Accumulation and Evolution of Design Knowledge in Design Science Research: A Journey Through Time and Space.* Journal of the Association for Information Systems, 2020. **21**(3): p. 520-544.
40. Gregor, S. and A. Hevner, *Positioning and Presenting Design Science Research for Maximum Impact.* MIS Quarterly, 2013. **37**(2): p. 337-355.
41. Onwuegbuzie, A.J. and N.L. Leech *On Becoming a Pragmatic Researcher: The Importance of Combining Quantitative and Qualitative Research Methodologies.* International Journal of Social Research Methodology, 2005. **8**(5): p. 375-387.
42. Isaac, S. and W.B. Michael, *Handbook in research and evaluation: A collection of principles, methods, and strategies useful in the planning, design, and evaluation of studies in education and the behavioral sciences*. 3rd ed. 1995: EdITS Publishers.
43. Prat, N., I. Comyn-Wattiau, and J. Akoka, *A Taxonomy of Evaluation Methods for Information Systems Artifacts.* Journal of Management Information Systems, 2015. **32**(3): p. 229–267.
44. Schlosser, S., et al., *Toward a Functional Reference Model for Business Rules Management*, in *47th Hawaii International Conference on System Science*. 2014, IEEE. p. 3837-3846.
45. Meth, H., B. Mueller, and A. Maedche, *Designing a Requirement Mining System.* Journal of the Association for Information Systems, 2015. **16**(9): p. 799-837.