ARTICLE IN PRESS

Journal of Purchasing & Supply Management xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Purchasing and Supply Management

journal homepage: www.elsevier.com/locate/pursup

Notes and Debates

# Advancing purchasing as a design science: Publication guidelines to shift towards more relevant purchasing research

Raphael Stange [a,*], Holger Schiele [b], Jörg Henseler [a,c]

[a] University of Twente, Faculty of Engineering Technology, P.O. Box 217, NL-7500, AE, the Netherlands
[b] University of Twente, Faculty of Behavioural, Management and Social Sciences, P.O. Box 217, NL-7500, AE, the Netherlands
[c] Universidade Nova de Lisboa, Nova Information Management School, Campus de Campolide, Lisbon, Portugal

ARTICLE INFO

*Keywords:*
Purchasing
Procurement
Design science
Publication guidelines

ABSTRACT

Due to rapidly changing business environments, purchasing and supply management (PSM) organisations are constantly confronted with new problems impacting organisational performance. PSM research can address these problems through design science research. Design science is also regarded as the science of the artificial. Design science research is a methodology that aims to systematically generate knowledge for the design, synthesis, testing, and evaluation of human-made artefacts (e.g., tools, interventions, policies) that solve practical problems. PSM artefacts such as the purchasing portfolio matrix invented by Kraljic (1983) represent a valuable opportunity to solve problems in the PSM discipline. However, our artificial-intelligence (AI)-based analysis of the discipline's flagship journal, the Journal of Purchasing and Supply Management (JPSM), indicates that design-oriented publications in PSM are underrepresented, accounting for less than 4% of the total publications. We argue that existing PSM research should be complemented with more design-oriented research, and address the following research question: How can PSM scholars publish more design-oriented research? Our objectives are to (1) provide arguments for advancing PSM as a design science, (2) nurture a better understanding of design science research as a methodology, and (3) propose publication guidelines that enable researchers to present design-oriented research in a management journal.

## 1. Introduction: The need to advance purchasing as a design science

Due to rapidly changing business environments, purchasers are constantly confronted with new problems that impact organisational performance (Kamann et al., 2016; Knight et al., 2020; Steiber and Alänge, 2016). These problems include the climate change affecting supply chains (Halldórsson and Kovács, 2010), the impact of increasing digitalisation (Srai and Lorentz, 2019), the impact of increasing globalisation (Horn et al., 2014; Zheng et al., 2007), as well as the constant pressure on PSM organisations to continuously mature and use new strategies to achieve cost reductions (Schiele et al., 2011; Schulze-Horn et al., 2018). Solving these problems or at least mitigating their consequences is of the utmost importance to PSM organisations, and one might expect that research in PSM could play a crucial role in this regard. However, this is hardly ever the case. Despite all the rigorous PSM research produced every year, an academic-practitioner gap remains, as evidenced by another review being added once in every few years, justifying the failed attempts to bridge the gap (De Frutos-Belizón, Martín-Alcázar and Sánchez-Gardey, 2019; Hodgkinson et al., 2001; Huff, 2000; Shani et al., 2007; Shapiro et al., 2007).

If conducting more, similar research does not reduce the academic-practitioner gap, it might be more fruitful to try an alternate form of research. One way to address PSM-related problems and reduce the academic-practitioner gap is to advance PSM more towards design science – a step already taken by allied fields such as organization science (Romme, 2003), information systems research (Hevner et al., 2004), and operations management (van Aken et al., 2016). Design science comprises the two terms "design" and "science". Design is the creative act of giving meaning to matter or, in the words of Charles Eames, "a plan for

*Abbreviations:* PSM, purchasing and supply management; JPSM, Journal of Purchasing and Supply Management; AI, artificial-intelligence.

* Corresponding author. , University of Twente, Faculty of Engineering Technology, Department of Design, Production & Management. , .
*E-mail address:* r.t.stange@utwente.nl (R. Stange).
*URL:* https://people.utwente.nl/r.t.stange (R. Stange).

https://doi.org/10.1016/j.pursup.2022.100750
Received 21 October 2021; Received in revised form 9 February 2022; Accepted 15 February 2022

arranging elements to accomplish a particular purpose."[1] Design science is regarded as a science of the artificial (Simon, 1996); it aims to systematically generate knowledge for, through, about, and with the design (Baskerville, 2008; Simon, 1996). Whereas natural and behavioural science aim at understanding the current world and the humans living in it, design science imagines a future world and aims at shaping the world and people's behaviour (Henseler and Guerreiro, 2020; Simon, 1996). With its focus on artificial phenomena, design science complements natural and behavioural sciences, which concentrate on the production of knowledge about natural and social phenomena (Dresch et al., 2015; March and Smith, 1995; Peffers et al., 2018). Design science's dominant research methodology is design science research; it aims at generating knowledge for the design, synthesis, testing, and evaluation of artefacts (van Aken, 2004). In the realm of PSM, the portfolio matrix invented by Kraljic (1977, 1983) is an example of an artefact, which helps purchasers to select the optimal supply management strategy based on a portfolio classification. Artefacts are the means to create a desired future for a particular stakeholder or group (Romme, 2003; Simon, 1996). Recent calls embrace this future-orientation. For example, Knight et al. (2020) call for a wider range of future-oriented methodologies in PSM such as scenario planning – a classic design thinking tool (Lewrick et al., 2020).

Despite the increased attention garnered by design science in other management disciplines such as marketing (Henseler and Guerreiro, 2020), service design (Teixeira Jorge, Patrício and Tuunanen, 2019), and entrepreneurship (Zhang and Van Burg, 2020), the value of design science research appears to have been overlooked in the PSM discipline. As demonstrated later through AI-based literature analysis, less than 4% of the published papers in JPSM display characteristics of design science studies. It seems that PSM lags other management disciplines in discovering the value of design science research for problem-solving and decision-making. One reason might be that PSM researchers are not trained to apply design science research and fear that, in competing with explanatory research papers, their design manuscripts may get rejected during the review process (Baskerville et al., 2018; Cross, 2007). If so, we assume that there is a vicious cycle suppressing the take-up of design science research in PSM: unfamiliarity with design science research among scholars leads to a lack of design-oriented research published in PSM journals; so, the lack of design-oriented journal papers means there is a lack of role models and conveys the impression that design science research is "not done" or is "hard to publish" in PSM journals; which in turn prevents PSM scholars from familiarizing themselves with and engaging in design science research.

To help break this vicious cycle, we argue that existing PSM research should be complemented with more design-oriented research and address the following research question: How can purchasing scholars publish more design-oriented purchasing research? The next section introduces design science and its applications in PSM. The following section presents design science research as methodology. The fourth section provides publication guidelines for researchers to position and present design-oriented research in a management journal. The conclusion answers our central research question.

## 2. The case for design science

### 2.1. *The value of design science for research in management and PSM: problem-solving, knowledge-broadening, and reduction of practice gap*

Over the past decades, many publications have called for and discussed the potential value of design science for management research (Romme, 2003; van Aken, 2004, 2005).

First, design science means to do research differently. As shown in Fig. 1, classical research offers methodologies tailored to build and test theories to understand/explain phenomena in the current world (Romme, 2003; Romme and Damen, 2007). However, van Aken (2004, p. 220) criticizes this approach: "(…) understanding a problem is only halfway to solving it". At this point, design science and its complementary research methodologies enter the stage. Design science and its methodologies are tailored to design and build artefacts that solve problems for a group of stakeholders (Bayazit, 2004; Vaishnavi and Kuechler, 2015). The management research toolbox is enriched by methodologies such as action research, design science research, design thinking, or intervention-based research (Ågerfalk and Wiberg, 2018; Baskerville, 2008; Chandrasekaran et al., 2020; Gruber et al., 2015).

Second, design science produces a type of knowledge different from classical research, thereby enriching the knowledge base of management research. While classical research tends to produce description-driven knowledge to explain phenomena (van Aken, 2004), design science produces actionable, normative, and anticipatory knowledge that prescribes how to address a problem using an artefact (Auernhammer, 2020; van Aken and Romme, 2009; vom Brocke et al., 2020). Classical research in PSM, for example, produces descriptive knowledge that explains a construct like supply management maturity and its impact on purchasing performance (e.g., testing a causal model). In contrast, design science produces actionable knowledge which prescribes how purchasers should use an artefact (e.g., maturity guidelines) to increase supply management maturity.

Third, design science can help to reduce the rigour-relevance gap in management research and close the academic-practitioner gap (Gulati, 2007). On the one hand, van Aken and Romme (2009, p. 10) claim: "The actor perspective and solution orientation of design science research can mitigate the relevance problem of organization and management studies by producing knowledge that is geared toward designing solutions for field problems". Conversely, Hevner (2007, p. 90) states, "Research rigor in design science research is predicated on the researcher's skilled selection and application of the appropriate theories and methods for constructing and evaluating the artefact". If appropriately applied, design science research can produce highly relevant scientific output, which is in no way inferior to classical research in terms of scientific rigour (Avenier, 2010). For example, the design world café method targets at the combination of rigorous and relevant research through adding a design phase (Schiele et al., 2022).

Having put forward the case for design science in the management field in general, design science similarly has potential value and can complement classical research in PSM. Although PSM often is regarded as social science, the boundaries of PSM research are not restricted to understanding and explaining behavioural phenomena like buyer-supplier relationships in isolation. Instead, PSM is part of a complex system, where artificial, natural, and behavioural phenomena constantly impact one another. For example, natural phenomena like Covid 19 impact buyer-supplier relationships. Similarly, artefacts like negotiation design algorithms also impact buyer-supplier relationships. Design science and its methodologies are suited to investigate and anticipate the impact of artefacts on behavioural phenomena like buyer-supplier relationships in the context of PSM, to solve problems and reach the desired outcome. Design science has the potential to set new scientific standards for creating grounded and field-tested artefacts and to extend the PSM discipline knowledge base with actionable and prescriptive knowledge.

What would design science examples look like in PSM? Table 1 provides an overview of examples based on different artefact types.

### 2.2. *Examples of design science in PSM: processes, matrices, and checklists*

> *Example 1 – supplier selection process*: Classical PSM research focuses on building and testing theories to understand the supplier selection process in the current world. Based on their observations, researchers propose theories and test them to generalise their findings. In contrast, design science research focuses on building a supplier

[1] https://youtu.be/3xYi2rd1QCg.

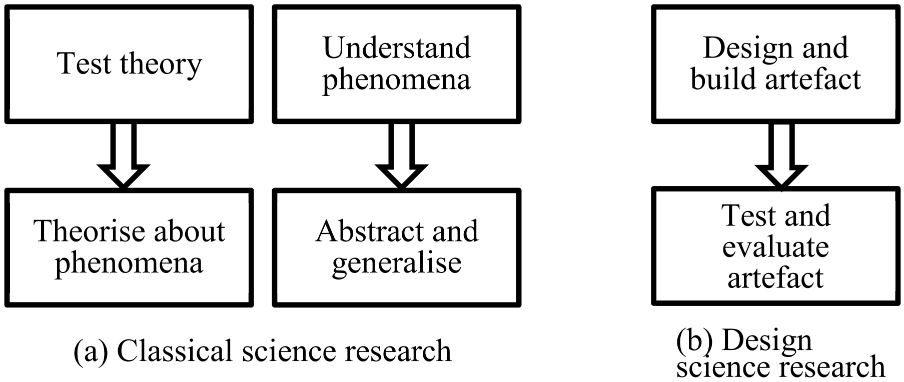


**Fig. 1.** Classical versus design science research based on Weber (2018).

**Table 1**
Examples for design-oriented PSM research based on different artefact types.

| Artefact Type | Example of PSM-related artefact | Reference to literature |
|---|---|---|
| Instantiations | purchasing process | Bäckstrand et al. (2019) |
| | supplier selection process | Bevilacqua et al. (2006); Choudhary and Shankar (2013); de Boer and van der Wegen (2003); Humphreys et al. (2007); Luo et al. (2009) |
| | process models of outsourcing to strategic planning | Momme and Hvolby (2002) |
| Models | portfolio matrix | Kraljic (1983); Padhi et al. (2012) |
| | preferred customer matrix | Schiele (2012) |
| Constructs | supply management maturity concept | Bemelmans et al. (2013); Schiele (2007) |
| Methods | design-or-buy-design decision-making approaches | Le Dain, Calvi, and Cheriti (2010) |
| | supply risk management approaches | Brusset and Bertrand (2018); Kırılmaz and Erol (2017) |
| | collusion detection approaches in procurement auctions | Padhi and Mohapatra (2011) |
| | robustness and validity methodologies to verify e-procurement software | Ronchi et al. (2010) |
| | supplier (innovation) performance evaluation methodologies | Ancarani (2009), Goldberg and Schiele (2018) |
| | multi-attribute analysis methodologies for contractor selection decisions | Holt et al. (1994) |
| | performance measurement systems for industrial collaboration | Ukko and Saunila (2020) |
| | design principles for digitalisation interventions | Srai and Lorentz (2019) |
| | negotiation rules based on mechanism design theory | Schulze-Horn et al. (2018) |

selection process artefact that is useful to PSM stakeholders and prescribes how to use the artefact to achieve the desired outcome. A practical example of design-oriented PSM research on the supplier selection process is the paper of Humphreys et al. (2007). The authors propose a supplier selection assessment tool for evaluating supplier involvement during product development. Though the authors do not explicitly label their research as a design contribution, design metrics for supplier selection are developed. They test their design at a multinational telecommunications company and evaluate its effectiveness. In building the artefact, the authors contribute to answering the following design-oriented research question: “How can purchasers evaluate supplier involvement during product development to improve supplier selection process performance?”.

*Example 2 – Purchasing and supply in a strategic context:* Classical research in PSM, for example, focuses on building and testing theories to understand purchasing and supply in a strategic context. Again, classical researchers focus on abstracting theories and making generalisations. In contrast, design science research focuses on building an artefact that is useful to PSM stakeholders and for example provides prescriptions for selecting suitable purchasing and supply strategies such as the work of Kraljic (1983). He proposes a PSM artefact, namely a portfolio matrix, which enables purchasers to select the right supply strategy to maximize supply security and reduce costs, based on a purchasing portfolio categorization. However, the author does not explicitly report testing the portfolio matrix. His work represents an example of a partial design (see Fig. 2). A typical design-oriented research question for Kraljic’s (1983) study would be: “How can purchasers select the right supply strategy to maximize supply security and reduce costs?”.

Example 3 – *Information management and information & communication technology (ICT):* Classical research on this key topic concentrates on building and testing theories about ICT in the current world. Researchers focus on abstracting and testing theories in their search for truth and rigour. In contrast, design science focuses on building an ICT-artefact that is useful to PSM stakeholders. A topic-related example is the research of Srai and Lorentz (2019). The authors develop an approach to evaluate designs for digitalisation interventions in PSM. In contrast to the previous examples, the authors explicitly mention the use of design science and follow the logic of a design science process. The authors largely comply with design science principles, as they demonstrate the utility of their design in a field test. A further strength of their work is their intent to derive normative/prescriptive design principles for digitalisation interventions. Thus, the authors produce actionable knowledge. A typical design-oriented research question for their artefact is: “How should purchasers design digitalisation interventions in PSM functions?”.

We acknowledge that design science is also subject to critiques and limitations. On the one hand, Weber (2018) criticises that the boundaries between classical research and design science remain unclear. Although most literature agrees that the goal of design science is to produce an artefact, some researchers question whether classical research too can aim to produce artefacts such as “constructs” (Gregor and Jones, 2007; Hevner et al., 2004; Kuechler and Vaishnavi, 2012; Weber, 2018). On the other hand, design science may raise ethical issues, since it serves the purpose of individual stakeholder groups, which can lead to unwanted side effects for society (Iivari, 2007). For example, the recent research of Wieland (2021) criticised that the supply chain management discipline overall created harmful and vulnerable supply chains, as a result of its focus on optimality, rationality, objectivity, and controllability of parts of the system.

### 2.3. Lack of studies in PSM: less than 4% of JPSM papers being design science

We continue to investigate the distribution of design science publications in PSM. Bäckstrand et al. (2019), for instance, working on the example of purchasing process models, report a small and even declining number of design proposals. We assume that design science studies tend to be under-represented in PSM journals. The question is, is the impression of under-representation of design science publications true? To analyse the distribution of design science within the discipline, it is necessary to trace it back, for which we used AI-based analysis software and applied it to analyse more than 800 articles published in the journal JPSM. To avoid restricting the analysis to small samples due to resource constraints affecting a manual process, we designed an automated method of analysis, applying a classical design process such as described here to create an AI-based artefact – an algorithm automatically distinguishing design papers from explanatory papers in PSM.

We decided to explore the possibility of using artificial intelligence (machine learning) as the input for a tool to identify the selected papers (Bala, 2022). The principle of machine learning is that the dataset to be analysed is subdivided into two parts, one being the learning set defining the algorithm and the other, the application set to be predicted. We constructed a learning set comprising approximately a 27th part of the total – the first issue for each of the 27 volumes of JPSM and downloaded all articles contained in this set to avoid time biases. Then, we input the full text of all articles in an Excel tool with 16 theoretically derived terms considered to be related to design papers, such as the term "design" itself. The Excel tool, counting the occurrence of keywords, generated a list of potential design papers. Simultaneously, three researchers manually checked the training set. Then, the two sets were compared. The Excel solution overestimated the number of papers 3.5-fold – it was not sensitive enough.

Next, an application prototype was developed, relying on the open-source AI software Weka. Taking the manually created test sample as true values, AI compares it to the sample, identifying a much better set of typical keywords than our original Excel set. Applying this mechanism, we amplified the set gradually, cross-checking the first findings manually. Eventually, we applied the algorithm to the complete set of 809 papers published in JPSM until the moment of this analysis, identifying 30 as design papers.

Assessing the quality of the solution, there was one paper that the algorithm did not correctly classify, indicating 96.6% accuracy. It can be concluded that AI software can be trained to identify types of academic papers, in our case, the design papers. The algorithm proved useful for analysing large sets of papers. In comparison to full text search in online library databases, the AI software Weka offered additional features and algorithms for data analysis and visualization. For example, the software analysed how often a keyword occurred in a certain article which formed a basis for the decision whether the article was regarded as a design paper (e.g., it makes a difference whether the word "design" is used once in the context of "research design" versus as a stand-alone term which occurs multiple times).

Having distilled a comprehensive set of design papers published in JPSM (and having designed a tool for literature reviews), we can now analyse the distribution of design papers among JPSM. Of the 30 design papers published in the 27 years of JPSM's existence, 10 appeared in the first half, and the remaining 20 in the second half. No year contained more than three design papers. These papers represent just 3.7% of the total number published, testifying to the clear under-representation of design science in the context of PSM's flagship journal.

## 3. Design science research as methodology: full and partial design research

Dresch et al. (2015, p. 67) depict design science as "(…) the epistemological basis for the study of what is artificial. Design science research is a method that establishes and operationalizes research when the desired goal is an artefact or a recommendation". In other words, design science research is a methodology within the design science space (see Appendix and Fig. 3 for a more detailed explanation of the design science space). Design science research builds on design science process models (Alturki et al., 2011), which commonly summarise a series of steps researchers should consider when conducting design science research. Fig. 2 illustrates a sequence of process steps derived from a review of process models from extant design literature.

*Step 1 – Identification of problem:* Most design processes share an unwanted change/challenge/risk/situation or an unaddressed desire/need/opportunity triggering the identification (Baskerville et al., 2009; March and Storey, 2008) or awareness of a problem (Takeda et al., 1990; Vaishnavi and Kuechler, 2015). Based on initial problem identification, according to Sein et al. (2011), the outcome of this process step is an initial conceptualisation of the research opportunity and an initial formulation of research questions.

*Step 2 – Clarify the problem:* Many process models emphasise the need to explore the problem in detail (Alturki et al., 2011). Key activities are to define the problem (Cole et al., 2005; March and Storey, 2008; Österle et al., 2011), to describe the problem environment (Hevner et al., 2004), to describe the relevance of the problem (Peffers et al., 2007), to relate the problem to a broader class of problems (Walls et al., 1992) and to formalize the problem (Sein et al., 2011). Beyond this, Peffers et al. (2007) suggest formulating solution objectives which can be expressed in terms of functionalities of an artefact (Nunamaker et al., 1990) or (meta-)requirements for the artefact design (Baskerville et al., 2009; Eekels and Roozenburg, 1991; Walls et al., 1992). The outcome of this process step is a detailed understanding of the problem.

Step 3 – *Explore the solution space:* According to some research artefact designs are rooted in existing *descriptive knowledge* such as theories from natural or behavioural sciences (kernel theories) (Walls et al., 1992) or existing *prescriptive knowledge* such as constructs, models, methods, instantiations or design theories (Gregor and Hevner, 2013). The design process of Dresch et al. (2015) prescribes the conduct of a systematic literature review to explore the solution space for existing satisfactory solutions, solutions in need of optimization, or valuable knowledge which inspires the design of an entirely new solution. The outcome of this process step is a selection of descriptive and prescriptive knowledge that informs the artefact design.

*Step 4 – Select research methodology:* Some models suggest describing the procedures for artefact development and artefact evaluation (e.g.,Walls et al., 1992). An activity involved in this step is defining the design techniques useful for the solution design. During this step, researchers indicate the motivations for their selection. The outcome is a selection of design techniques for the development and evaluation of the proposed solution.

*Step 5 – Design solution concept*: Many design processes address the development of the solution concept (Dresch et al., 2015). For each solution concept development, researchers complete design microcycles to arrive at an acceptable prototype (Lewrick et al., 2020). Every microcycle comprises an iterative sequence of activities such as ideation, synthesis, demonstration, and evaluation. Further, every microcycle yields tentative testable designs that are assessed and evaluated (Eekels and Roozenburg, 1991). In this regard, some authors emphasise the need for testable design propositions (Gregor and Jones, 2007; Walls et al., 1992) aimed at verifying the extent to which the design is consistent with the previously defined requirements and functionalities. If a satisfactory prototype/concept is reached, the outcome is a final prototype whose usefulness can be demonstrated in practice, marking the step from partial to full design science research.

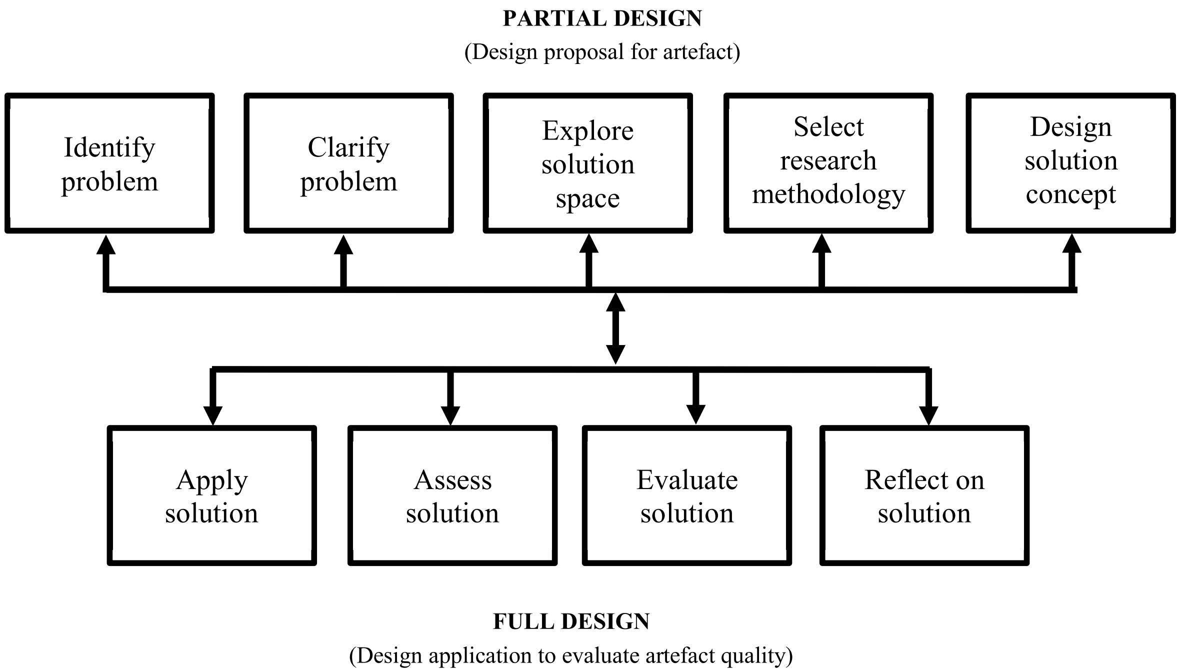


**Fig. 2.** Literature-grounded design science process.

*Step 6 – Apply the solution:* Many process models focus on demonstrating and applying the final prototype within their application domain to assess whether it works as intended (Peffers et al., 2007). More specifically, these models suggest to test whether the artefact fulfils the requirements, to outline how experts judge it and to assess the artefact quality criteria based on a laboratory experiment, field test, case study, or simulation (Gregor and Hevner, 2013; Tremblay et al., 2010). The outcome of this process step is a decision on how the developed artefact will be applied to test artefact quality.

*Step 7 – Assess the solution:* Some process models suggest to assess the prototype based on pre-defined assessment criteria. This assessment could involve to test the artefact against the initially defined artefact requirements or functionalities, to test the artefact against initially defined testable design propositions, or against standardised criteria such as quality, pragmatic validity, utility, or efficacy (Gregor and Hevner, 2013). The outcome of this process step is the decision on whether the prototype satisfies the requirements or whether researchers should complete another microcycle to improve the solution.

*Step 8 – Evaluate the solution:* Many process models also propose a more generic evaluation of the solution (Peffers et al., 2018). During this step, researchers evaluate whether the problem can be regarded as solved and elaborate on the strengths and weaknesses of the artefact, its contribution to theory and practice, and the novelty of the solution (Gregor and Hevner, 2013). If available, the designed artefact should be evaluated relative to alternatives.

*Step 9 – Reflect on solution*: Finally, many process models prescribe reflecting on the solution design by taking a meta-view and describing the key learnings (Dresch et al., 2015). This reflection involves to determine whether the solution design reveals design theory that should be added to the knowledge base, to outline what can be learned from the design process, or to indicate the extent to which the solution raises societal or ethical questions. Further, limitations of the research are addressed.

In applying a design process model, constant adherence to the generic principles of scientific research is needed to produce high-quality results (Österle et al., 2011). In the following, a systematic approach for doing so is presented.

## 4. How to present and publish design science research in PSM?

This section presents publication guidelines based on the above review of process models and design techniques for artefact development. Our goals for the publication guidelines are to (1) show researchers how to conduct design science research, (2) show researchers how they can get design science published, and (3) provide editors and reviewers with the means to evaluate "good" design science research.

For the design of the publication guidelines, virtual workshops were conducted in which we applied several creativity procedures proposed by Lewrick et al. (2020). *Inter alia*, personas, and user stories were discussed to understand the needs of potential users of our solution (Miaskiewicz and Kozar, 2011). Next, brainstorming was applied to discuss potential design concepts for a solution such as handbooks, guidelines, propositions, checklists, audits, requirements, processes, and schemes (Tsai et al., 2020). The outcome of the ideation phase was the decision to design publication guidelines.

The publication guidelines were synthesized iteratively during a sequence of virtual workshops, either in a group or in individual discussions. As part of the design science project, the authors of this paper and one more researcher participated in the virtual workshops; thus, four researchers contributed to the design of the guidelines: a professor and a researcher with a doctoral degree in the context of PSM, and a professor and a PhD student in the context of engineering technologies.

The process of ideation and synthesis resulted in a final concept design for the publication guidelines. Overall, the guidelines are comprised of the following:

(1) *A classification into partial design and full design (see Table 2, column 1, "CS")* highlights that a partial design concentrates on activities leading to the development of a solution concept, whereas a full design involves applying, assessing, evaluating, and reflecting on the artefact. Conceptual papers in management research often represent partial designs.

**Table 2**
Guidelines for publishing design science research (Page 1/2).

| CS | Section | Steps | No. | Design element | Design proposition | PI |
|---|---|---|---|---|---|---|
| Partial design | 1. Introduction | Identify research challenge | G01 | Situation | Introduce the reader to the situation as it is. | ++ |
| | | | G02 | Complication | Introduce the reader to the complication related to the current state, describe a missed opportunity or unaddressed need. | ++ |
| | | | G03 | Question | Introduce the reader to the design-oriented research question. | ++ |
| | | | G04 | Answer/Purpose | Introduce the reader to the answer to the question and present the solution developed by your design science research. | + |
| | | | G05 | Contribution claims | Introduce the reader to the claims concerning the theoretical and practical contribution to the knowledge base. | + |
| | | | G06 | Findings | Introduce a teaser for the findings of your design science research. | + |
| | | | G07 | Structure | Introduce the reader to the red thread of your paper, giving an overview of the structure of the paper. | ◯ |
| | 2. Problem review | Clarify problem | G08 | Class of problems | Review the problem within the broader class of problems outside the application domain. | + |
| | | | G09 | Problem | Review the problem within the application domain for which you aim to design a solution. | ++ |
| | | | G10 | Solution objectives | Describe the solution objectives. | ++ |
| | 3. Solution space review | Explore solution space | G11 | Extant solutions | Review explanatory and prescriptive knowledge relevant to solving your problem. | + |
| | | | G12 | Solution gap | Describe the solution gap by showing the gap between extant solutions and the required solution that solves your problem. | + |
| | 4. Methodology | Select research methodology | G13 | Research methodology | Describe and motivate the design science process that will be used for solution development and evaluation. | + |
| | | | G14 | Research procedure | Describe and motivate the design science research methodology that wlil be used for solution development and evaluation. | + |
| | 5. Creative leap | Design solution concept | G15 | Ideation | Illustrate your ideation process by describing how you generated ideas that solve the problem. | ◯ |
| | | | G16 | Synthesis | Illustrate your solution synthesis by describing how the ideas were synthesized into your solution. | + |
| | | | G17 | Concept proposition | Draw up a testable concept model based on ideation and synthesis. | ++ |
| Full design | 6. Application | Apply solution | G18 | Solution | Present the final solution developed under the design science research project that solves the actual problem. | ++ |
| | | | G19 | Application test | Describe how you performed an application test in the application domain to test your artefact. | ++ |
| | 7. Assessment | Assess solution | G20 | Quality | Assess the quality of the solution, stating whether the solution design satisfies relevant quality attributes. | + |
| | | | G21 | Pragmatic validity | Assess the pragmatic validity of the solution, indicating whether the design works and performs what it has been designed for. | + |
| | | | G22 | Efficacy | Assess the efficacy of the solution, explaining whether the realized design can produce the desired outcome. | + |
| | | | G23 | Utility | Assess the utility of the solution, indicating whether the achievement of goals has value outside the problem environment. | + |
| | 8. Discussion | Evaluate solution | G24 | Interpretation of results | Discuss the usefulness of the solution by indicating the extent to which the problem can be regarded as solved. | + |
| | | | G25 | Relative performance | Discuss how the solution performs relative to alternatives by highlighting the main differences in the research approach. | + |
| | | | G26 | Strengths/ limitations | Discuss the strengths and limitations of your solution design. | + |
| | | | G27 | Novelty of solution | Discuss the extent to which the solution developed is novel and adds to the knowledge base. | + |
| | | | G28 | Generalization | Discuss to what extent the solution is generalisable. | + |
| | | | G29 | Contributions | Discuss the main theoretical and practical contributions of your solution design. | ++ |
| | | | G30 | Research directions | Discuss areas of your solution design that may require further investigation or development. | + |
| | 9. Conclusion and learnings | Reflect on solution | G31 | Summary findings | Conclude by answering the research question and restating the most important findings. | + |
| | | | G32 | Key learnings | Reflect on the key learnings of the research for design (solution); through design (process); about design (theory). | ◯ |

Abbr. explained: CS = Categorization scheme; G = Guideline; PI = Perceived importance; ++ = Mandatory; + = Recommended; ◯ = Optional.

**Table 3**
Definitions and explanations of the design terminology used as part of the guidelines (Supplement to Table 2).

| No. | Design Element | Definition and reference to relevant literature |
|---|---|---|
| G01 | Situation | A situation is a statement of undesired present conditions. In design science research, the current situation is the departure point. See Minto (2009) for the SCQA principle. |
| G02 | Complication | A complication describes a(n) (unaddressed) change to the current state that complicates an aspect of the situation. See Minto (2009) for the SCQA principle. |
| G03 | Question | A design-oriented research question typically asks: "How can …?" or "How should...?" and is oriented towards solution design. See Henseler and Guerreiro (2020) who define typical research questions of design-oriented paradigms. |
| G04 | Answer/Purpose | The answer to a design-oriented research question is a solution design. The solution is an artefact and could be, for example, the design of concepts, models, methods, instantiations such as systems, products, and processes or design theories that aim to solve the problem (Gregor and Hevner, 2013). |
| G05 | Contribution claims | Contribution claims communicate your expectations regarding the theoretical or practical value of your design science research (Peffers et al., 2007). Describe your expectations about the role that your solution will play in solving the problem as well as the associated theoretical implications (Gregor and Hevner, 2013). |
| G06 | Findings | Findings in design science research present information discovered during the design and evaluation of a solution. This section involves a brief statement about whether the solution (design product) worked as intended during the demonstration and fulfils its purpose. Findings might also include information about the design process (Walls et al., 1992). |
| G07 | Structure | In the academic sciences, it has become a generally accepted practice to introduce the reader to the structure of the research paper. In different disciplines of design science, different communication schemes and processes have been proposed for presenting design science research (Gregor and Hevner, 2013; Peffers et al., 2007). The guidelines in this article propose a template for the structure of a design science research paper in business administration disciplines such as PSM. |
| G08 | Class of problems | The class of problems represents a wider group of problems. In design science research, a class of problems relates the problem in a specific application domain, for example, PSM, to a broader group of problems, for example, academic management (van Aken and Berends, 2018). The application domain represents the domain in which the solution will be used (Peffers et al., 2007). By relating the problem to the group of problems, the reader can relate design science research to prior work (Sein et al., 2011, p. 40). |
| G09 | Problem | A problem might be defined as the imbalance between a current and desired state in an application domain, with which stakeholders are dissatisfied ( van Aken and Berends, 2018). Problem analysis involves the definition of a problem statement, problem causes, problem consequences, and problem relevance. See Lewrick et al. (2020) for useful tools for problem analysis. |
| G10 | Solution objectives | Solution objectives are the aims that a future solution design should address. They might be inferred "(…) from the problem definition and knowledge of what is possible and feasible. The objectives can be quantitative, such as terms in which a desirable solution would be better than current ones, or qualitative, such as a description of how a new artefact is expected to support solutions to problems not hitherto addressed" (Peffers et al., 2007, p. 55). For this purpose, Walls et al. (1992, p. 43) introduce meta-requirements that refer to the requirements an artefact needs to address. |
| G11 | Extant solutions | For solution design, researchers should inspire their design with extant solutions from the explanatory or prescriptive knowledge base. Gregor and Hevner (2013) provide a useful categorization scheme, that lists examples of descriptive and prescriptive knowledge. Design science researchers call theories from the explanatory knowledge base that inspire artefact construction, kernel theories. According to Walls et al. (1992, p. 43), kernel theories are "(…) theories from natural or social sciences governing design requirements (…)" or the design process. |
| G12 | Solution gap | The solution gap represents an empty space in the prescriptive knowledge base (solution space) and represents an opportunity to solve a problem that is yet unaddressed. According to Gregor and Hevner (2013, p. 351), "The overarching problem area needs to be identified at the highest level possible (the classic concern), and the deficiencies or gaps in knowledge identified". |
| G13 | Research methodology | Research methodologies in design include action research, design science research, design thinking, or intervention-based research (Ågerfalk and Wiberg, 2018; Baskerville, 2008; Chandrasekaran et al., 2020; Gruber et al., 2015). |
| G14 | Research procedure | Walls et al. (1992, p. 43) define a design method as "[a] description of procedure(s) for artefact construction". Design science research provides various methods for solution design (Lewrick et al., 2020) and solution evaluation (Hevner et al., 2004; Pries-Heje and Baskerville, 2008; Sein et al., 2011). Design methods are prototype construction, demonstration, reference modelling, CASE tools, and method engineering. Evaluation methods are pilot applications, laboratory experiments, simulation procedures, field experiments, or expert reviews (Österle et al., 2011). |
| G15 | Ideation | Basadur (1995) defines ideation as a diverging step of option generation without evaluation. The goal is to collect as many ideas for the solution design as possible. Further, Lewrick et al. (2020, p. 22) state, "Ideation is a step towards finding solutions for our problem". The authors suggest several creativity techniques that could be used for ideation. |
| G16 | Synthesis | Kolko (2010, p. 17) defines synthesis as "an abductive sensemaking process. Through efforts of data manipulation, organization, pruning, and filtering, designers produce information and knowledge". Synthesis involves "(…) acts of prioritizing, judging, and forging connections". (Kolko, 2010, p. 21). It is a convergent step where formerly generated ideas are prioritized and structured. Eekels and Roozenburg (1991, p. 201) claim "(…) synthesis in the design cycle is *a priori* of a possible material reality that eventually but not necessarily may be realized later". |
| G17 | Concept proposition | Design propositions are statements about interrelationships between the components and between the artefact and target variables, and the emergence of the artefact (Gregor and Jones, 2007; Niehaves and Ortbach, 2016; Peffers et al., 2018; Sein et al., 2011; Walls et al., 1992). |
| G18 | Solution | The solution answers the central research question of a design science research project and is an artefact intended to solve the problem. |
| G19 | Application test | Application tests are conducted to demonstrate the functionality of the solution. Demonstration "(…) could involve its [the solution's] use in experimentation, simulation, case study, proof, or other appropriate activity. Resources required for the demonstration include effective knowledge of how to use the artefact to solve the problem". (Peffers et al., 2007, p. 55). |
| G20 | Quality | According to Hevner et al. (2004, p. 85), artefact quality "(…) can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization, and other relevant quality attributes". |
| G21 | Pragmatic validity | Pragmatic validity reflects whether the realized solution works and performs what it has been designed for (van Aken et al., 2016). In other words, pragmatic validity might be evaluated by the extent to which the goals can be achieved using the solution (Am Worren, Moore and Elliott, 2002, p. 1228). |
| G22 | Efficacy | Efficacy describes whether the realized solution might produce the intended result or desired outcomes (Gregor and Hevner, 2013, p. 351). "This activity involves comparing the objectives of a solution to actual observed results from use of the artefact in the demonstration (…)" (Peffers et al., 2007, p. 56). Further literature: Hevner et al. (2004, p. 83). |
| G23 | Utility | Utility reflects "(…) whether the achievement of goals has value outside the development environment" (Gregor and Hevner, 2013, p. 351). Hence, the usefulness of the solution outside the application domain is evaluated. Further literature: Hevner et al. (2004, p. 83). |
| G24 | Interpretation of results | Gregor and Hevner (2013) recommend that the discussion includes the interpretation of results with respect to the previously defined objectives. |
| G25 | Relative performance | According to Gregor and Hevner (2013), the discussion might include a comparison with alternative solutions. |
| G26 | Strengths /limitations | A discussion of the strengths and weaknesses of the solution design might include discussing the need for additional design cycles (Sein et al., 2011, p. 43); discussing the limitations in terms of anticipating unwanted side effects of the solution (March and Smith, 1995, p. 254); or discussing limitations in terms of the perishability/ephemerality of the solution. |
| G27 | Novelty of solution | The discussion of the novelty of the solution might include discussing the knowledge contribution using the framework of Gregor and Hevner (2013, p. 345), which proposes classification into improvement, invention, routine design, and exaptation. |
| G28 | Generalisation | Generalisability addresses the extent to which the solution applies to other situations or people (Gregor and Hevner, 2013, p. 352). |

(*continued on next page*)

**Table 3** (*continued*)

| No. | Design Element | Definition and reference to relevant literature |
|---|---|---|
| G29 | Contributions | Design science researchers might discuss the main theoretical and practical contributions (Sein et al., 2011, p. 45). |
| G30 | Research directions | Gregor and Hevner (2013) state that the discussion might include a description of areas requiring further work. |
| G31 | Summary findings | Gregor and Hevner (2013) aver that the reflection section concludes by answering the research question and restating the most important findings. |
| G32 | Key learnings | Key learnings in design science research are learnings regarding the design product (research for design), the design process (research through design), or design theory (research about design). For the design product, researchers can reflect on the use for a broader class of problems. For the design process, researchers can address what other researchers or designers can learn from their design process. For design theories, researchers can reflect on learnings considering selected theories (Delle Monache and Rocchesso, 2014, p. 150; Sein et al., 2011, p. 45). |

(2) *A design for structure (see Table 2, column 2, "section"),* which provides PSM scholars with a template for a structure for arranging the sections of a design paper. This template was derived based on a review of a publication scheme proposed by Gregor and Hevner (2013).
(3) *A design for process (see Table 2, column 3, "steps")* prescribes a series of steps that PSM researchers are advised to consider when presenting a design paper.
(4) *A numeration of design elements, design propositions, and design requirements (See Table 2, column 4, "No."),* which, in combination, are considered as a guideline (e.g., G01 is considered guideline number 1).
(5) *Design elements (see Table 2, column 5, "design element"),* which represent a list of essential ingredients for each of the sections.
(6) *Design propositions (see Table 2, column 6, "design proposition")* are normative and prescriptive instructions that PSM scholars should consider when writing a design-oriented purchasing paper.
(7) *Design requirements (see Table 2, column 7, "PI"),* which indicate the perceived relative importance of every design guideline for publication. The labels (e.g., mandatory [++], recommended [+], or optional [o]) were determined based on individual judgements from a virtual dot voting workshop (Lewrick et al., 2020) and a subsequent discussion to achieve consensus.
(8) *A supplement (Table 3)* that summarises, defines, and explains the design terminology used as part of the guidelines and refers to the relevant design literature for understanding design science in greater detail. The supplement is like a glossary and explains the design science terminology used in Table 2.

The guidelines presented above are not PSM-specific. Due to the high degree of abstraction, we expect the publication guidelines can be readily adapted and applied to any discipline in the management field. PSM researchers employing the guidelines are advised to thoughtfully adapt the structure and requirements to the logic of their individual design science research project. We propose a structure for a design science publication which is carefully aligned with the process, but not mandatory. We advise users of these guidelines to address to some extent all 39 design requirements, to produce a complete design science publication.

Our design guidelines have several strengths. For example, the structured representation by means of Tables 2 and 3 enables simple and quick navigation when writing a design science paper and thus supports our initial objective to make the guidelines easy to apply. Next, the guidelines include normative design propositions that provide scholars with instructions on writing a design-oriented purchasing paper. Table 3 is a supplement to our guidelines and provides brief explanations of the most important concepts from the design literature, enabling PSM researchers to develop a quick understanding of the related design science terminology. The supplement (Table 3) refers to helpful design literature, in case purchasing researchers require a better understanding of design science research.

## 5. Conclusion: Design science can make PSM research more relevant and our guidelines help PSM researchers to exploit its potential

This Notes & Debates article makes the case for design science and its methods as a valuable way to solve practical problems in PSM and make research more relevant.

On the one hand, design science and its methods are valuable to PSM scholars. Design science complements traditional PSM research, which focuses on identifying and explaining problems in the contemporary world (problem focus). Conversely, design science focuses on creating artefacts that solve problems (solution focus) to create a future desired world. In doing so, design science enriches the PSM research toolbox with its solution-focused research methods. Examples of these methods include action research, design science research, design thinking, or intervention-based research. Using these methods, PSM scholars produce actionable, normative, and prescriptive knowledge. This knowledge complements the prevailing explanatory knowledge in the extant PSM knowledge base. When design science is properly applied by PSM scholars, its output is on par with classical research in terms of scientific quality and rigour. In fact, design science has the potential to enhance the quality of solution-oriented PSM research.

On the other hand, design science and its methods are valuable to PSM practitioners. The artefacts created by design science research are relevant to solving practical problems in the day-to-day business of practitioners. An example of a relevant and useful PSM artefact is a mechanism design-based negotiation method developed by Schulze-Horn et al. (2018). The artefact aims to make negotiations more effective and improve purchasing performance. In addition to their negotiation method, the authors also derive negotiation rules that provide suppliers with incentives to reduce purchasing prices. These negotiation rules represent normative knowledge.

In summary, design science is valuable to PSM scholars and practitioners alike and has the potential to narrow the academic-practitioner gap in PSM. Consequently, design science can contribute to the welfare of the discipline as a whole.

To conduct design science research and publish in academic journals, we recommend that PSM researchers follow typical design science research processes or the publication guidelines suggested in this article. Design process models typically summarise a series of steps that researchers should consider when conducting design science research. The publication guidelines presented in this article additionally show PSM researchers how to present a design paper in order to publish it in a scientific journal. Thus, our publication guidelines are aimed at various stakeholders in PSM who are interested in conducting, presenting, or assessing the quality of design science research.

On the one hand, the guidelines are aimed at scientists in PSM. The guidelines show PSM scientists which steps to follow in order to conduct design science research properly. Furthermore, they guide scientists on how they should structure a design paper. They indicate which sections and elements should be reported and how important these elements are. Finally, the guidelines are complemented by an appendix that explains the design terminology used within the guidelines and refers to relevant literature. The appendix is a handout for PSM researchers who are not yet familiar with design science.

On the other hand, the guidelines are aimed at editors, reviewers, and ultimately also the readers of PSM. Firstly, the guidelines enable editors, reviewers, and readers to assess the quality of design science research - to separate the wheat from the chaff. Second, the differentiation between partial and full design papers enables editors, reviewers, and readers to assess the maturity and effectiveness of an artefact presented in a design paper. An artefact presented in a partial design paper is usually less mature and effective because it has not yet been applied and tested under real-world conditions. Finally, the guidelines may encourage publishers to verify whether their evaluation rubrics in submission portals or their author guidelines sufficiently take design science research into account. In developing the guidelines, we have focused on making them useful for researchers, editors, reviewers, and readers. However, they may also prove useful for supervisors, reflective practitioners, consultants, or students.

All in all, we are convinced that design science can advance PSM as a science, initiate a shift towards solving important problems in the discipline, and contribute to the publication of more relevant research in academic journals.

## CRediT authorship contribution statement

**Raphael Stange:** Conceptualization, Methodology, Software, Resources, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Holger Schiele:** Conceptualization, Methodology, Resources, Writing Original, Writing – review & editing. **Jörg Henseler:** Conceptualization, Methodology, Software, Resources, Writing – original draft, Writing – review & editing, Visualization.

## Declaration of competing interest

No funding was available for this research, nor do any conflicts of interest appear

## Acknowledgements

We would express our gratitude to Alex Bala, who worked on the conception and application of the AI algorithm to identify design papers, in his master thesis also applying this technology to the Journal of Supply Chain Management, identifying a similar pattern as with JPSM, in that case 2.9% of all papers being design papers (Bala, 2022).

## Appendix Illustrating the design science space based on the research onion

This appendix provides a broader understanding for the design space using an enhanced research onion based on Saunders et al. (2019). The design space is a collection of characteristics that are associated with design science from a meta-perspective. We illustrate the main characteristics of design science based on the 9 layers illustrated in Fig. 3.

❶ Research discipline: Design science is a relatively young research discipline and forms the epistemological foundation for the study of the artificial (Dresch et al., 2015). Archer (1979) advocate that in addition to science and humanities, design represents a third discipline. Some authors argue that examples of applied fields in design are medicine, engineering, or management which among others seek to produce instruments or tools for problem-solving (Cooper et al., 2009; Hevner and Chatterjee, 2010; March and Vogus, 2010; Pandza and Thorpe, 2010).

❷ Research purpose: The purpose of design science is to develop relevant, useful and validated artefacts to address problems in a certain field. The purpose of such artefacts is to make improvements and prescriptions on how to transform an existing situation into a future desired situation (Romme, 2003). Some authors claim, that when designing and evaluating artefacts, practical useful solutions are more important to design science than the search for truth is (Bunge, 1967; Iivari, 2003).

❸ Research paradigm: Design science largely follows pragmatist worldviews (Buchanan, 1992; Goldkuhl, 2011; Horváth, 2004). An inherent assumption of design science is that humans can intentionally shape reality to serve a particular purpose (Peffers et al., 2007). To intentionally shape reality according to human needs pragmatic design science develops artefacts.

❹ Research question: According to Henseler and Guerreiro, (2020, p. 4) “A different worldview also becomes apparent in the way how research questions are formulated and how research is conducted, which is largely influenced by the pursued scientific paradigm”. Typical formulations of research questions under the pragmatist paradigm are of the form “How can…?”, “How should…?”, “Can we…?”, “What is the best…?” or “How can we get … working?” (Henseler and Guerreiro, 2020).

❺ Research objectives: Design science largely follows the objective to produce normative and prescriptive knowledge (Dresch et al., 2015). For example, Goldkuhl (2011) states that under a pragmatist paradigm research objectives are largely of normative concern.

❻ Type of reasoning: To answer a design-oriented research question, design science on the one hand employs inductive or deductive reasoning but also is largely focusing on abductive reasoning (Haig, 2018). Abductive reasoning involves making the best plausible conclusion based on incomplete observations, creative thinking and what is known (Burks, 1946; Haig, 2018; Kolko, 2010).

❼ Research process: Design science largely focuses on problem-solving processes (Archer, 1979; van Aken and Berends, 2018). Van Aken and Berends (2018) differentiate three knowledge-generating research processes: (1) a theory development process, (2) a theory testing process, and (3) a problem-solving process. Design science approaches tend to focus on the third type. According to Archer (1979) problem-solving processes contain the steps of imagination, synthesis, invention, implementation, and evaluation.

❽ Research methodology: Design science methodologies are for example action research, design science research (also known as constructivist research), design thinking, or intervention-based research (Ågerfalk and Wiberg, 2018; Baskerville, 2008; Chandrasekaran et al., 2020; Gruber et al., 2015). Lewrick et al. (2020) propose several creativity techniques to synthesize solutions.

❾ Knowledge: Design science concentrates on the production of practical knowledge that is manifested in the artificial (Bunge, 1979; Simon, 1996). Design science knowledge manifests itself for example in instantiations, models, constructs, and methods (Gregor and Hevner, 2013).

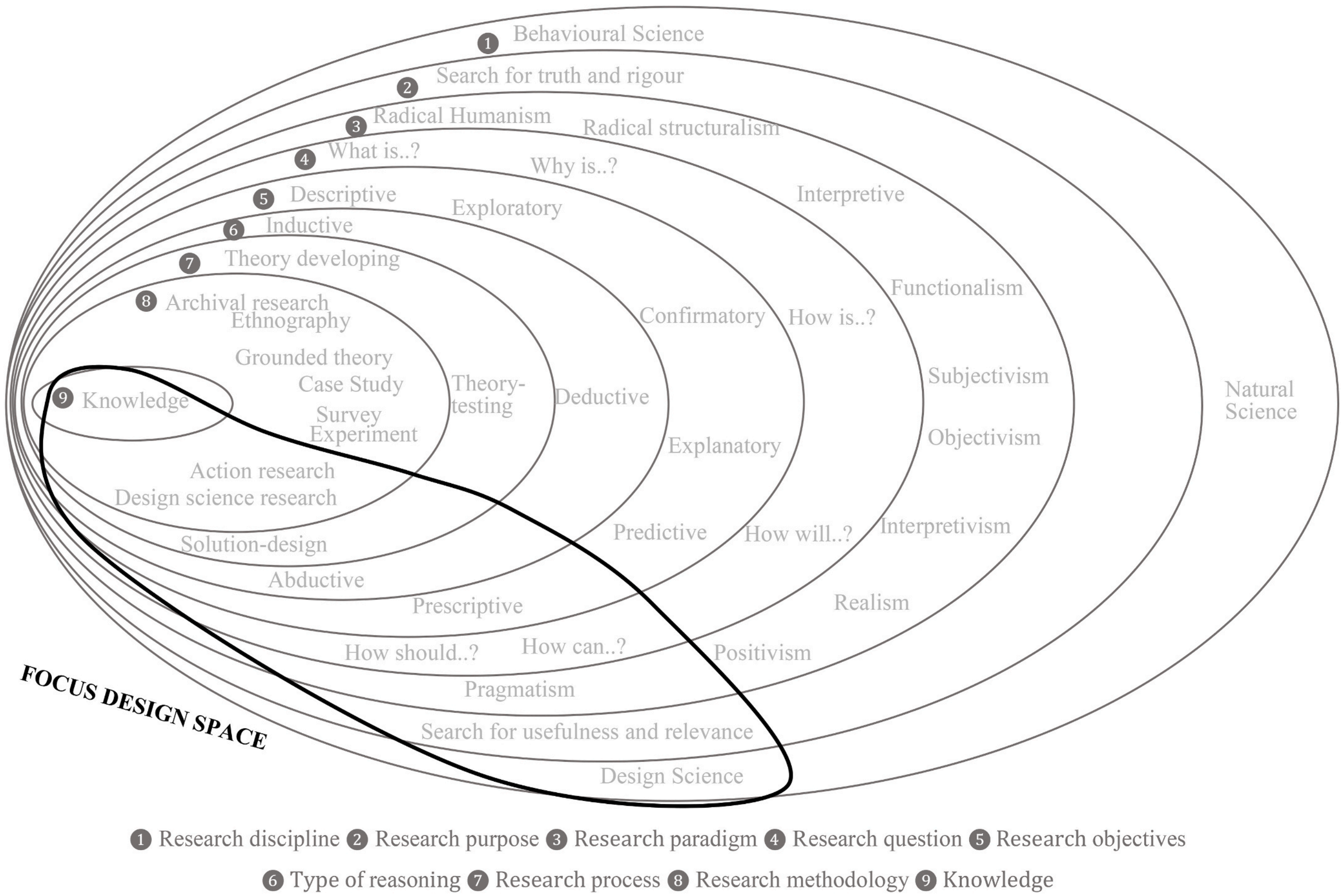


**Fig. 3.** Enhanced research onion illustrating the design space (building upon Saunders et al., 2019).

## References

Ågerfalk, P.J., Wiberg, M., 2018. Pragmatizing the normative artifact: design science research in scandinavia and beyond. Commun. Assoc. Inf. Syst. 43 (1), 68–77. https://doi.org/10.17705/1cais.04304.

Alturki, A., Gable, G.G., Bandara, W., 2011. A design science research roadmap. In: Paper Presented at the Service-Oriented Perspectives in Design Science Research. Berlin, Heidelberg.

Am Worren, N., Moore, K., Elliott, R., 2002. When theories become tools: toward a framework for pragmatic validity. Hum. Relat. 55 (10), 1227–1250. https://doi.org/10.1177/0018726702055010082.

Ancarani, A., 2009. Supplier evaluation in local public services: application of a model of value for customer. J. Purch. Supply Manag. 15 (1), 33–42. https://doi.org/10.1016/j.pursup.2008.09.003.

Archer, B., 1979. Design as a discipline. Des. Stud. 1 (1), 17–20. https://doi.org/10.1016/0142-694X(79)90023-1.

Auernhammer, J., 2020. Design research in innovation management: a pragmatic and human-centered approach. R D Manag. 50 (3), 412–428. https://doi.org/10.1111/radm.12409.

Avenier, M.-J., 2010. Shaping a constructivist view of organizational design science. Organ. Stud. 31 (9–10), 1229–1255. https://doi.org/10.1177/0170840610374395.

Bäckstrand, J., Suurmond, R., van Raaij, E., Chen, C., 2019. Purchasing process models: inspiration for teaching purchasing and supply management. J. Purch. Supply Manag. 25 (5), 100577. https://doi.org/10.1016/j.pursup.2019.100577.

Bala, A., 2022. Design Science Research throughout the Years. Master Thesis. University of Twente, Enschede.

Basadur, M., 1995. Optimal ideation-evaluation ratios. Creativ. Res. J. 8 (1), 63–75. https://doi.org/10.1207/s15326934crj0801_5.

Baskerville, R., 2008. What design science is not. Eur. J. Inf. Syst. 17 (5), 441–443. https://doi.org/10.1057/ejis.2008.45.

Baskerville, R., Baiyere, A., Gregor, S., Hevner, A., Rossi, M., 2018. Design science research contributions: finding a balance between artifact and theory. J. Assoc. Inf. Syst. Online 19 (5), 358–376. https://doi.org/10.17705/1jais.00495.

Baskerville, R., Pries-Heje, J., Venable, J., 2009. Soft design science methodology. In: Paper Presented at the 4th International Conference on Design Science Research in Information Systems and Technology. DESRIST '09, Philadelphia, CA.

Bayazit, N., 2004. Investigating design: a review of forty years of design research. Des. Issues 20 (1), 16–29. https://doi.org/10.1162/074793604772933739.

Bemelmans, J., Voordijk, H., Vos, B., 2013. Designing a tool for an effective assessment of purchasing maturity in construction. Benchmark Int. J. 20 (3), 342–361. https://doi.org/10.1108/14635771311318126.

Bevilacqua, M., Ciarapica, F.E., Giacchetta, G., 2006. A fuzzy-QFD approach to supplier selection. J. Purch. Supply Manag. 12 (1), 14–27. https://doi.org/10.1016/j.pursup.2006.02.001.

Brusset, X., Bertrand, J.-L., 2018. Hedging weather risk and coordinating supply chains. J. Oper. Manag. 64, 41–52. https://doi.org/10.1016/j.jom.2018.10.002.

Buchanan, R., 1992. Wicked problems in design thinking. Des. Issues 8 (2), 5–21.

Bunge, M., 1967. Scientific Research II: the Search for Truth. Springer.

Bunge, M., 1979. Treatise on Basic Philosophy: Ontology II: A World of Systems, vol. 4. Springer Netherlands.

Burks, A.W., 1946. Peirce's theory of abduction. Philos. Sci. 13 (4), 301–306. https://doi.org/10.1086/286904.

Chandrasekaran, A., de Treville, S., Browning, T., 2020. Editorial: intervention-based research (IBR)—what, where, and how to use it in operations management. J. Oper. Manag. 66 (4), 370–378. https://doi.org/10.1002/joom.1093.

Choudhary, D., Shankar, R., 2013. Joint decision of procurement lot-size, supplier selection, and carrier selection. J. Purch. Supply Manag. 19 (1), 16–26. https://doi.org/10.1016/j.pursup.2012.08.002.

Cole, R., Purao, S., Rossi, M., Sein, M., 2005. Being proactive: where action research meets design research. In: Paper Presented at the International Conference on Information Systems ICIS 2005 Proceedings.

Cooper, R., Junginger, S., Lockwood, T., 2009. Design thinking and design management: a research and practice perspective. Des. Manag. Rev. 20 (2), 46–55. https://doi.org/10.1111/j.1948-7169.2009.00007.x.

Cross, N., 2007. Forty years of design research. Des. Stud. 28 (1), 1–4. https://doi.org/10.1016/j.destud.2006.11.004.

de Boer, L., van der Wegen, L.L.M., 2003. Practice and promise of formal supplier selection: a study of four empirical cases. J. Purch. Supply Manag. 9 (3), 109–118. https://doi.org/10.1016/S1478-4092(03)00018-9.

De Frutos-Belizón, J., Martín-Alcázar, F., Sánchez-Gardey, G., 2019. Reviewing the "Valley of Death" between management research and management practice. Manag. Res. Rev. 42 (8), 926–953. https://doi.org/10.1108/MRR-02-2018-0096.
Delle Monache, S., Rocchesso, D., 2014. Bauhaus legacy in research through design: the case of basic sonic interaction design. Int. J. Des. 8 (3), 139–154.
Dresch, A., Lacerda, D.P., Antunes Jr., J.A.V., 2015. Design Science Research: A Method for Science and Technology Advancement. Springer International Publishing.
Eekels, J., Roozenburg, N.F.M., 1991. A methodological comparison of the structures of scientific research and engineering design: their similarities and differences. Des. Stud. 12 (4), 197–203. https://doi.org/10.1016/0142-694X(91)90031-Q.
Goldberg, J., Schiele, H., 2018. Early supplier integration: assessing supplier innovation ideas. IEEE Eng. Manag. Rev. 46 (3), 94–102.
Goldkuhl, G., 2011. Design research in search for a paradigm: pragmatism is the answer. In: Paper Presented at the European Design Science Symposium.
Gregor, S., Hevner, A.R., 2013. Positioning and presenting design science research for maximum impact. MIS Q. 37 (2), 337–355. https://doi.org/10.25300/misq/2013/37.2.01.
Gregor, S., Jones, D., 2007. The anatomy of a design theory. J. Assoc. Inf. Syst. Online 8 (5), 312–335. https://doi.org/10.17705/1jais.00129.
Gruber, M., de Leon, N., George, G., Thompson, P., 2015. Managing by design. Acad. Manag. J. 58 (1), 1–7. https://doi.org/10.5465/amj.2015.4001.
Gulati, R., 2007. Tent Poles, tribalism, and boundary spanning: the rigor-relevance debate in management research. Acad. Manag. J. 50 (4), 775–782. https://doi.org/10.5465/amj.2007.26279170.
Haig, B.D., 2018. An abductive theory of scientific method. In: Haig, B.D. (Ed.), Method Matters in Psychology: Essays in Applied Philosophy of Science. Springer International Publishing, Cham, pp. 35–64.
Halldorsson, Á., Kovács, G., 2010. The sustainable agenda and energy efficiency. Int. J. Phys. Distrib. Logist. Manag. 40 (1/2), 5–13. https://doi.org/10.1108/09600031011018019.
Henseler, J., Guerreiro, M., 2020. Design and marketing: intersections and challenges. Creativ. Innovat. Manag. 29 (S1), 3–10. https://doi.org/10.1111/caim.12412.
Hevner, A., Chatterjee, S., 2010. Design science research in information systems. In: Hevner, A., Chatterjee, S. (Eds.), Design Research in Information Systems: Theory and Practice. Springer US, Boston, MA, pp. 9–22.
Hevner, A., March, S.T., Park, J., Ram, S., 2004. Design science in information systems research. MIS Q. 28 (1), 75–105. https://doi.org/10.2307/25148625.
Hevner, A.R., 2007. A three cycle view of design science research. Scand. J. Inf. Syst. 19 (2), 4.
Hodgkinson, G.P., Herriot, P., Anderson, N., 2001. Re-aligning the stakeholders in management research: lessons from industrial, work and organizational psychology. Br. J. Manag. 12 (s1), S41–S48. https://doi.org/10.1111/1467-8551.12.s1.5.
Holt, G.D., Olomolaiye, P.O., Harris, F.C., 1994. Applying multi-attribute analysis to contractor selection decisions. Eur. J. Purch. Supply Manag. 1 (3), 139–148. https://doi.org/10.1016/0969-7012(94)90003-5.
Horn, P., Scheffler, P., Schiele, H., 2014. Internal integration as a pre-condition for external integration in global sourcing: a social capital perspective. Int. J. Prod. Econ. 153, 54–65. https://doi.org/10.1016/j.ijpe.2014.03.020.
Horváth, I., 2004. A treatise on order in engineering design research. Res. Eng. Des. 15 (3), 155–181. https://doi.org/10.1007/s00163-004-0052-x.
Huff, A.S., 2000. 1999 presidential address: changes in organizational knowledge production. Acad. Manag. Rev. 25 (2), 288–293. https://doi.org/10.2307/259014.
Humphreys, P., Huang, G., Cadden, T., McIvor, R., 2007. Integrating design metrics within the early supplier selection process. J. Purch. Supply Manag. 13 (1), 42–52. https://doi.org/10.1016/j.pursup.2007.03.006.
Iivari, J., 2003. The IS core-VII: towards information systems as a science of meta-artifacts. Commun. Assoc. Inf. Syst. 12 (1), 37. https://doi.org/10.17705/1cais.01237.
Iivari, J., 2007. A paradigmatic analysis of Information Systems as a design science. Scand. J. Inf. Syst. 19 (2), 23.
Kamann, D.-J.F., Dullaert, W., de Leeuw, S., 2016. Preparing for new competitive challenges: special issue on the 24th annual IPSERA conference. J. Purch. Supply Manag. 22 (3), 155–159. https://doi.org/10.1016/j.pursup.2016.05.005.
Kırılmaz, O., Erol, S., 2017. A proactive approach to supply chain risk management: shifting orders among suppliers to mitigate the supply side risks. J. Purch. Supply Manag. 23 (1), 54–65. https://doi.org/10.1016/j.pursup.2016.04.002.
Knight, L., Meehan, J., Tapinos, E., Menzies, L., Pfeiffer, A., 2020. Researching the future of purchasing and supply management: the purpose and potential of scenarios. J. Purch. Supply Manag. 26 (3), 100624. https://doi.org/10.1016/j.pursup.2020.100624.
Kolko, J., 2010. Abductive thinking and sensemaking: the drivers of design synthesis. Des. Issues 26 (1), 15–28. https://doi.org/10.1162/desi.2010.26.1.15.
Kraljic, P., 1977. Neue Wege im Beschaffungsmarketing. Manag. Mag. 7 (11), 72–80.
Kraljic, P., 1983. Purchasing must become supply management. Harv. Bus. Rev. 61 (5), 109–117.
Kuechler, W., Vaishnavi, V., 2012. A framework for theory development in design science research: multiple perspectives. J. Assoc. Inf. Syst. Online 13 (6), 395–423. https://doi.org/10.17705/1jais.00300.
Le Dain, M.-A., Calvi, R., Cheriti, S., 2010. Developing an approach for design-or-buy-design decision-making. J. Purch. Supply Manag. 16 (2), 77–87. https://doi.org/10.1016/j.pursup.2010.03.010.
Lewrick, M., Link, P., Leifer, L., 2020. The Design Thinking Toolbox: A Guide to Mastering the Most Popular and Valuable Innovation Methods (Hoboken, New Jersey: Wiley).
Luo, X., Wu, C., Rosenberg, D., Barnes, D., 2009. Supplier selection in agile supply chains: an information-processing model and an illustration. J. Purch. Supply Manag. 15 (4), 249–262. https://doi.org/10.1016/j.pursup.2009.05.004.
March, S.T., Smith, G.F., 1995. Design and natural science research on information technology. Decis. Support Syst. 15 (4), 251–266. https://doi.org/10.1016/0167-9236(94)00041-2.
March, S.T., Storey, V.C., 2008. Design science in the information systems discipline: an introduction to the special issue on design science research. MIS Q.: Manag. Inf. Syst. 32 (4), 725–730. https://doi.org/10.2307/25148869.
March, S.T., Vogus, T.J., 2010. Design science in the management disciplines. In: Hevner, A., Chatterjee, S. (Eds.), Design Research in Information Systems: Theory and Practice. Springer US, Boston, MA, pp. 195–208.
Miaskiewicz, T., Kozar, K.A., 2011. Personas and user-centered design: how can personas benefit product design processes? Des. Stud. 32 (5), 417–430. https://doi.org/10.1016/j.destud.2011.03.003.
Minto, B., 2009. The Minto Pyramid Principle: Logic in Writing, Thinking and Problem Solving. Financial Times Prentice Hall.
Momme, J., Hvolby, H.-H., 2002. An outsourcing framework: action research in the heavy industry sector. Eur. J. Purch. Supply Manag. 8 (4), 185–196. https://doi.org/10.1016/S0969-7012(02)00003-5.
Niehaves, B., Ortbach, K., 2016. The inner and the outer model in explanatory design theory: the case of designing electronic feedback systems. Eur. J. Inf. Syst. 25 (4), 303–316. https://doi.org/10.1057/ejis.2016.3.
Nunamaker Jr., J.F., Chen, M., Purdin, T.D.M., 1990. Systems development in information systems research. J. Manag. Inf. Syst. 7 (3), 89–106. https://doi.org/10.1080/07421222.1990.11517898.
Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Sinz, E.J., 2011. Memorandum on design-oriented information systems research. Eur. J. Inf. Syst. 20 (1), 7–10. https://doi.org/10.1057/ejis.2010.55.
Padhi, S.S., Mohapatra, P.K.J., 2011. Detection of collusion in government procurement auctions. J. Purch. Supply Manag. 17 (4), 207–221. https://doi.org/10.1016/j.pursup.2011.03.001.
Padhi, S.S., Wagner, S.M., Aggarwal, V., 2012. Positioning of commodities using the Kraljic portfolio matrix. J. Purch. Supply Manag. 18 (1), 1–8. https://doi.org/10.1016/j.pursup.2011.10.001.
Pandza, K., Thorpe, R., 2010. Management as design, but what kind of design? An appraisal of the design science analogy for management. Br. J. Manag. 21 (1), 171–186. https://doi.org/10.1111/j.1467-8551.2008.00623.x.
Peffers, K., Tuunanen, T., Niehaves, B., 2018. Design science research genres: introduction to the special issue on exemplars and criteria for applicable design science research. Eur. J. Inf. Syst. 27 (2), 129–139. https://doi.org/10.1080/0960085X.2018.1458066.
Peffers, K., Tuunanen, T., Rothenberger, M.A., Chatterjee, S., 2007. A design science research methodology for information systems research. J. Manag. Inf. Syst. 24 (3), 45–77. https://doi.org/10.2753/mis0742-1222240302.
Pries-Heje, J., Baskerville, R., 2008. The design theory nexus. MIS Q. 32 (4), 731–755. https://doi.org/10.2307/25148870.
Romme, A.G.L., 2003. Making a difference: organization as design. Organ. Sci. 14 (5), 558–573. https://doi.org/10.1287/orsc.14.5.558.16769.
Romme, A.G.L., Damen, I.C.M., 2007. Toward science-based design in organization development: codifying the process. J. Appl. Behav. Sci. 43 (1), 108–121. https://doi.org/10.1177/0021886306297011.
Ronchi, S., Brun, A., Golini, R., Fan, X., 2010. What is the value of an IT e-procurement system? J. Purch. Supply Manag. 16 (2), 131–140. https://doi.org/10.1016/j.pursup.2010.03.013.
Saunders, M., Lewis, P., Thornhill, A., 2019. Research Methods for Business Students. Pearson Education Limited, Harlow.
Schiele, H., 2007. Supply-management maturity, cost savings and purchasing absorptive capacity: testing the procurement–performance link. J. Purch. Supply Manag. 13 (4), 274–293. https://doi.org/10.1016/j.pursup.2007.10.002.
Schiele, H., Horn, P., Vos, B., 2011. Estimating cost-saving potential from international sourcing and other sourcing levers. Int. J. Phys. Distrib. Logist. Manag. 41 (3), 315–336. https://doi.org/10.1108/09600031111123813.
Schiele, H., 2012. Accessing supplier innovation by being their preferred customer. Res. Technol. Manag. 55, 44–50. https://doi.org/10.5437/08956308X5501012.
Schiele, H., Krummaker, S., Hoffmann, P., Kowalski, R., 2022. The "research world café" as method of scientific enquiry: Combining rigor with relevance and speed. J. Bus. Res. 140, 280–296.
Schulze-Horn, I., Pulles, N., Schiele, H., Scheffler, P., 2018. Using mechanism design theory in negotiations to improve purchasing performance. Int. J. Procure. Manag. 11 (6), 777–800. https://doi.org/10.1504/IJPM.2018.095658.
Sein, M.K., Henfridsson, O., Purao, S., Rossi, M., Lindgren, R., 2011. Action design research. MIS Q. 35 (1), 37–56. https://doi.org/10.2307/23043488.
Shani, A.B., Mohrman, S.A., Pasmore, W.A., Stymne, B., Adler, N., 2007. Handbook of Collaborative Management Research, p. 696. https://doi.org/10.4135/9781412976671.
Shapiro, D.L., Kirkman, B.L., Courtney, H.G., 2007. Perceived causes and solutions of the translation problem in management research. Acad. Manag. J. 50 (2), 249–266. https://doi.org/10.5465/amj.2007.24634433.
Simon, H.A., 1996. The Sciences of the Artificial. MIT Press.
Srai, J.S., Lorentz, H., 2019. Developing design principles for the digitalisation of purchasing and supply management. J. Purch. Supply Manag. 25 (1), 78–98. https://doi.org/10.1016/j.pursup.2018.07.001.
Steiber, A., Alänge, S., 2016. The world is changing. In: Steiber, A., Alänge, S. (Eds.), The Silicon Valley Model: Management for Entrepreneurship. Springer International Publishing, Cham, pp. 1–17.

Takeda, H., Veerkamp, P., Tomiyama, T., Yoshikawa, H., 1990. Modeling design processes. AI Mag. 11 (4), 37–48.

Teixeira Jorge, G., Patrício, L., Tuunanen, T., 2019. Advancing service design research with design science research. J. Serv. Manag. 30 (5), 577–592. https://doi.org/10.1108/josm-05-2019-0131.

Tremblay, M.C., Hevner, A.R., Berndt, D.J., 2010. The use of focus groups in design science research. In: Hevner, A., Chatterjee, S. (Eds.), Design Research in Information Systems: Theory and Practice. Springer US, Boston, MA, pp. 121–143.

Tsai, M., Liao, Y., Chang, Y., Chen, H., 2020. A brainstorming flipped classroom approach for improving students' learning performance, motivation, teacher-student interaction and creativity in a civics education class. Think. Skills Creativ. 38, 100747. https://doi.org/10.1016/j.tsc.2020.100747.

Ukko, J., Saunila, M., 2020. Understanding the practice of performance measurement in industrial collaboration: from design to implementation. J. Purch. Supply Manag. 26 (1), 100529. https://doi.org/10.1016/j.pursup.2019.02.001.

Vaishnavi, V.K., Kuechler, W., 2015. Design Science Research Methods and Patterns: Innovating Information and Communication Technology, second ed. CRC Press.

van Aken, J.E., 2004. Management research based on the paradigm of the design sciences: the quest for field-tested and grounded technological rules. J. Manag. Stud. 41 (2), 219–246. https://doi.org/10.1111/j.1467-6486.2004.00430.x.

van Aken, J.E., 2005. Management research as a design science: articulating the research products of mode 2 knowledge production in management. Br. J. Manag. 16 (1), 19–36. https://doi.org/10.1111/j.1467-8551.2005.00437.x.

van Aken, J.E., Berends, H., 2018. Problem Solving in Organizations. Cambridge University Press.

van Aken, J.E., Chandrasekaran, A., Halman, J., 2016. Conducting and publishing design science research: inaugural essay of the design science department of the Journal of Operations Management. J. Oper. Manag. 47–48, 1–8. https://doi.org/10.1016/j.jom.2016.06.004.

van Aken, J.E., Romme, G., 2009. Reinventing the future: adding design science to the repertoire of organization and management studies. Org. Manag. J. 6 (1), 5–12. https://doi.org/10.1057/omj.2009.1.

vom Brocke, J., Hevner, A., Maedche, A., 2020. Introduction to design science research. In: vom Brocke, J., Hevner, A., Maedche, A. (Eds.), Design Science Research. Cases. Springer International Publishing, Cham, pp. 1–13.

Walls, J.G., Widmeyer, G.R., El Sawy, O.A., 1992. Building an information system design theory for vigilant EIS. Inf. Syst. Res. 3 (1), 36–59. https://doi.org/10.1287/isre.3.1.36.

Weber, R., 2018. Chapter 11 - design-science research. In: Williamson, K., Johanson, G. (Eds.), Research Methods, second ed. Chandos Publishing, pp. 267–288.

Wieland, A., 2021. Dancing the supply chain: toward transformative supply chain management. J. Supply Chain Manag. 57 (1), 58–73. https://doi.org/10.1111/jscm.12248.

Zhang, S.X., Van Burg, E., 2020. Advancing entrepreneurship as a design science: developing additional design principles for effectuation. Small Bus. Econ. 55 (3), 607–626. https://doi.org/10.1007/s11187-019-00217-x.

Zheng, J., Knight, L., Harland, C., Humby, S., James, K., 2007. An analysis of research into the future of purchasing and supply management. J. Purch. Supply Manag. 13 (1), 69–83. https://doi.org/10.1016/j.pursup.2007.03.004.