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Design Science Research in Entrepreneurship

Scaffolding Artifacts for the Venturing Process

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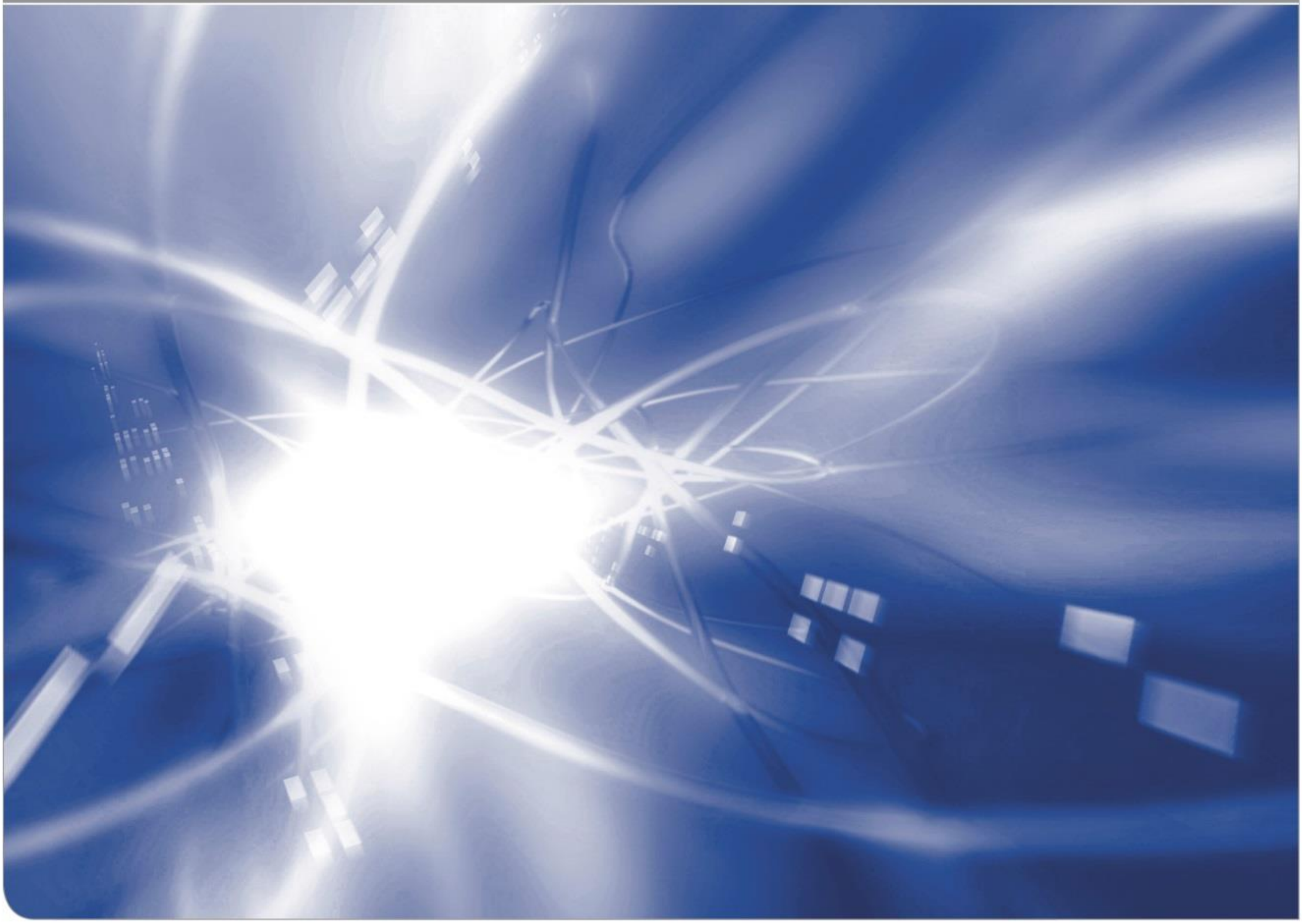

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Abstract: We propose a design science research approach to entrepreneurship. We introduce the notion of 'scaffolding artifacts', which support and enable entrepreneurs to pursue the venturing process. We suggest creating such artifacts in a manner that is inspired by design science practices in information systems. The researcher can build on different knowledge types in the research process by drawing from science and practice. We see the design science researcher as a specific 'third role', which differs from the practitioner and the 'naturalistic' researcher. Design science researchers combine knowledge generation with the design of purposeful artifacts, constituting a third way. In entrepreneurship, this third role may become a fruitful way of looking not just 'at the entrepreneurs but looking with them.[1] We suggest an iterative process with five steps to create scaffolding artifacts. It starts with a heuristic front-end, followed by requirement definition, design and implementation of an artifact, validation, and reflection and communication.

Keywords: Entrepreneurship; new-venture creation; design science; rigor and relevance; the sciences of the artificial

Introduction

In entrepreneurship research and research in the management sciences, there is a long-standing discussion about the 'rigor-relevance gap' as a balance between the scientific contribution and the practical utility of research.[2] The question is to what extent entrepreneurship research can satisfy scientific criteria (rigor) and practical applicability (relevance) at the same time. On an epistemological level, one may ask which research paradigms promise a good balance in this respect.

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[1] Dimo Dimov, *The entrepreneurial scholar.* (Cheltenham, UK, Northampton, MA: Edward Elgar Publishing, Game changers and ground breakers, 2020), 60.

[2] Schon, Donald A. (1983): The reflective practitioner. New York: Basic Books, chapter 2. Kevin G. Corley and Dennis A. Gioia, "Building theory about theory building: what constitutes a theoretical contribution?," *Academy of management review 36*, no. 1 (2011): 12-32.; Juergen Freimann, "Das Theorie-Praxis-Dilemma der Betriebswirtschaftslehre," in *Das Theorie-Praxis-Problem der Betriebswirtschaftslehre* (Gabler Verlag, 1994), 7-24.; Ranjay Gulati, "Tent poles, tribalism, and boundary spanning: The rigor-relevance debate in management research," *Academy of management journal 50*, no. 4 (2007): 775-782.; Alfred Kieser, Alexander Nicolai, and David Seidl, "The Practical Relevance of Management Research: Turning the Debate on Relevance into a Rigorous Scientific Research Program," *Academy of Management Annals 9*, no. 1 (2015): 143-233.; Elco Van Burg and A. Georges Romme, "Creating the Future Together: Toward a Framework for Research Synthesis in Entrepreneurship," *Entrepreneurship Theory and Practice* 38, no. 2 (2014): 369-397.; Andrew H. Van de Ven and Paul E. Johnson, “Knowledge for theory and practice,” *Academy of management review* 31, no. 4 (2006): 802-821.; Andrew H. Van de Ven, *Engaged Scholarship: A Guide for Organizational and Social Research* (New York: Oxford University Press, 2007).

Traditional economics and management research aims to understand, describe, explain, and predict the economic world.[3] However, it may happen that we are not content with merely 'understanding' real-life problems but that we seek to develop interventions and artifacts. These interventions and artifacts may be related to scientific knowledge in various ways. They may be based on scientific knowledge, create new knowledge about the interventions and artifacts, and finally, potentially produce new knowledge related to their application domain. In this sense, it may connect the 'retrospective and prospective aspects of research'.[4] In this perspective, the definition of a particular problem and how to solve it becomes an object of research and scientific interest.[5] As Van Aken puts it, we need prescription-driven research that provides solutions for management problems and description-driven research that enables us to understand its nature.[6] The Business Model Canvas – as a prominent example in the domain of entrepreneurship – is the result of such a combination of research types.[7,8]

The entrepreneurship and management literature has discussed the topic over the past decades.[9] According to Pandza and Thorpe, there are three basic positions on how the two poles relate: (i) Practical relevance and scientific rigor are incompatible. (ii) There is a compromise between practical relevance and scientific rigor. (iii) Practical relevance should become "a cornerstone of a new branch of management studies."[10] We suggest viewing design science research as this new branch of management studies and relating it to Simon's 'Science of the Artificial.' For Simon, natural science deals with how things are, whereas the sciences of the artificial are concerned with how things "ought to be."[11] We suggest that this approach opens an exciting possibility for entrepreneurship research, leading to a systematic study of interventions and artifacts that can serve the practitioner and contribute to the body of scientific knowledge.

Design science is discussed as a research paradigm in various disciplines, including information systems, engineering disciplines, and medical research. For example, the information systems community has developed elaborate frameworks and guidelines for design science research over the past years.[12] As many artifacts in the

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3 Joan E. Van Aken, "Management Research as a Design Science: Articulating the Research Products of Mode 2 Knowledge Production in Management," *British Journal of Management* 16, no. 1 (2005), 33.

4 A. Georges Romme and Isabelle M. Reymen, "Entrepreneurship at the Interface of Design and Science: Toward an Inclusive Framework," *SSRN Electronic Journal* (2018), 5.

5 Dimo Dimov, "Toward a design science of entrepreneurship," *Advances in entrepreneurship, firm emergence and growth* 18 (2016), 22.

6 Joan E. Van Aken, "Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-Tested and Grounded Technological Rules," *Journal of Management Studies 41*, no. 2 (2004), 220.

7 Alexander Osterwalder and Yves Pigneur. *Business model generation: A handbook for visionaries, game changers, and challengers*, Vol. 1. (New York: John Wiley & Sons, 2010).

8 Alexander Osterwalder, "The business model ontology a proposition in a design science approach," PhD diss., Université de Lausanne, Faculté des hautes études commerciales, 2004, Accessed March 3, 2020, https://serval.unil.ch/resource/serval:BIB_R_4210.P001/REF.pdf

9 Joan E. Van Aken, "Management Research as a Design Science: Articulating the Research Products of Mode 2 Knowledge Production in Management," *British Journal of Management* 16, no. 1 (2005), 19-36. Joan E. Van Aken and A. Georges Romme, "A Design Science Approach to Evidence-Based Management," in *The Oxford Handbook of Evidence-based Management*, ed. Denise M. Rousseau (New York: Oxford University Press, 2012), 43-57.; Elco Van Burg and A. Georges Romme, "Creating the Future Together: Toward a Framework for Research Synthesis in Entrepreneurship," *Entrepreneurship Theory and Practice* 38, no. 2 (2014), 369-397.; Dimo Dimov, "Toward a design science of entrepreneurship," *Advances in entrepreneurship, firm emergence and growth* 18 (2016), 1-31.; A. Georges Romme and Isabelle M. Reymen, "Entrepreneurship at the Interface of Design and Science: Toward an Inclusive Framework," *SSRN Electronic Journal, vol. 10* (2018), doi:10.2139/ssrn.3277494.; Berglund et al., "Opportunities as artifacts and entrepreneurship as design," *Academy of Management Review* 45, no. 4 (2020), 825-846.; Christoph Seckler, René Mauer, and Jan vom Brocke, "Design science in entrepreneurship: Conceptual foundations and guiding principles," *Journal of Business Venturing Design* 1, no. 1-2 (2022) (to appear).

10 Krsto Pandza and Richard Thorpe, "Management as design, but what kind of design? An appraisal of the design science analogy for management," *British Journal of Management* 21, no. 1 (2010), 171.

11 Herbert A. Simon, *The Sciences of the Artificial* (Cambridge: MIT Press, 1969), 5.

12 Alan Hevner et al., "Design science in information systems research," MIS quarterly (2004), 75-105.; Ken Peffers, Tuure

information systems domain refer to an organizational or business context, the approaches in this field are an interesting source of inspiration for design science methods in entrepreneurship.

This paper contributes to the literature on entrepreneurship research methodologies and suggests an approach that balances scientific rigor and practical utility.[13,14] We argue that the mode of activity of the design scientist is valuable for entrepreneurship research. We can learn from related design disciplines and adopt successful design principles and guidelines for entrepreneurship researchers. This will enable them to develop purposeful, grounded, and evidence-based interventions that serve practitioners to solve problems while simultaneously contributing to the body of knowledge.

The paper is organized as follows. First, we introduce some basic concepts. Second, we suggest three roles: the practitioner, the 'naturalistic scientist,' and the 'design scientist'. Subsequently, we discuss the types of artifact features and the knowledge related to the artifact specification. In the following section, we give examples of artifacts in entrepreneurship and discuss to which extent they can be seen as design science efforts. As a synthesis, we suggest guidelines that can be applied in Design Science Research projects. In our conclusion, we show how the paper connects entrepreneurship theory and practice systematically and gives an outlook.

Basic Concepts

In this section, we would like to reflect on some basic concepts to gain clarity for what follows.

Design

Let us start with the word 'design'. It is a word with a rich history and complex semantics. If you look it up in a dictionary, you find various meanings for both the verb and the noun: to create and fashion, to conceive and plan out in mind, to intend, to devise for a specific function, and to make a drawing, pattern, or sketch. 'Design' refers to drawings, patterns, or sketches.[15] The modern understanding of the term seems to go back to the Renaissance 'Accademia del Disegno' in Florence, founded by Giorgio Vasari. In ordinary Italian, "disegnare" means to draw or sketch something.[16]

Hevner & and Chatterjee quote Charles Eames (an American designer, architect, and filmmaker) with the following definition for 'design': "A plan for arranging elements in such a way as to accomplish a particular

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Tuunanen, Marcus A. Rothenberger, and Samir Chatterjee, "A design science research methodology for information systems research," *Journal of management information systems* 24, no. 3 (2007), 45-77.; Alan Hevner, and Samir Chatterjee, "Design science research in information systems," in *Design research in information systems* (Boston: Springer, 2010), 9-22.; Frederik Ahlemann et al., "A process framework for theoretically grounded prescriptive research in the project management field," *International Journal of Project Management* 31, no. 1 (2013), 43-56.; Paul Johannesson, and Erik Perjons, *An introduction to design science* (Springer, 2014).; Richard Baskerville et al., "Design science research contributions: Finding a balance between artifact and theory," *Journal of the Association for Information Systems* 19, no. 5 (2018).; Jan Vom Brocke, Alan Hevner, and Alexander Maedche, eds. *Design Science Research. Cases* (Cham: Springer (Progress in IS), 2020).

[13] Kevin G. Corley and Dennis A. Gioia, "Building theory about theory building: what constitutes a theoretical contribution?," *Academy of management review* 36, no. 1 (2011): 12-32.; Andrew H. Van de Ven and Paul E. Johnson, "Knowledge for theory and practice," *Academy of management review* 31, no. 4 (2006): 802-821. Andrew H. Van de Ven, *Engaged Scholarship: A Guide for Organizational and Social Research* (New York: Oxford University Press, 2007).

[14] Per Davidsson, "Looking back at 20 years of entrepreneurship research: what did we learn?," in: *Entrepreneurship sustainable growth and performance*, ed. Hans Landström, Hans Crijns, Eddy Laveren, and David Smallbone (2008), 13-26.; Michael Frese et al., "Evidence-based entrepreneurship: Cumulative science, action principles, and bridging the gap between science and practice," *Foundations and Trends in Entrepreneurship* 8, no. 1 (2012).; R. Duane Ireland, Justin W. Webb, and Joseph E. Coombs, "Theory and methodology in entrepreneurship research," in *Research methodology in strategy and management*, Vol. 2, ed. David J. Ketchen and Donald D. Bergh 2, no. 3 (2005), 111-141.

[15] „Design," Merriam-Webster.com, Accessed June 7, 2020. https://www.merriam-webster.com/dictionary/design.

[16] Karen-Edis Barzman, *The Florentine Academy and the Early Modern State the Discipline of "disegno"(*Cambridge: Cambridge University Press, 2000).

purpose best."[17] They see design as a system of instructions based on specific knowledge that turns things into something valuable and something people use. In line with this understanding, design is a plan according to which you make things. It is the blueprint for a purposeful arrangement, not necessarily the arrangement itself. It is the instruction rather than its implementation. An example of a design is a set of drawings for constructing a machine or building.

As designing is tightly connected with instruction and planning, it is not purely formal or logical because creativity, intuition, and inspiration play an important role. As Amabile states, creativity leads to a "novel and appropriate response, product, or solution to an open-ended task."[18] Here, 'appropriate' means that the solution must be valuable, feasible, and fit a particular goal. 'Open-ended' means that there is no single, obvious, or purely algorithmic solution to the task.

Ultimately, a response is creative to the extent that it is recognized as creative by people familiar with the domain in which it was produced. Thus, "being designed" refers to the reasonable form of activities, which are nevertheless by no means the result of purely logical decisions alone nor just the instantiation of a scheme of activity. By using 'designed' as a qualifier for an activity's respective form, we want to emphasize the difference between understanding the pure result of an activity and the wise and mode in which some action or activity is performed and executed.

Not being purely logical does not imply that rationality has no place in design. Indeed, design often builds on rational knowledge but goes beyond it.

Science

The notion of knowledge is linked to our second term, 'science'. What constitutes science is a big question that is beyond the scope of this paper. Still, we need to say some words to clarify why speaking about the 'design scientist' makes sense.

Since Bacons Novum Organon it is widely accepted that a prominent goal of science is to develop knowledge as well as know-how[19]. In its more mature form, knowledge is organized in theories that formulate 'laws of nature' or at least 'regularities' of natural or social phenomena, establish cause and effect relationships, describe dispositions and typologies, provide frameworks of explanation, reduction, and prediction and establish specific patterns of epistemic injunction (which might be addressed by the Kuhnian term 'paradigm').[20,21]

Based on a paradigm, we can derive hypotheses, which must be falsifiable, as they should be tested empirically. Empirically validated theories form the body of accepted knowledge in many scientific contexts.

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17 Alan Hevner and Samir Chatterjee, "Design science research in information systems," in *Design research in information systems* (Boston: Springer, 2010), 1.

18 Teresa M. Amabile, "Componential theory of creativity," Harvard Business School Working Paper, no. 12-096 (2012), 1.

19 This process may lead to a purely instrumentalist concept of science, reducing effectively knowledge to know-how.

20 Kuhn provides a purely reconstructive or historical concept of paradigm; we are applying paradigm as a cover term for the complex and intricate aspects of actual scientific research mentioned above.

21 Thomas S. Kuhn, *Die Struktur wissenschaftlicher Revolutionen. 2. rev. und um das Postskriptum von 1969 erg*, 20th ed. (Frankfurt am Main: Suhrkamp, 1989).; Karl R. Popper, *Logik der Forschung. 9., verb. Aufl.* (Tübingen: Mohr, 1989).; Peter Janich, *Kleine Philosophie der Naturwissenschaften*, (Munich: C.H. Beck, 1997).; Ian Hacking, *Introduction to the Philosophy of Science* (Stuttgart: Reclam, 1996).

As to the conduct of scientific research, many believe there is no simple recipe or set of rules that prescribes the scientific procedure. Scientific discovery is a complex process that mirrors the complexity of our epistemic and practical relations to the world and our coping with it on several scientifically relevant levels.[22]

This observation leads to a non-Positivist view of science, emphasizing the systematic (and not only heuristic) value of 'abductive' reasoning.[23] This view avoids typical hypothetical-deductive approaches, which usually underestimate the relevance of finding dispositional regularities by modeling and pre-structuring data: for the formulation of natural laws, the discovery and description of regularities are central. Deduction and induction play a crucial role in the scientific process, but only insofar as we have already gained some instructive starting points.[24]

In contrast to both procedures, 'abduction' (or 'retroduction' in Peirce's terms) aims to find a starting point for the process of reasoning itself, which shows some similarity to probing several keys to open a door.[25] We explicitly refer to the 'abductive' procedures in sciences, as we think they relate particularly to design science research. As we will see below, there is a stage where heuristic search and abductive reasoning are prominent in the design science process.

Finally, by 'research', we refer to a practice of generating knowledge. It is about a search that 'involves care, and it involves looking for something which is defined in advance.'[26] The 'care' is linked to a set of methods and procedures and to the practice of thorough reporting. It is about the systematic and intersubjective collection, interpretation, and evaluation of data to create scientific knowledge.

Artifacts

Artifacts are essential outcomes of design science research. Therefore, it is important to clarify the term 'artifact.' We do not want to reduce 'artifact' to the pure results of design[27]. Instead, we wish to include the constitutive process as well as its use and application in different contexts. We see an artifact as a practical unit consisting of a multitude of causally ordered elements, standing in functional relations to each other and to the unit itself in terms of effective, efficacious, and causal knowledge.[28]

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[22] Heinz R. Pagels, *The dreams of reason: The computer and the rise of the sciences of complexity* (New York: Bantam Books, 1989).; Ian Hacking, *Introduction to the Philosophy of Science* (Stuttgart: Reclam, 1996).; David L. Hull, *Science as a Process* (The University Press, 1988).; Nancy Cartwright, *Nature's Capacities and their measurement* (Oxford: Oxford University Press, 1989).; Peter Janich, *Kleine Philosophie der Naturwissenschaften* (Munich: C.H. Beck, 1997).

[23] Covering a lot of positions differing in detail (e.g. Carnap, 1986, Popper 1989), our use of the term simply refers to the central assumption of some "given" data-set independent of a description; in our case, this would be the problem itself, which we assume to be utterly description-depending.

[24] Charles S. Peirce, "A Neglected Argument for the Reality of God," in *Charles S. Peirce: Selected Writings*, ed. Philip P. Wiener (New York: Dover Publications Inc., 1958), 370.

[25] Of which we already know, that they are keys, i.e. that they – at least once – contributed to a problem-solution. To put it more generally with Aristotle (anal. post. 71a1) "Πᾶσα διδασκαλία καί πᾶσα μάθησις διανοητικὴ ἐκ προϋπαρχούσης γίνεται γνώσεως"; on the problem of methodical starting points see Gutmann (2017).

[26] Frayling, Christopher (1993): Research in art and design. *Royal College of Art* 1, 1.

[27] Seeing an artifact as the result of the design process may be its original meaning inspired by the Aristotelian differentiation between φύσις and τέχνη (=ars, hence artifex and artifact). The 'thing made by man' as opposed to the 'thing made by nature' is the ‚technasma' (τέχνασμα) or artifact.

[28] This definition applies to all kinds of tools – irrespective of their actual physical structure because a tool is not just a 'thing' that we 'apply' to realize some presupposed aims. The most important aspect of tools is that they are being used as well as how this is done. We tend to overlook exactly these aspects of their "being ready to hand", by reducing artifacts to their objective appearance, being "present at hand" (Heidegger's 'Zuhandensein').

The artifact is human-made, with a goal outside the domain of pure cognition. The goal of a bridge is not restricted to knowledge; its main goal is to establish a connection between two sides of a river.

The business model canvas (BMC) can be seen as an example of an artifact in entrepreneurship. It consists of its nine building blocks, their arrangement, and their headings (and semantics). In addition, knowing how to work with it, moderating a BMC workshop, and being aware of its advantages and limitations are part of its definition.[29]

This pragmatist form of definition keeps in mind that the use and application of an artifact have no strictly causal relation to its structure: neither can we infer the structure of an artifact from its function nor vice versa[30]. According to this indeterminacy, we must be cautious to directly connect the successful construction of an artifact with its successful application.

Gregor and Hevner use the term 'artifact' to refer to something "that has, or can be transformed into a material existence as an artificially made object (e.g., model, instantiation) or process (e.g., method, software)".[31] In our context, we suggest considering artifacts as an entity (e.g., objects, processes, principles) related to some specific task and purpose in entrepreneurship.

It is important to stress that the artifact embeds a solution to an understood task or problem in design science research. It is a means to an end, a 'tool' in the broader sense. In this context, Romme defines the artifact as a 'socially constructed vehicle' with a functional meaning.[32] The 'vehicle' metaphor suggests that the artifacts are means to 'transport' the user from one state to another, again stressing the means-to-an-end aspect.

An artifact is 'the cause embodying the intended effect (solve the problem).'[33] We discern causes and effects in naturalistic scientific research and develop hypotheses about regularities. Once we have articulated some hypotheses, by deductive reasoning, we predict effects and evaluate our initial hypotheses through empirical data[34]. In design science, we reverse the logic. Given the laws (or theories), we try to design an artifact, which is the cause for the desired effect. We try to produce effects that serve the purpose we have in mind. In this sense, we can describe artifacts as the embodiment of effectual knowledge.

Dimov, referring to March and Smith, argues that design and science are interrelated in three ways: (1) the artifacts created through design can become the subject of scientific inquiry; (2) artifacts are created with an understanding of laws and regularities; (3) the effectiveness of artifacts can provide substantive tests for 'naturalistic' theories.[35,36] This implies that design science research goes beyond knowledge creation for the sake

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[29] As far as we see, even an algorithm falls under this definition – which is "practical" in a comprehensive way (including πρᾶξις in the sense of communicative action as well as ποίησις in the sense of instrumental action).

[30] In biology, we can discern the functionality of structure given in terms of the causal relations between its constituents (say the muscles, tendons, connective tissue, bones, etc. of a vertebrate's forelimb) and the fungibilty or use of this structure: on the one side, the said structures can be used for different purposes say flying, digging, swimming and walking, on the other side it is possible to perform one and the same activity with different organic structures (for further reading s. Gutmann 2002, 2012).

[31] Shirley Gregor and Alan Hevner, "Positioning and presenting design science research for maximum impact," *MIS quarterly* (2013): 341.

[32] A. Georges Romme, "Organizational Development Interventions: An Artifaction Perspective," *The Journal of Applied Behavioral Science 47*, no. 1 (2011): 12.

[33] Andreas Drechsler and Alan Hevner, "Effectuation and its implications for socio-technical design science research in information systems," in *At the Vanguard of Design Science: First Impressions and Early Findings from Ongoing Research Research-in-Progress Papers and Poster Presentations from the 10th International Conference, DESRIST 2015* (Dublin, Ireland, 2015): 2.

[34] E.g. the thermodynamic equation of state, which allows us to understand the dispositional functions as special cases.

[35] Dimo Dimov, "Toward a design science of entrepreneurship," *Advances in entrepreneurship, firm emergence and growth* 18, (2016), 7.

[36] Salvatore T. March and Gerald F. Smith, "Design and natural science research on information technology," *Decision*

of knowledge. And it also goes beyond the creation of an artifact for the mere sake of utility. Indeed, it combines both, and there is a systematic method (with many variations) by which design scientists typically create and validate artifacts.

Scaffolding

It is important to distinguish between two different domains of design in entrepreneurship. First, there are the entrepreneurs and their venturing projects. In their pursuit of value creation, they identify opportunities, mobilize resources, execute their vision, and manage risks.[37] In their business venturing project, entrepreneurs are involved in various design activities. Berglund et al. see opportunities as artifacts and entrepreneurship itself as design.[38] The entrepreneurial artifact can be seen as the venture itself. Entrepreneurs indeed create many more artifacts. They design products, business models, pitch deck narratives, etc. They act as 'business architects' envisioning and designing a new organization.

Second, there is the entrepreneurship researcher or – in a broader perspective – the 'entrepreneurial scholar' with a research interest in descriptive and prescriptive knowledge. One possibility for such a scholar is to design artifacts based on scientific knowledge, validated through scientific methods, and to support the entrepreneurs as acting subjects in their venturing projects.[39]

The analogy to 'scaffolding' may help clarify the relationship. The term was first used in pedagogy. Wood, Bruner, and Ross deal with the role of tutoring in problem-solving.[40] 'Scaffolding' is a metaphor to describe a particular way of support by educators, coaches, or peers to accomplish a task. Berglund et al. speak of "[…] artifacts that can […] function as cognitive scaffolds, where the main purpose is to alter […] the way we think".[41] Entrepreneurship design science research can significantly contribute by developing 'scaffolding artifacts.' They are designed to help the entrepreneur to master a task effectively and efficiently. *Scaffolding artifacts are 'devices' or methods that assist entrepreneurs in fulfilling a task* – often in cooperation with agents from the entrepreneurial support system (educators, coaches, peers, and others). Science comes into play as soon as these artifacts draw from scientific knowledge, are validated with scientific methods, and produce new knowledge.

Prominent examples of scaffolding artifacts in entrepreneurship are the business model canvas mentioned above, the 'Lean Startup' method[42], and the various templates used in the 'Design Thinking' process.[43]

Support Systems 15, no. 4 (1995), 255.

[37] Thomas H. Byers, Richard C. Dorf, and Andrew J. Nelson, *Technology ventures. From idea to enterprise* (New York: McGraw-Hill Education, 2019), Kindle Edition, pos 497, chapter 1.

[38] Henrik Berglund, Marouane Bousfiha, and Yashar Mansoori, "Opportunities as artifacts and entrepreneurship as design," *Academy of Management Review 45*, no. 4 (2020), 825.

[39] Dimo Dimov, *The entrepreneurial scholar* (Cheltenham, UK, Northampton, MA: Edward Elgar Publishing (Game changers and ground breakers), 2020), 60.

[40] David Wood, Jerome S. Bruner, and Gail Ross, "The Role of Tutoring in Problem Solving" *Journal of Child Psychology and Psychiatry* 17, no. 2 (1976), 90.

[41] Henrik Berglund, Marouane Bousfiha, and Yashar Mansoori, "Opportunities as artifacts and entrepreneurship as design," *Academy of Management Review* 45, no. 4 (2020), 831.

[42] Eric Ries, *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses* (New York: Crown Business, 2011).

[43] Michael Lewrick, Patrick Link, and Larry Leifer, *The Design Thinking Playbook: Mindful Digital Transformation of Teams, Products, Services, Businesses and Ecosystems* (Hoboken, New York: John Wiley & Sons, 2018).

Just like scaffolds are used to construct buildings, these scaffolding artifacts are used in the venturing process. As soon as the entrepreneurs take responsibility for the task and develop the competence to accomplish it, scaffolding is removed and fades out.

In a paper on prescriptive research in the project management field, Ahlemann states that "project management methods can be regarded as artifacts that have been designed to assist project managers during their work."[44] We can again see the two distinct levels: 'scaffolding artifacts' enable project managers to develop their 'project artifacts.'

Interestingly, some of the commonly used artifacts in entrepreneurship have been developed in a practitioner context (e.g., the Lean Startup approach), while some emerged in a more academic context (e.g., the foundations of the business model canvas were created in a Ph.D. thesis). Some examples have been developed in a conscious design science research mode, like guidelines for university spin-offs and a framework for competitor analysis for startups.[45,46]

We want to emphasize that scaffolding artifacts are not the only way to contribute to design science in entrepreneurship. Valuable contributions have been made with, e.g., design principles. Design principles are a "coherent set of normative ideas and propositions, grounded in […] research, which serve to design and construct detailed solutions."[47]

Roles and Modes

So far, we have talked about some basic concepts in the context of design science. Let us now suggest three distinct roles and modes that may clarify different approaches to the same domain.

To do so, we suggest focusing on an example of information systems (IS) research. We can discern analytically[48] between three distinct roles in this context: the practicing information system developer, the techno-organizational sociologist, and the design scientist in IS. All three, in their own way, deal with information technology and its impact on human actors and organizations, but they do so in distinct and different modes.

Practicing IS engineers (application developers) make efforts to understand the needs of concrete users in a concrete application domain. Based on their educational knowledge and professional experience, they suggest and implement concrete solutions. This role is mainly concerned with 'operation,' that is, with solving concrete problems of concrete people and organizations in concrete situations. We will refer to this mode as 'operational mode' (modus operationis).

The goal of the practitioner is to develop a solution. To the extent needed, developers gather and compile knowledge, but the focus remains on developing a useful artifact. As a possible side effect, the practitioner may create relevant and interesting data and new knowledge based on experiences with and around the artifact. Often, the knowledge gathered by practitioners is effectual knowledge (knowledge related to efficacy)[49]. This

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44 Frederik Ahlemann et al., "A process framework for theoretically grounded prescriptive research in the project management field," *International Journal of Project Management* 31, no. 1 (2013), 43-56.

45 Elco Van Burg et al., "Creating University Spin-Offs: A Science-Based Design Perspective," *Journal of Product Innovation Management* 25, no. 2 (2008), 114-128.

46 Nadja Hatzijordanou, *Competitor Analysis Framework* (Karlsruhe: KIT Open, 2019), DOI: 10.5445/IR/1000104208.

47 van Burg, Elco; Romme, A. Georges L.; Gilsing, Victor A.; Reymen, Isabelle (2008): Creating university spin-offs. A science-based design perspective. In *Journal of product innovation management* 25 (2), 116.

48 Accordingly, we do not assume these roles to be considered ontological constituents but aspects of human activities.

49 In German, there is a special word for effectual knowledge: *Bewirkungswissen*.

knowledge may be decisive for the practice, is mostly episodic, and often 'pre-scientific,' as the practitioner is not focused on knowledge-centric processes and standards.

Second, we consider techno-organizational sociologists. This role is about science in the traditional sense and knowledge creation for the sake of knowledge. The prevalent mode of this role is the cognitional mode (modus cognitionis), where the activity is characterized by emphasizing theory construction and empirical validation[50]. It creates knowledge about how organizations, organizational sub-systems, processes, structures, technical systems, culture, and human actors behave and interact.

Typically, this role proposes models to gain insights into cause-and-effect relationships. It develops theories to explain the function (or dysfunction) and behavior of organizational systems. And it then seeks to validate or falsify the theories by gathering and interpreting empirical data.

Third, we consider design scientists in information systems. IS design scientists invest significant time and professional effort in a specific form of scientific research. They typically focus on the needs of very specific and new IS problems, often combined with novel technical possibilities. They play a critical role in translational research, connecting basic research findings (e.g., from sociology, psychology, informatics, or computer science) to IS applications. IS design science researchers typically transfer discoveries into effective novel approaches, transforming the mode of the solution itself. They develop new artifacts, but they may also suggest new concepts and theories (on design or the domain or technologies under consideration) and provide relevant empirical data fed back into the overall scientific discourse.

The activity for this role is mainly related to the third mode[51], which we call the transformational mode (modus transformationis). What design scientists have in common with practitioners is that they develop artifacts; what they have in common with the 'naturalistic' scientist is that they produce knowledge following accepted scientific methods and standards.

These three roles also appear in other domains. Although the example of medicine includes further aspects, we again find the three roles mentioned above. (i) Practicing physicians serve concrete patients in their concrete circumstances (operational mode). (ii) Human biologists or physiologists see the body as an object of natural sciences (cognitional mode) (iii) Medical researchers or physician-scientists are clinical physicians with a focused specialization and related 'designs' like diagnostic and therapeutic interventions (transformational mode).[52]

The three roles also exist in entrepreneurship. Here, we want to focus on the creation and application of scaffolding artifacts, on the devices, methods, and practices that entrepreneurs will apply in their venturing process. With this focus in mind, we first see the practitioners. There are mentors, consultants, coaches, and entrepreneurship educators, but also experienced executives and investors who all support entrepreneurs and enterprising teams around concrete projects, concrete people, and concrete situations. Based on their education, experience, and 'best practices,' they try to understand the challenges and find solutions. These practices often come from the accumulated experience of the individuals or the ecosystems in which the practitioners operate.

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[50] With the term ‘theories’, we do not only refer to scientific theories but also to theories of everyday life, see table 1.
[51] Like “roles” the “modes” of activities are analytic distinctions. So, even if the modus transformationis is predominantly connected here to “design” (and insofar to “design science”), it can be found in all three roles.
[52] In the US, there are special ‘Medical Scientist Training Programs’ (MSTPs), supported by the National Institutes of Health (NIH). This kind of research is not human biology but designs diagnostics and interventions. https://www.nigms.nih.gov/Training/InstPredoc/Pages/PredocOverview-MSTP.aspx Accessed in February 2020.

Usually, there is no systematic evidence of whether these practices are causally related to the company's success.[53]

Second, we see the role of the 'naturalistic' entrepreneurship researcher. In this role, the cognitional mode is prevalent. This scientific community develops theories with constructs and relationships, derives hypotheses, and validates or falsifies them empirically. With evidence-based knowledge, research sheds light on the phenomena related to entrepreneurship and describes, explains, and, where possible, predicts them.
The third role, the entrepreneurship design science researcher, is, e.g., concerned with the design of 'scaffolding artifacts' that respond to relevant challenges of entrepreneurs and innovators. Design science researchers will build on a scientific knowledge base to create purposeful artifacts. These artifacts will become the object of scrutiny and rigorous scientific investigation in the validation effort. Researchers identify relevant problems, compile knowledge, create designs, validate them empirically, and (where possible) explain why the artifacts work. To use van Aken's words, this mode deals with tested and grounded artifacts. 'Grounding' means relating the design process with scientific knowledge and explanation, while 'testing' stresses the need for empirical validation of artifacts.[54]

Knowledge types

Johannesson and Perjons point out that "in traditional crafts, representing and transferring design knowledge is most commonly done by embedding it within objects.[55] "This is […] because objects are able to embed design knowledge with all its richness and nuance."

The scaffolding artifacts we have in mind (which may be objects or processes) embed such knowledge. They respond to recurring challenges of business venturing. Examples are topics like opportunity recognition/construction, problem/solution fit, product/market fit, management of financial resources, team dynamics, pricing or cost issues, competition, conception and implementation of a business model, positioning in value creation networks, venture financing, and investor relations, or set-up and growth of an organization. Artifacts responding to such challenges are based on knowledge, embody knowledge, and their application can become the source of empirical data and evidence. In this context, it is worth reflecting on the different types of knowledge that come into play.

A key goal of design science research is to develop something that creates a purposeful impact. In other words, designing an effective artifact is important (and often not trivial). This means that we deal with effectual knowledge, which complements explanatory knowledge. Sometimes, people refer to effectual knowledge as 'know-how' and explanatory knowledge as 'know that.'[56] An interesting aspect is that 'know-how' is often related to tacit knowledge embedded in a given practice, and making this tacit knowledge explicit may be challenging. The creation of artifacts can be conceived as a cultural achievement of acting people under concrete contextual conditions. This perspective is close to a broader discourse in the philosophy of technology. Technology can be seen as the knowledge-based creation of purposeful artifacts.[57] In the context of the cultural turn (e.g., Janich

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53 Alfred Kieser and Alexander Nicolai, "Trotz eklatanter Erfolglosigkeit: Die Erfolgsfaktorenforschung weiter auf Erfolgskurs," *Die Betriebswirtschaft, DBW Stuttgart 62*, no. 6 (2002): 593.
54 Joan E. Van Aken, "Management Research as a Design Science: Articulating the Research Products of Mode 2 Knowledge Production in Management," *British Journal of Management* 16, no. 1 (2005): 19.
55 Paul Johannesson and Erik Perjons, *An introduction to design science* (Springer, 2014), 39.
56 Jason Stanley, "Knowing (How)," *Noûs* 45, no. 2 (2011), 207-238.
57 In this sense, we could talk about the development of 'entrepreneurship technology' when we talk about 'scaffolding artifacts'.

and Hartmann), human activity is conceived as a unit of design, theory, practice, and experience. This is true for our daily life and its quotidian situations as it is true for scientific activities.[58] Therefore, 'theory' is neither a synonym for 'science' nor 'practice' a synonym for 'everyday lifeworld.' Science and everyday lifeworld are different forms of human activities, including conceptualizations, experiences, practices, and designs.

Based on these considerations, we suggest four types of knowledge. They refer to effectual and explanatory knowledge in 'practitioner' and 'scientist' contexts. The design science process draws on all knowledge types to penetrate the situations and the challenges to develop creative solutions. However, design scientists follow accepted scientific methods and standards regarding validation and explanation.

Diverse sources of information are thus considered for the 'relevance' and 'rigor' cycles.[59] They may become the basis for abductive reasoning, which will suggest new solutions or make proposals for theory building.

Effectual knowledge is well-known in the practitioner context. It includes the content of 'how to' books, 'step-by-step guides,' 'checklist' and 'success recipes' literature.

This form of effectual knowledge can be part of the initial knowledge base. Design science may start from such considerations, but it will go beyond and 'lift' it into a form of knowledge that both formally and empirically uses other standards.

Let us briefly comment on the knowledge type of scientific effectual knowledge. Hevner and Chatterjee argue that the "prescriptive knowledge of artifacts forms a knowledge area of its own and cannot be reduced to the descriptive knowledge of theories and empirical regularities."[60] Gregor and Jones stress that expressing design knowledge as a theory means we give a sounder basis for arguing for the rigor of design science disciplines.[61] It goes beyond the scope of the article to go deeper into these questions. Still, we would like to stress that the question of how to gain and express effectual knowledge is a relevant epistemological question in design science research.

Guidelines for Entrepreneurship Research as Design Science

In the previous sections, we discussed some background for design science research and looked at examples in the domain of entrepreneurship. Our objective is not only to describe and understand the role of the design scientist but also to give clear guidelines for executing and evaluating entrepreneurship research as design science.

We draw on different papers and compile them into a framework that we consider suitable for design science research in entrepreneurship.[62] As stated above, grounded and validated artifacts are an essential output of

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[58] Peter Janich and Dirk Hartmann, *Die kulturalistische Wende: Zur Orientierung des philosophischen Selbstverständnisses* (Frankfurt am Main: Suhrkamp, 1998).
[59] Alan Hevner et al., "Design science in information systems research," *MIS quarterly* (2004), 80.
[60] Alan Hevner, and Samir Chatterjee, "Design science research in information systems," in *Design research in information systems* (Boston: Springer, 2010), 63.
[61] Shirley Gregor and David Jones, "The anatomy of a design theory," *Journal of Association for Information Systems* 8, no. 5 (2007), 1.
[62] Alan Hevner et al., "Design science in information systems research," *MIS quarterly* (2004), 75-105.; Ken Peffers et al., "A design science research methodology for information systems research," *Journal of management information systems* 24, no. 3 (2007):45-77.; Alan Hevner and Samir Chatterjee, "Design science research in information systems," in *Design research in information systems* (Boston: Springer, 2010), 9-22.; Joan E. Van Aken and A. Georges Romme, "A Design Science Approach to Evidence-Based Management," in *The Oxford Handbook of Evidence-based Management*, ed. Denise M. Rousseau (New York: Oxford University Press, 2012): 43-57.; Paul Johannesson, and Erik Perjons, *An introduction to*

design science research. Consequently, we find a design activity at the heart of all mentioned approaches. Before entering this activity, it is necessary to explore a problem, gather data and information around it, and define the requirements for a solution. On the other side, once the artifact has been developed, it is essential to validate it. Finally, the artifact and the related knowledge must be communicated to the communities of design scientists and users.

We, therefore, suggest a framework of five core activities: (i) Heuristic Front-end, (ii) Requirement Definition, (iii) Artifact Design, (iv) Artifact Validation, and (v) Reflection and Communication to the scientific and practitioner communities (see figure 1).

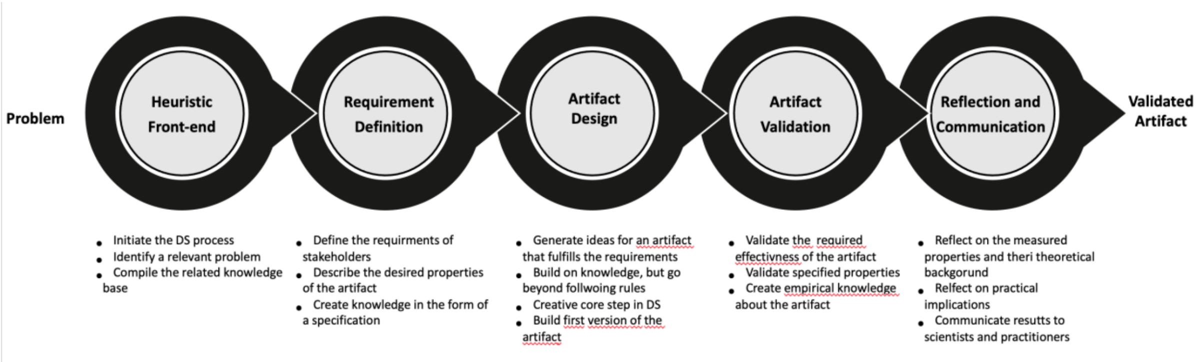

Figure 1: The idealized procedure of the design science researcher

The sequence of these activities follows an inherent logic, but they may occur in iterations with potentially varying sequences. Let us look at these activities in more detail.

Heuristic Front-end

'Heuristic' stems from the Greek word heuriskein, which means 'to find.' This initial activity concerns finding a relevant problem and identifying the related knowledge base.

Four different types of knowledge play a role: explanatory practical knowledge and effectual practical knowledge, as well as explanatory scientific knowledge and effectual scientific knowledge. This knowledge base creates a rich foundation for the identification of challenges as well as for design ideas (that is, ideas for potential artifacts).

We want to indicate how these four knowledge types can be collected in the form of typical questions for each type. These questions may be seen as a first input to set up an interview guideline for qualitative research or perform a systematic literature review or mapping.[63] [64] [65]

design science (Springer, 2014).; Dimo Dimov, "Toward a design science of entrepreneurship," *Advances in entrepreneurship, firm emergence and growth* 18, (2016), 1-31.; John Venable, Jan Pries-Heje, and Richard Baskerville, "FEDS: a Framework for Evaluation in Design Science Research," *European Journal of Information Systems* 25, no. 1 (2016), 77-89.; Richard Baskerville et al., "Design science research contributions: Finding a balance between artifact and theory," *Journal of the Association for Information Systems* 19, no. 5 (2018): 3.

63 Philipp Mayring and Thomas Fenzl, "Qualitative Inhaltsanalyse," in *Handbuch Methoden der empirischen Sozialforschung* (Wiesbaden: Springer VS, 2014), 543-556.; Matthew B. Miles, A. Michael Huberman, and Johnny Saldaña, *Qualitative data analysis: A methods sourcebook* (Thousand Oaks: Sage publications, 2014).

64 Jan vom Brocke et al., "Reconstructing the giant: On the importance of rigour in documenting the literature search process," *ECIS,* vol. 9 (2009), 2206-2217.; Barbara Kitchenham et al., "Systematic literature reviews in software engineering–a systematic literature review," *Information and software technology* 51, no. 1 (2009), 7-15.

65 Kai Petersen et al., "Systematic Mapping Studies in Software Engineering," in *12th International Conference on*

In the field environment, questions that relate to factual or explanatory knowledge may be: What are your problems regarding X (the object of research, e.g., recognition of opportunities, competitor analysis, testing of business ideas, etc.)? How would you describe the context of the problem? Why does the problem exist? What are its consequences?

Concerning effectual knowledge from the field environment, you may ask experts questions like: How do you deal with this challenge or solve the problem today? Why do you think your solution works or has limitations? What are the requirements for a good solution?

In addition to qualitative research, reviewing the practitioners' sources may make sense. This includes books, guides, and web sources. These sources can shed light on the problem space and provide the first ideas for the artifact design.

You may use well-known approaches in academic research to find relevant explanatory and factual knowledge in science. You may ask questions like the following: Which theories and empirical data are relevant to the problem? Is there a textbook or similar review that summarizes the relevant scientific knowledge? If such a summary is not available, What are adequate research questions that can become the starting point of a systematic literature review?

Effectual knowledge from the scientific domain may also be vital for the design process. The following questions may help in this respect: Which design science projects around the topic can be found in the scientific literature? Which scientific theories, methods, and practices may be relevant for solving the problem? How can these scientific theories, methods, and practices be applied or adapted to suggest an artifact?

Requirement Definition

In this step, the problem identified and the knowledge compiled must be translated into requirements for potential solutions. The guiding question is: Which requirements for the artifact are important for the stakeholders?

In this step, the design scientist systematically gathers information and creates descriptive knowledge in the form of a specification. The desired effects and properties of the artifact are made explicit in this step. The specification will be used for the design and development as well as for the validation of the artifact.

There is a broad range of specification categories mentioned in the literature. They include efficacy, efficiency, quality, utility, innovation, performance, usability, flexibility, reliability, elegance, ethicality, adaptability, and portability.[66]

An essential aspect of the specification is the core functional requirement. Artifacts are designed to serve a specific purpose, and making this purpose explicit is an indispensable part of the specification. But as the list above shows, requirements may reflect many more aspects. It is a core task of design scientists to analyze and compile the information and knowledge gathered in the heuristic front-end and make decisions to come up with a sound and justified specification. Requirement definition is not a purely analytic process but also a matter of informed choice to emphasize certain priorities. For instance, one may look for solutions that show excellent usability and learnability to facilitate the diffusion of an artifact, while other aspects may be considered to be secondary.

Evaluation and Assessment in Software Engineering (EASE) 12, 2008), 1-10.

[66] Paul Johannesson and Erik Perjons, *An introduction to design science* (Springer, 2014), 110.; ISO norm 9126.

The core design science process has been described repeatedly as iteration.[67] One may start with the first set of requirements, create an artifact, validate it, and thus generate empirical knowledge. The requirements may be revised, extended, or adapted based on this knowledge.

Artifact Design

After understanding the problem, gathering and compiling related knowledge, and translating it into a requirement definition, we design a purposeful artifact that addresses the chosen problem and responds to the specification. One can consider three sub-phases in this activity: the creative generation of ideas, the selection of an idea, and artifact development.

Idea generation is a creative activity and not restricted to mere analysis and observation. Design can build on rational knowledge but indeed goes beyond it. Authors like Amabile[68] and Csikszentmihaly[69] have described the creative process in the business context. It has also been discussed in the context of information systems, e.g., by Garfield et al.[70] In the ideation step of the design science process, the main goal is to generate ideas for adequate artifacts. Based on the problem formulation, the scientific and practical knowledge base, and the requirements definition, it is about finding potential solutions that address the challenge under consideration. In addition, novelty is desirable, as design science research seeks to extend the limits of the known.

Creativity techniques may be applied in this step. They frame, stimulate, and direct creative actions, particularly idea generation and divergent thinking. Some techniques can be accomplished alone, while others require groups of two or more people. As creativity is often a social process and not only an individual mental activity, the interaction between diverse people can support the development of novel artifacts. The goal is to adequately frame the diversity of differing perspectives and stimulate productive friction. Varying the point of view and changing perspectives is essential to these processes.

The design science researcher can build on a broad set of methods like the TRIZ contradiction matrix[71], the Creative Problem Solving Process or Osborn-Parnes-process,[72] the Lateral Thinking Process, and the Six Thinking Hats[73] , or commonly used methods like brainstorming and brainwriting. It is beyond the scope of this paper to discuss the effectiveness and validity of these techniques or give recommendations. Kaufman & Sternberg[74], in their 'Handbook of Creativity,' provide a reading across psychology, business, entrepreneurship, education, and neuroscience.

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67 Alan Hevner et al., "Design science in information systems research," *MIS quarterly* (2004), 96.; Ken Peffers et al., "A design science research methodology for information systems research," *Journal of management information systems* 24, no. 3 (2007), figure 1.; Paul Johannesson, and Erik Perjons, *An introduction to design science* (Springer, 2014), 82.

68 Amabile, Teresa M. "The social psychology of creativity: A componential conceptualization," *Journal of personality and social psychology* 45, no. 2 (1983): 357. Teresa M. Amabile, “Componential theory of creativity,” Harvard Business School Working Paper, no. 12-096 (2012), 1-10.

69 Mihaly Csikszentmihalyi, Creativity: *The Psychology of Discovery and Intervention* (New York: Harper Perennial Modern Classics, 2013).

70 Monica J. Garfield et al., "Modifying paradigms—Individual differences, creativity techniques, and exposure to ideas in group idea generation," *Information systems research* 12, no. 3 (2001), 322-333.

71 Genrich Altshuller, Uri Fedoseev, and Lev Shulyak. *40 principles: TRIZ keys to innovation*. Worcester: Technical Innovation Center, Inc., 2002.

72 H. Scott Fogler, Steven E. LeBlanc, and Benjamin R. Rizzo, *Strategies for creative problem solving*, 3rd ed. (Upper Saddle River, Prentice Hall, 2008).

73 Edward De Bono, *Lateral thinking, creativity step by step* (New York: Harper & Row, 1990): 38–40.
Edward De Bono, *Six thinking hats* (Bosten: Back Bay Book, 1999).

74 James C. Kaufman and Robert J Sternberg, *The Cambridge handbook of creativity across domains*, 2nd ed. (Cambridge: University Press, 2019).

The result of the creative activity includes prescriptive knowledge about the artifact as well as descriptive knowledge documenting the design decisions and their background. Typically, ideation produces a variety of potential solutions, and the design researcher needs to select one of them to develop and build the first version of the artifact. The selection process is the systematic determination of the suitability of an idea to become a valuable artifact. Selection criteria can be derived from the requirement definition, but additional criteria may emerge (and be fed back into the requirements) during this activity. The researcher can apply techniques like those used in design thinking projects to select an idea.[75]

Finally, the researcher must implement the artifact to validate it in the next phase. Typically, the first versions of the artifact are prototypes that require only as much time and effort as necessary to generate data in the validation phase. The creative process leads to concrete artifacts, which generate data and insights to stimulate reflection and creativity iteratively.

Artifact Validation

Once the artifact has been designed, the critical question is whether it fulfills the specified requirements. Does it solve the explicated problem? Is it effective? Does it fulfill the other requirements? What collateral effects does it produce? Validation is concerned with these questions.

We fundamentally have three options for validating an artifact: empirical evidence, simulation, and logic. The artifact is seen as an object of 'conventional' research in empirical validation. Like any object in the natural or social world, empirical methods can be applied to examine the artifact. Research explores its effectiveness and potential collateral consequences and leads to evidence about postulated cause-and-effect relationships. The design activity creates a proposal for an artifact, but it remains to be proven that this artifact indeed works, that it fulfills the specification of the requirement definition, and that it is indeed a cause for the desired effect.

All qualitative and quantitative data collection methods, including experiments, surveys, case studies, and ethnography, can be used in this stage.[76] The application of qualitative and quantitative research methods implies scientific rigor, which goes beyond episodic evidence. At this point, the design science researcher is using the same methods and frameworks as a naturalistic researcher in the cognitive mode. As in any empirical research, there are limitations in artifact validation, and the design scientist must report these limitations adequately.

The observations and measurements in this step may also lead to a better understanding of how the artifact works in detail. This understanding may feed back into the applied theories and will create new perspectives and questions. Just as the design of new pharmaceuticals may lead to new questions in biochemistry and microbiology, the design of effective artifacts in entrepreneurship may lead to new cognitive perspectives about key concepts in entrepreneurship theories. The knowledge created in this step is descriptive knowledge and may include explanatory knowledge of why the artifact can solve the problem.

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[75] Lewrick, Michael; Link, Patrick; Leifer, Larry (Eds.) (2018): Das Design Thinking Playbook. Mit traditionellen aktuellen und zukünftigen Erfolgsfaktoren. 2., überarbeitete Auflage. München, Zürich: Verlag Franz Vahlen Gmb; Versus Verlag, 84-86.

[76] Stefan Kühl (Ed.). *Handbuch Methoden der Organisationsforschung. Quantitative und qualitative Methoden* (Wiesbaden: Verl. für Sozialwissenschaften, 2009).; Paul Johannesson and Erik Perjons, *An introduction to design science* (Springer, 2014).

In addition to the empirical methods, one may also apply simulations in this context. Based on theories, mathematical models that map the reality at hand may be derived. The environment, its regularities, and the artifact must be part of this model to simulate the intervention and its interaction with the environment. As in other sciences, an adequate form of simulation could play an increasing role in artifact validation in the future. Interesting approaches exist in entrepreneurship research that could serve as a starting point (e.g., Welter and Kim[77]).

The third principal way of validating an artifact is logical validation. Here, the answer to the question of whether the artifact fulfills the requirements is derived from the internal structure of the artifact (see also Johannesson and Perjons,[78])

It is also worth mentioning that Venable et al.[79] proposed a 'framework for evaluation in design science research' (FEDS) that can guide the researcher to make informed choices for the validation strategy.

Reflection and Communication

The final step is related to the reflection on the results of the previous steps and the communication to research and practitioner communities. The reflection can raise questions like: What is the structure and function of the artifact? Which variations exist? Which requirements are fulfilled and why? Which requirements are not fulfilled and why? What have we learned from the evaluation? How reliable is the validation data? Are there control variables that determine when the artifact is effective and when not? What can we learn from this? What are discrepancies, inconsistencies, or anomalies? What does not fit into the picture? Are there additional observations and ideas about other problems, design principles, other related knowledge, and other artifacts?

The designed artifact may be of immediate interest to the practitioner community, that is the entrepreneurs, educators, coaches, and mentors of startups. Here, a different kind of communication is needed to introduce the artifacts and familiarize the practitioner community with the new possibilities that have been explored.

Knowledge generated in the design science process will be communicated to the scientific community. The interaction of the artifacts with the domain in which it is deployed creates new perspectives, and they may lead to new follow-up questions and insights. The grounding of the artifact in existing theories and the data analysis around the empirical validation is of particular interest.

The five core activities in design science research described above (see Figure 1) are not linear but can be visualized by a spiral (see Figure 2). An initial problem is considered, which serves as a starting point for the process. This initial problem may have different origins, such as a pattern of relevant unsolved problems, frustration about current methods, failure experiences, observed anomalies, etc.

After completing the first iteration of the design science research cycle, further cycles may follow. The insights of this first iteration expand the knowledge base according to the necessities and constraints that became obvious in the previous cycle. Every further iteration articulates, differentiates, and expands our knowledge base in an ongoing hermeneutic process. The process usually comes to a (preliminary) end when the artifact satisfies the requirements.

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[77] Christopher Welter and Sungho Kim, "Effectuation under risk and uncertainty: A simulation model," *Journal of Business Venturing* 33, no. 1 (2018), 100-116.

[78] Paul Johannesson and Erik Perjons, *An introduction to design science* (Springer, 2014): 52.

[79] John Venable, Jan Pries-Heje, and Richard Baskerville, "FEDS: a Framework for Evaluation in Design Science Research," *European Journal of Information Systems* 25, no. 1 (2016), 77-89.

We want to emphasize that iterations occur not only over the 'full cycle.' We often need to go back by only one or two steps (e.g., from validation to re-design). For visual simplicity, we did not put all iterations into Figure 2 but took the spiral as a metaphor for the superposition of linear and iterative processes.

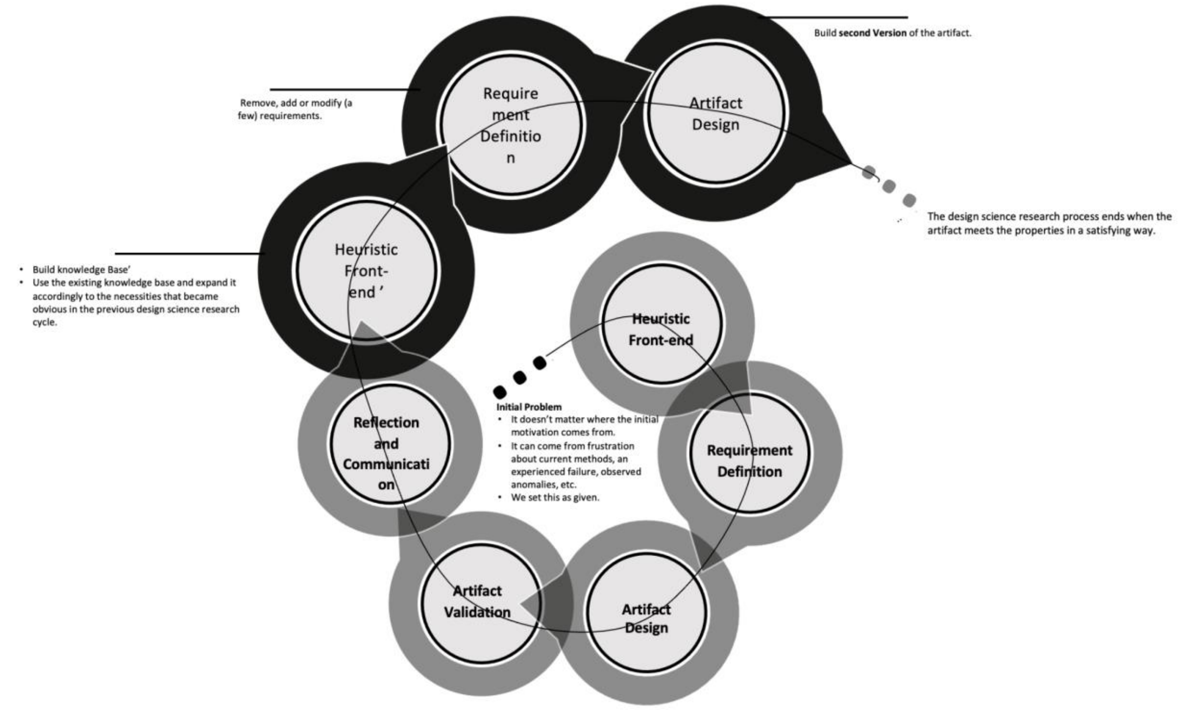

Figure 2: The activity of the design science researcher in its broader hermeneutical context.

At the end of this paragraph, we want to remind the reader that we see design as a transformative form of activity. Therefore, we cannot provide more than an outline of guidelines. Everything more deterministic and algorithmic would result in a pure paradox: We reconstructed exactly those 'creative' aspects of the self-transformation of activities, which contradict a simple rule-application-perspective on design.

Conclusion and Outlook

This paper proposes a specific way to apply design science research in entrepreneurship. We think of artifacts to support entrepreneurs in all processes in business venturing, including the preparation, implementation, and growth of startups. Inspired by the pedagogical literature, we speak of 'scaffolding artifacts.' These artifacts support and enable entrepreneurs to pursue their goals.

Further, we propose to delineate the role of the design science researcher from that of both a pure practitioner and a descriptive researcher. The design science researcher develops purposeful artifacts that will support entrepreneurs. The artifact is developed against the background of existing prior knowledge, and this knowledge may be descriptive, explanatory, or effectual. Scientific sources constitute the core knowledge base, but data and reflections from practitioners can also be compiled for understanding the problem and gathering inspiration for solutions. In any case, the validation of artifacts follows accepted scientific methods and standards.

We formulate guidelines for design science research by merging existing approaches from information systems and applying them to 'scaffolding artifacts' for entrepreneurship. These guidelines can help academic researchers to develop useful, grounded, and validated artifacts. In our view, design science research is a promising approach to creating a new form of entrepreneurial scholarship that can contribute to scientific knowledge and effective entrepreneurial practices.

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