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A NEW WAY TO DESIGN DIGITAL INNOVATION UNITS: A MODEL FOR GROWING NEW WAYS OF WORKING IN ESTABLISHED ENTERPRISES

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submitted by

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Zusammenfassung

Digital innovation units (DIUs) werden zunehmend zum Mittel der Wahl, wenn die digitale Transformation des eigenen Unternehmens vorangetrieben werden soll. Die Adoption von DIUs in Unternehmen nimmt zu. Dennoch mangelt es an dedizierter Forschung in diesem Themenbereich. Die vorliegende Dissertationsschrift bietet den ersten dedizierten Forschungsvorstoß. In diesem Zusammenhang präsentiert das vorliegende Werk ein Modell, das darauf abzielt die gemeinsame Gestaltung, Planung und Entwicklung von DIUs mit verschiedenen Stakeholdern im Unternehmen zu unterstützen. Die Entwicklung des Modells fußt auf der Erarbeitung des State of the Art digitaler Innovationseinheiten, der Verarbeitung von deskriptivem sozio-technischen Wissen zu präskriptivem Gestaltungswissen, und auf den Einsichten, die aus einer Langzeitstudie mit einem global-aktiven Großunternehmen gewonnen werden konnten.

Abstract

Digital innovation units (DIUs) are increasingly being adopted as a core means of driving the digital transformation of firms. However, while practitioners are increasingly adopting this concept, there is a lack of dedicated research on this topic. This thesis presents the first dedicated advance in terms of DIU research. It elaborates the state of the art in terms of DIUs, transforms descriptive socio-technical knowledge to prescriptive knowledge for the design and development of DIUs, and leverages the insights of a longitudinal in-depth study that has been conducted in the DIU of a large globally active corporation. Together, these elements form the basis for the primary outcome of this research, namely a model that can guide the design and development of DIUs.

Keywords: Digital Innovation Units, Digital Units, Innovation Labs, Digital Innovation, Digital Transformation, New Ways of Working, Lean Startup, Design Thinking, DevOps, BizDevOps, Spotify Matrix, Spotify Rhythm, Google OKR, Socio-Technical Design, Socio-Technical Congruence, Socio-Technical Coordination, Socio-Technical Architecting, Conway’s Law, Modularity, Mirroring Hypothesis, Action-Design Research, Design Science Research, Progressive Design Research, Generalization

“[…] *experience, creativity, intuition, and problem-solving capabilities* […]”

Alan R. Hevner, Salvatore T. March, Jinsoo Park, Sudha Ram (2004),
Design Science in Information Systems Research

“*It is as though the practitioner says to his academic colleague, ‘While I do not accept your view of knowledge, I cannot describe my own.’ Sometimes, indeed, the practitioner tends to say, ‘My kind of knowledge is indescribable,’ or even, ‘I will not attempt to describe it lest I paralyze myself.’*”

Donald A. Schön (1983),
The Reflective Practitioner – How Professionals Think in Action

“*Assuming that two men and one hundred men cannot work in the same organizational structure* […] *our homomorphism says that they will not design similar systems;* […] *From experience we know that the two men, if they are well chosen and survive the experience, will give us a better system.*”

Melvin E. Conway (1968),
How do Committees Invent?

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Table of Abbreviations

ADR	Action Design Research
CUDIT	Customer and User-Driven IT
COBIT	Control Objectives for Information and Related Technology
CDO	Chief Digital Officer
DIBB	Data-Insights-Beliefs-Bets
DR	Design Research
DSR	Design Science Research
DSRM	DSR Method
DIU	Digital Innovation Unit
DT	Design Thinking
GA	Google Analytics
HR	Human Resources
IS	Information Systems
ISR	IS Research
IT	Information Technology
ITIL	IT Infrastructure Library
LS	Lean Startup
MVP	Minimum Viable Product
N2DIU	New Way to Design Digital Innovation Units
NWoW	New Ways of Working
PDR	Progressive Design Research
ST	Socio-Technical
STCd	ST Coordination
STCg	ST Congruence

1. Introduction

The customer and user demands increasingly sophisticated digital products or services. Attempting to fulfill these demands drives competition amongst companies. The competition is fueled by the increasing speed of technological advancements and the rate of societal adoption thereof. To remain competitive, companies undergo what has become known as *digital transformation*. Competition and transformations take place in an environment that is commonly described using the acronym VUCA,[1] that is, an environment that is characterized by *volatility*, *uncertainty*, *complexity*, and *ambiguity* (see Böhmann et al. 2015, Rieß et al. 2016, Drews et al. 2017).

Companies respond by developing and improving their digital disciplines for developing innovative digital products and services (Hess et al. 2016, Haffke et al. 2017). Innovation is predominantly sought through the perspective of the the customer and user. Companies adopt this perspective to strengthen customer and user engagement (see Chanias and Hess 2016, Rieß et al. 2016, Haffke et al. 2016, Horlach et al. 2016, 2017, Andersson and Rosenqvist 2018, Corso et al. 2018, Weingarth et al. 2019).

Seeking innovation from a customer and user perspective requires a *new way of working* (NWoW) that focuses on learning with and about the customer and user (Böhmann et al. 2015, 2016, Haffke et al. 2017) and enables the exploration, development, and operation of innovative digital products or services in a lean and agile way (Drews et al. 2017, Corso et al. 2018, Weingarth et al. 2019; see also Rieß et al. 2016). The direct feedback provided makes it possible to swiftly distinguish between promising and non-promising ideas. Therefore, NWoW can save development efforts and reduce time to market (Weingarth et al. 2019; see also Adersberger and Siedersleben 2018, Urbach and Röglinger 2019). Rapid iterations and re-orientations enable those who employ such a fast-paced way of working to achieve a high degree of environmental embeddedness. However, a way of working based on learning and adaption requires supporting structures that learn about and adapt to the requirements of a such a way, that is, a lean and agile way of working must be embedded in lean and agile structures to enable continuous alignment with the needs of a market.

The organizational flexibility required to adopt such a way of working often cannot be provided by the established structures of an enterprise (see Urbach et al. 2017). NWoW are fundamentally

[1] The term *VUCA* made its first appearances in American army reports and articles in the early 1990s (see, e.g., Kennedy 1991), where it was used to describe the nature of scenarios. Today, *VUCA* is commonly used to describe the attributes of the competitive environment related to the development of digital products and services.

different from the default mode of operation and thus require a departure from existing structures. Today's enterprises transform their organizational and technological structures to overcome this hurdle. This transformation takes place in so-called *digital innovation units* (DIUs).

DIUs are organizational units that are used to depart from existing structures. They consolidate business and IT efforts in the form of novel interdisciplinary organizational structures. A core mission of DIUs is to establish NWoW that emphasize agility, enable swift decision-making, and strengthen customer and user orientation (see Haag 2017, Urbach et al. 2017). These changes are intended to enable the development and operation of innovative digital products and services (Drews et al. 2017, Urbach et al. 2017, Haffke et al. 2017).

DIUs have become an established measure in various companies (see Simon 2014, Westerman et al. 2014, Galbraith 2014, Amberti 2015, Hearn 2016, Hess et al. 2016, Kaufmann and Horton 2015, Chanias and Hess 2016, Rieß et al. 2016, Drews et al. 2017, Swaminathan and Meffert 2017, vom Brocke et al. 2017, Åkesson et al. 2018, Duerr et al. 2018, Gimpel et al. 2018, Harpham 2018, Miyazaki and Sato 2018, Osmundsen et al. 2018, Ross et al. 2018, Fortmann et al. 2019, Weingarth et al. 2019). While various companies have accepted and utilize DIUs as a strategic vehicle for driving change (Ismail et al. 2017), neither scholars nor practitioners have explicitly provided information on how to build these novel organizational units. A defined theoretical structure for creating DIUs that presents core elements and their relations, as is common for other methods and approaches (e.g., Scrum) or management frameworks (e.g., ITIL and COBIT), is lacking.

This thesis closes this gap by presenting a model for guiding the development of DIUs. Based on comprehensive empirical and theoretical insights, I design a model that places the core elements of new ways of working at the core of a DIU and enables an interdisciplinary business-IT co-evolution of growth. The model enables its users to identify, communicate, and plan either the initial development of a new DIU or the advanced development of existing DIUs.

Research Questions

Traditional software design processes in established enterprises often rely on a waterfall approach or a waterfall approach with Scrum properties, also referred to as *ScrumBut* or *Water-Scrum-Fall*. In comparison, customer- and user-driven development approaches are said to enable higher levels of customer and user engagement and reduced time to market.

These NWoW are fundamentally different and require a departure from existing organizational and technological structures; this implies the design and creation of new structures that are suitable for embedding NWoW. DIUs go hand-in-hand with adopting NWoW and can provide the required new organizational and technological structures.

However, there is currently no answer to the question of how the structures of this new socio-technical system should be designed. Therefore, I adopted the following as my overall guiding research question:

Guiding Research Question:

How can the design and development of DIUs be guided?

Design activities such as designing and developing DIUs require a preliminary understanding of the target system. Practitioners drive the creation of DIUs, whereas scholars reflect on individual aspects of these transformation journeys. However, there is a lack of a cohesive summary of the available knowledge. Thus, I decided to conduct a mixed literature review that draws on both academic and practitioner sources to elaborate on the current state of the art with regard to DIUs.

Research Question 1:

What is the state of the art regarding the concept of DIUs?

Investigating the state of the art with regard to DIUs provides empirical insights into the core elements and properties of DIUs but does not offer a structured perspective on the development of such units. A theoretical construct that can be used to structure the development of DIUs is lacking.

DIUs target the development and operation of innovative digital products and services. There is a direct relationship between the production of a digital product or service and the organizational structures used to produce it. I conducted a second literature review focusing on this socio-technical relationship to investigate how the development and growth of a DIU can be informed and structured.

Research Question 2:

Which theories on socio-technical design can be leveraged for the development of DIUs?

Answering Research Questions 1 and 2 provides valuable insights that can be utilized for the design and development of a DIU. However, answering these two questions provides relatively little in-depth knowledge concerning the socio-political context within and around a DIU.

I conducted an in-depth longitudinal study within the DIU of a large, globally active company to develop a model that can guide the design and development of DIUs. To ensure a high degree of relevance, I employed a three-year iterative research and design approach.

Conducting field research involves solving a two-fold challenge, namely striking a balance between providing practitioner-relevant results while also offering generalized scientific insights for scholars. To this end, I added an external evaluation phase to ensure a high degree of generalization of my research outcomes.

Both the application of the model within a DIU and its external evaluation enabled me to deeply reflect on not only the resulting model but also its creation. This formative and summative reflection enabled me to identify and describe the design principles (see Peffers et al. 2007, Sein et al. 2011, Chandra et al. 2015) underlying the development of my artifact.

> Research Question 3:
>
> *What does a model that can guide the development of DIUs look like,*
> *and what are its underlying design principles?*

The results of my research expand the boundaries of both the ways in which practitioners develop DIUs and the scientific body of knowledge regarding the foundations and structures of DIUs and how scholars develop artifacts for developing DIUs.

Structure of This Thesis

The remainder of this thesis is structured as follows (see **Figure 1**): **Chapter 2** lays the theoretical foundations by presenting the current state of the art of DIUs and theories that describe the relationship between organizational structures and product design. Subsequently, **Chapter 3** describes the overall research approach, the focal case of my research, and further empirical investigations. **Chapter 4** presents the resulting model for guiding the design of DIUs, while **Chapter 5** presents the evaluation that has driven the generalization and applicability of the model. This thesis closes by identifying contributions, limitations, and future research opportunities in **Chapter 6**.[2]

[2] Please note that this thesis uses both first-person singular and plural pronouns, related possessive adjectives, and possessive pronouns, as certain outcomes are the result of individual research and certain outcomes are the result of a research team effort similar to the concept of an action design research team (see Sein et al. 2011).

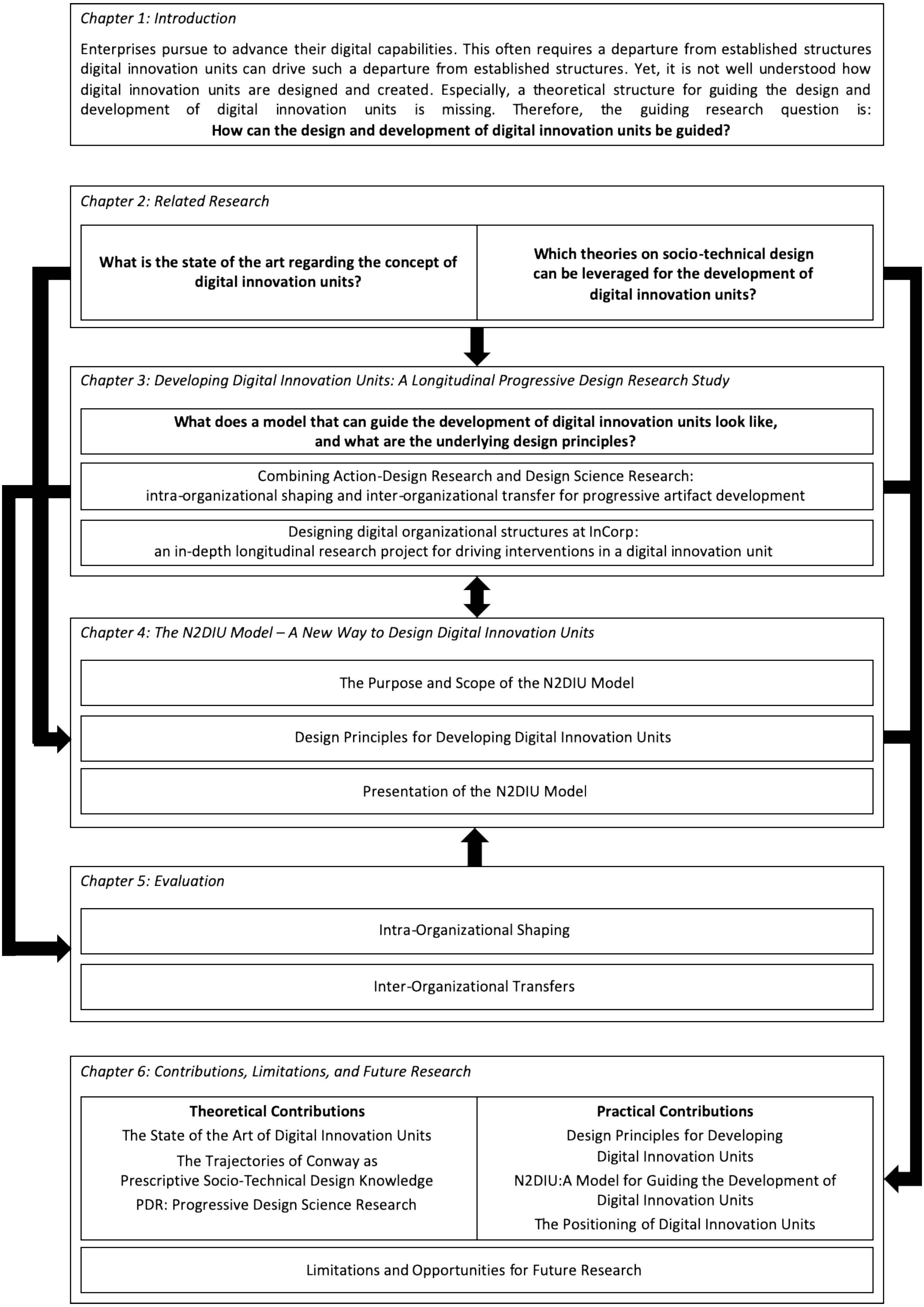

Figure 1. Structure of this thesis (own depiction).

2. Related Research

Existing research on the creation of DIUs is scarce. Neither an overview of the core elements that constitute a DIU nor a structured representation is available. Moreover, all current research related to DIUs is exclusively empirical in nature. A theoretical perspective that can be used for analyzing or supporting the development of DIUs is lacking.

The theoretical foundations of this research address these two shortcomings by presenting an overview of the core elements that constitute a DIU and theories that inform the development DIUs from a structural design perspective.

This chapter proceeds as follows: First, I present the results of a literature review focused on the state of the art regarding the concept of DIUs. Due to the high relevance of this topic to practitioners, I designed this literature review as a mixed review; that is, it considers both scholarly articles and practitioner sources, such as specialist books. The insights obtained through this literature review provide contextual knowledge concerning the concept of DIUs and highlight the elements that constitute a DIU. Therefore, this review helped to determine the *what* of DIU, that is, *what* has to be done and which practices are required to operate a DIU successfully in the light of its overall target, that is, developing an innovative digital product or service from exploring first ideas to running a scaled business.

Second, I present the results of a further literature review. This review elaborates on the socio-technical relationship between the design of an organization and the design of the digital product or service that it produces. To obtain relevant insights, I designed the literature review as a pivotal review; that is, it starts with the first article to describe the aforementioned socio-technical relationship in the context of computer science (see Conway 1968) and then considers pertinent peer-reviewed sources that cited the initial article and focused on further elaborating on this socio-technical relationship. The insights obtained by this literature review figure prominently in the design of DIUs, as the purpose of a DIU is to design, develop, and operate innovative digital products or services. The insights further contribute to knowledge of the practices that must be adopted within DIUs. Furthermore, the insights contribute to understanding the *how* of DIUs, that is, how a DIU is structured from a socio-technical perspective and how the practices employed within such a unit relate to each other.

2.1. Digital Innovation Units: The State of the Art

There is a nascent empirical phenomenon. Companies are forming new organizational units to drive their digital transformations. The notion used to describe such units is *digital innovation units*. DIUs are tasked with improving customer engagement through designing, developing, providing, and operating innovative digital products and services.

DIUs represent a departure from the established structures within companies; these novel units participate in joint business and IT efforts that disembogue in new and fundamentally different ways of working. The common customer- and user-centric way of working strengthens a company internally and externally at the boundaries of the ecosystem. These so-called NWoW are pivotal to DIUs and enable business-IT collaboration on a new level.

DIUs play an important role in the digital transformation of companies. Unfortunately, little is known about the positioning of DIUs within companies. Furthermore, there is a lack of dedicated research concerning how the organizational and technological structures required to operate DIUs should be designed and developed.

The contribution made to DIU research by this thesis is timely. DIUs will play an increasingly important role in the future. Many firms are still at the beginning of their digital transformation journeys, but the implementation of DIUs as a means of transformation is gaining momentum, as indicated by the increasing number of mentions within the scholarly and practitioner literature (see Simon 2014, Westerman et al. 2014, Galbraith 2014, Amberti 2015, Kaufmann and Horton 2015, Hearn 2016, Hess et al. 2016, Chanias and Hess 2016, Rieß et al. 2016, Drews et al. 2017, Swaminathan and Meffert 2017, vom Brocke et al. 2017, Åkesson et al. 2018, Duerr et al. 2018, Gimpel et al. 2018, Harpham 2018, Miyazaki and Sato 2018, Osmundsen et al. 2018, Ross et al. 2018, Fortmann et al. 2019, Weingarth et al. 2019).

2.1.1. Approach

The literature review process is based on the suggestions of Webster and Watson (2002) and vom Brocke et al. (2009) concerning how literature reviews should be conducted. Specifically, vom Brocke et al. (2009) propose a five-step process involving the following actions:

1) defining the scope of the review,
2) conceptualizing the topic,
3) searching literature,
4) analyzing and synthesizing literature, and
5) defining a research agenda.

This sub-chapter is structured accordingly. The scope is defined following Cooper's taxonomy for literature reviews (see Cooper 1988 in vom Brocke et al. 2009). The conceptualization of the topic presents a definition of DIUs. The literature search presents the keywords used and databases consulted, while the literature analysis and synthesis present the process behind and the concepts used for the subsequent presentation of the state of the art with regard to DIUs.

This literature review answers the first research question of this thesis (see RQ 1 in **Chapter 1**) by presenting the state of the art with regard to DIUs. The research agenda that results from this literature review highlights two opportunities for future research.

The first research opportunity identified in this literature review is the need to understand the implications of organizational design for the design of a digital product or service within a DIU; this understanding is necessary to design a model intended to guide the development of DIUs. This research opportunity is addressed by Research Question 2 of this thesis (see RQ 2 in **Chapter 1**).

The second research opportunity identified in this literature review was the need for more empirical in-depth research on DIUs. The articles that have been identified as being relevant to the concept of DIUs address them peripherally; studies that primarily focus on DIUs are lacking.

Definition of Scope

I define the scope of this literature review based on Cooper's taxonomy for categorizing literature reviews (see **Table 1**). The review focuses (1) on applications (i.e., instantiations of DIUs in the field) and research outcomes. The goal (2) is the identification and integration of core elements and central issues within the process of designing, developing, and operating DIUs.

Characteristic		Categories			
(1)	focus	research outcomes	research methods	theories	applications
(2)	goal	integration	criticism	central issues	
(3)	organization	historical	conceptual	methodological	
(4)	perspective	neutral representation	espousal of position		
(5)	audience	specialized scholars	general scholars	practitioners	general public
(6)	coverage	exhaustive	exhaustive and selective	representative	central/pivotal

Table 1. Classification of the DU literature review (adapted from Cooper 1988 in vom Brocke et al. 2009).

The organization of findings (3) is conceptually integrated around the term DIU. The perspective (4) on the findings is neutral (as opposed to espousing a particular position). The target audience (5) consists of specialized scholars and practitioners in the field of digital transformation with a focus on nurturing joint business-IT efforts in shared organizational units, that is, in DIUs. The coverage (6) of this review has a strong focus on scholarly articles in the field of information systems (IS) but also considers additional scholarly and practitioner articles, as indicated by the choice of databases. Due to the wide choice of databases and keywords, this review can be considered to be exhaustive with regard to IS research.

Conceptualization of Digital Innovation Units – A Definition

The conceptualization phase of a literature review is suitable for providing a first working definition of the core concept being investigated (see vom Brocke et al. 2009). At this point, I provide a definition of the concept of DIU and present the search terms that I employed to research this concept.

Definition

DIUs act as vehicles for driving digital transformation and enable a departure from the established structures within companies (see Hess et al. 2016, Rieß et al. 2016, Drews et al. 2017, Åkesson et al. 2018, Urbach and Röglinger 2018, Weingarth et al. 2019). The departure from established structures requires the establishment of new structures. These new structures are commonly referred to as new ways of working. NWoW emphasize agility and innovation (Haag and Eckhardt 2017, Urbach et al. 2017). The purpose of NWoW is to develop innovative digital products or services (Drews et al. 2017, Urbach et al. 2017, Haffke et al. 2017) and to improve existing business models or explore innovative alternatives (Swaminathan and Meffert 2017, Åkesson et al. 2018, Andersson and Rosenqvist 2018; see also Galbraith 2014, Simon 2014, Westerman et al. 2014, Chanias and Hess 2016, Hess et al. 2016). Such a departure from a company's established structures implies a shift in culture and mindset (Haffke et al. 2017; see also Westerman et al. 2014, Cianni and Steckler 2017, Weingarth et al. 2019); such a change is often associated with the acquisition of new skills and capabilities (Hess et al. 2016, Haffke et al. 2017, Tumbas et al. 2018; see also Westerman et al. 2014, Cianni and Steckler 2017, Swaminathan and Meffert 2017).

To summarize this section, DIUs are tasked with the establishment of NWoW and the attraction and acquisition of new skills and capabilities with which to develop innovative digital products or services and new business models.

Keywords

Due to the novelty of the concept of DIUs, I cast a wide net. The keywords used were *digital innovation unit, digital unit, digital department, digital organizational unit, agile unit, agile business unit, agile IT unit, business-IT unit,* and *IT-business unit*.

Literature Search and Selection

The literature search process can be characterized as summative in nature. The summative search process enabled me to analyze and summarize the available literature at a particular point in time.[3] **Figure 2** presents an overview of the summative literature search and analysis process.

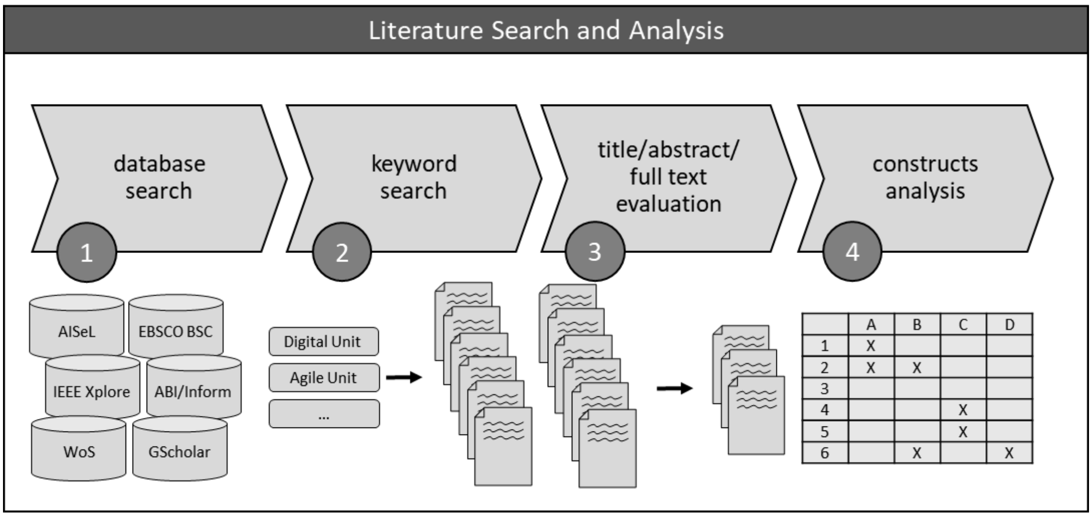

Figure 2. DU literature review – search and analysis process (own depiction).

The literature review was conducted using the following databases:

- AIS eLibrary,
- EBSCO Host Business Source Complete,
- IEEE Xplore,
- ProQuest ABI/Inform Complete,
- Web of Science, and
- Google Scholar.

I chose to add the database Google Scholar, as it widened the IS-specific and scholarly focus and complemented the review by providing practitioner-oriented literature. Considering practitioner-

[3] The search was conducted on the 31th of October 2018.

oriented literature in addition to scholarly literature increases the relevance of this literature review (see Marrone and Hammerle 2016).

I conducted full-text searches to increase the exhaustiveness of this review. Five out of six databases provide the option to conduct a full-text search. The search conducted using the Web of Science was limited to the database field *topic*, which enables searching in titles, abstracts, and keywords of a document. It turned out that employing a full-text search was useful for skimming practitioner-oriented books and articles that peripherally treated the searched concept (e.g., articles that address the topic being investigated in the context of strategies for the digital transformation of a firm).

The hit rates over the various databases and search terms was heterogeneous (see **Table 2**). The term *agile IT unit* yielded two hits in total. *Agile business unit*, *business-IT unit*, and *digital organizational unit* yielded a few hits, all of which were provided by the database Google Scholar. The terms *digital IT unit* and *digital business unit* yielded a few hits in the databases ABI/INFORM Complete, AIS eLibrary, Google Scholar, and AIS eLibrary, EBSCO Host Business Source Complete, IEEE Xplore, Google Scholar, respectively. The term *digital business unit* yielded a distinctly higher number of hits compared to *digital IT unit*. The search terms *digital unit*, *IT-business unit*, and *lean startup* yielded positive responses in all databases.

IT-business unit yielded a plethora of unrelated hits due to the databases' syntax interpretation; in all databases, the syntax interpretation is not strict but also considers similar expressions. In response to the databases' syntax interpretation, hits relating to the keyword *IT-business unit* mainly conformed to one of the two following patterns: 1) enumerations of organizational functions, as in "[…] IT, business unit, […]"; or 2) the organizational function of information technology, as in "[…] IT business unit […]" (without hyphen) or "[…] (IT) business unit […]." This terminological inaccuracy yielded a manageable number of hits in most databases but a plethora of hits in Google Scholar.

Most of the hits for *digital unit* had a technical focus. The articles in response to this term addressed technological topics (e.g., the transmission of digital units as in the transmission of radio signals and waves) or the use of such technologies in other areas (e.g., radiology and x-ray in health or cryptocurrency as a digital unit for monetary exchange). This conceptual inaccuracy yielded manageable quantities in most databases but, again, a plethora of hits in Google Scholar. In consequence, I further specified the two search terms *digital unit* and *IT-business unit* for the search in Google Scholar by including the additional term the additional term *digital transformation*. The new combination yielded an ample set of relevant articles for *digital unit* and a few for *IT-business unit*.

Search Term \ Database	ABI/INFORM Complete	AIS eLibrary	Business Source Complete	IEEE Xplore	Google Scholar	Web of Science	Sum	Distinct Hits
"agile business unit"	-	-	-	-	4	-	4	4
"agile IT unit"	-	2	-	-	-	-	2	2
"business IT-unit"	-	3	-	-	4	-	7	6
"IT-business unit"	25	100	21	10	3	2	161	142
"digital business unit"	-	4	4	3	38	-	49	35
"digital department"	-	9	1	25	54	9	98	88
"digital IT unit"	1	3	-	-	6	-	10	7
"digital organizational unit"	-	1	-	-	2	-	3	3
"digital unit"	37	11	15	52	48	63	223	172
“digital innovation unit”	3	2	1	-	26	-	32	24
Sum	66	135	42	90	185	74	**Overall Distinct Hits**	
Distinct Hits	58	117	24	56	156	72	**483**	

Table 2. DIU literature review – meta-perspective on the results of the literature search (own depiction).

In comparison, the search term *digital innovation unit* only yielded a few hits. However, I was able to observe that this search term had recently gained momentum, which indicates that the term *digital innovation unit* may become increasingly relevant in the future. One reason for this increasing trend can be related to the term’s conceptual clarity; as opposed to the term *digital unit*, which is currently the most frequently used term when discussing DIUs, the use of the term *digital innovation unit* seems to reduce ambiguity drastically. Due to the increasing trend and the reduced conceptual ambiguity, I have chosen to use the term *digital innovation unit* throughout this thesis.

All retrieved articles were filtered by applying a stage-gate process (see **Table 3**). Titles, abstracts, and the full texts of articles were reviewed. In the first two stages, articles were discarded if they did not unambiguously cover the topic (e.g., many articles dealt with digital units as the opposite of analog units in digital signal processing). If an article was not discarded during the first two stages, the full text was retrieved. I included articles that provided any information on DIUs. The full texts of all included articles were subsequently analyzed and synthesized using a concept matrix (see Webster and Watson 2002; see also vom Brocke et al. 2009).

Status \ Stage	0. distinct hits from search	1. filtered by title	2. filtered by abstract	3. filtered by full-text	final results
relevant		0	17	26	**43**
ambiguous	483	161	76	7 (unavailable)	7 (unavailable)
irrelevant		322	68	43	433

Table 3. DU literature review – meta-perspective on the stage-gate process (own depiction).

Various sources indicate the importance of establishing NWoW at the core of a DIU (see Westerman et al. 2014, Horlach et al. 2016, Denner 2017, Drews et al. 2017, Haffke 2017, Kohnke 2017, Trautmann 2017, Corso et al. 2018, Tumbas et al. 2018, Weingarth et al. 2019, Adersberger and Siedersleben 2018, Urbach and Röglinger 2019, Weingarth et al. 2019; see also Rieß et al. 2016); however, these sources provide only limited information concerning the specifics of such new approaches. I argue that successfully designing a DIU requires a fundamental understanding of NWoW. Therefore, I included additional sources, such as seminal literature and course material regarding *Design Thinking*, the *LEAN* series (the pivotal series of books behind the *Lean Startup* approach), and various sources that investigate the *DevOps* approach.

Literature Analysis: Construct Analysis

The construct analysis of relevant articles was inspired by Marrone and Hammerle's (2016) tool-supported approach for integrated literature reviews, that is, it involved the integration and synthesis of both scholarly and practitioner documents. I adapted the approach proposed by Marrone and Hammerle (2016) to the requirements of my review and employed a combined qualitative and lightweight tool-supported approach.

Given the novelty of the concept being investigated, keyword extraction approaches, as proposed by Marrone and Hammerle (2016), were insufficient to fully explore the relevant literature. Keyword extraction methods either rely on statistical metrics (e.g., the frequency of terms), supervised machine learning algorithms that require training, or linguistic and graph-based approaches; alternatively, they rely on a comparison against existing structured knowledge, such as Wikipedia articles (Louis et al. 2014).

This review, however, is highly explorative in nature, as there is no existing structured knowledge available; in particular, there are no topologies available that can be used in combination with semantic-oriented methods (e.g., graph-based approaches). Furthermore, an initial check indicated that keywords associated with the concept of DIU are various. The various keywords would drown in the overall context, as “[…] keywords that are pertinent but rare in documents are more difficult to identify […]” (Louis et al. 2014) with statistical methods. Machine learning algorithms, in contrast, must be trained and require an annotated corpus. Due to the novel nature of this research, no annotated corpus was available at the time of writing, rendering a machine learning approach inappropriate. Hence, I opted to adopt the approach proposed by Marrone and Hammerle (2016) to the needs of this research.

The variety of document types to be investigated suggested the need for a tool supported approach; compared with traditional review approaches, this integrated review includes comprehensive books and reports that do not focus on DIUs but contain somehow related information. In fact, not a single document that addresses DIUs as a pivotal concept was identified. Due to the novelty of the concept, I could also not rely on selecting book chapters as an initial filtering mechanism; no document or chapter that focuses on DIUs was identified. The considered books and reports often contain several hundreds of pages of unrelated information. Still, I deemed it relevant to skim all of the content of these books and reports in order to extract all relevant knowledge. Reading and skimming larger amounts of unrelated information can lead to routine blindness, which can in turn lead to errors; making such errors should of course be avoided.

In conclusion, I chose to add a lightweight tool support layer in addition to reading and skimming the material. Specifically, I used an in-document search functionality, as provided by various reading tools, to search for the keywords identified representing the concept of DIUs and to re-read certain passages if the results of applying the in-document search functionality suggested doing so. Instead of searching for all keywords, I used the smallest denominators, namely *unit* and *department.* If the in-document search produced a hit within a document, I read the adjacent paragraphs or chapters (with the choice of paragraph or chapter being based on how informative an identified passage was).

The tool-supported approach, which featured a degree of qualitative bias, allowed me to identify further keywords related to the researched concept. During the process, *digital factory* and *digital division* were identified as additional keywords that are occasionally related to the concept of DIUs. The term *digital factory*, however, is ambiguous, as it often may describe production facilities that increasingly utilize digital means. Overall, it was found that both terms are seldom used in the literature.

Literature Analysis: Triangulated Coding

In total, 64 documents went through the full text analysis process. I deemed 39 out of 64 documents relevant. The information found regarding DIUs was diffuse and multi-faceted. To create a uniform overview, I opted for a triangulated coding strategy (see also Müller-Bloch and Kranz 2015).

Not a single identified document focused on the concept of DIUs. Therefore, I selected and excerpted all paragraphs that were somewhat related to DIUs from the documents. I then applied a three-fold coding approach: First, I employed elaborative coding (see Auerbach and Silverstein 2003) based on my prior empirical research conducted within an DIU. Second, I open-coded (see Strauss 1987, Strauss and Corbin 1990) the excerpted material again to critically reflect on the categories identified during my prior empirical research and to identify further relevant axial codes. Third, I considered my findings against Strauss's coding paradigm for social science research (see Strauss in Böhm 2004) to produce a well-structured representation of the results. The following paragraphs describe these three steps in more detail.

Elaborative Coding

Elaborative coding (see Auerbach and Silverstein 2003) has been described as a top-down approach in which "[…] one begins coding with the theoretical constructs from the previous study in mind" (ibid.). In my case, I used practice-inspired axial codes identified during the early stages of my action design research (ADR). The early stages of my ADR drove interventions towards the implementation of NWoW within a DIU. In particular, I drew on the *Lean Startup* method and conducted BML cycles with an interdisciplinary team. These interventions uncovered several organizational, technological, and processual requirements successfully implementing NWoW within a DIU. I integrated these requirements into a model intended to facilitate the communication of my findings to relevant stakeholders.

The model for communicating the findings is based on seven disciplines (see **Figure 3**). Requirements towards a new way of working are represented by the discipline *way of working*. The organizational disciplines are represented by the three disciplines of *interdisciplinary organization*, *leadership*, and *vision*. The technological findings are represented by the three disciplines of *technology management*, *data*, and *scale.*

I used this structure to present my findings to the sponsors of the DIU. The presentation enabled me to evaluate whether the chosen theoretical structures were suitable for communicating my insights at the sponsorship level. I was able to observe fundamental structural changes in the DIU that were in line with my recommendations after I communicated my insights. Therefore, I determined that using the seven disciplines to communicate my findings was a suitable approach. I used the seven disciplines as axial codes during the elaborative coding.

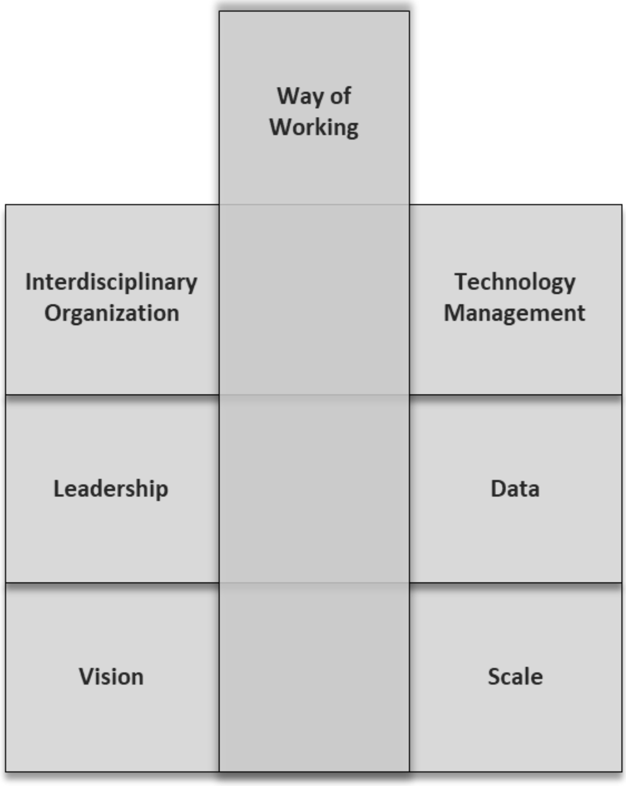

Figure 3. Practice-inspired axial codes for elaborative coding (own depiction).

Open Coding

I triangulated the elaborative coding (see above) using an open-coding approach (see Strauss 1987, Corbin and Straus 1990) to critically reflect on my inductively generated axial codes, that is, the seven disciplines. I was able to identify further related concepts at the interfaces of DIUs in the larger context of an enterprise. I subsumed the interfacing topics under the axial codes *pressures*, *goals*, *strategic measures, roles, new models for cross-functional collaboration,* and *organizational alignment*.

Reflecting on my Findings against Strauss's Coding Paradigm for Social Sciences

Finally, I drew on Strauss's coding paradigm (see Strauss in Böhm 2004) for social sciences to develop a structured representation of my findings. On that account, I compared the axial codes and the related findings of my elaborative and open coding with the proposed categories of Strauss's model. The result of this comparison was a new categorization and representation of my findings (see **Figure 4**).

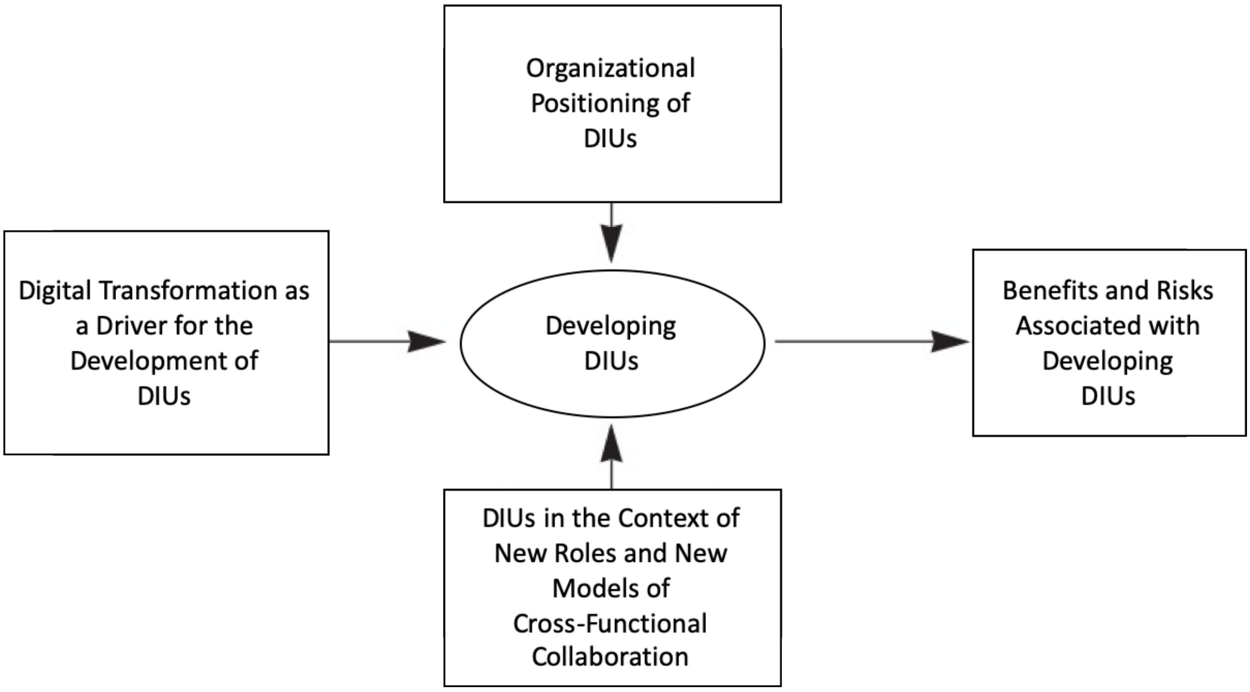

Figure 4. Structured findings of this literature review (own depiction, adapted from Strauss in Böhm 2004).

In the remainder of this section, the findings of this literature review are presented. **Chapter 2.1.2** presents *digital transformation as a driver for the development of DIUs,* **Chapter 2.1.3** presents *DIUs in the context of new roles and new models of cross-functional collaboration*, **Chapter 2.1.4** discusses the *organizational positioning of DIUs*, **Chapter 2.1.5** identifies core concepts that should be considered when *developing DIUs*, and, finally, **Chapter 2.1.6** presents the identified *benefits and risks associated with developing DIUs*. I close by presenting a research agenda for DIUs in **Chapter 2.1.7**.

2.1.2. Digital Transformation as a Driver for the Development of Digital Innovation Units

DIUs are commonly viewed as a transformational vehicle in the context of targets and strategic measures related to the digital transformation of a firm. Digital transformation drives firms to advance their digital capabilities to stay competitive (Hess et al. 2016, Haffke et al. 2017).

Firms aim for the identification of new digital business models and opportunities (Galbraith 2014, Denner 2017), the development of new digital products and services (Drews et al. 2017, Duerr et al. 2018), and the leveraging of digital means to innovate their value chains (Haffke 2017).

Companies seek innovation through the perspective of the customer and user of a digital product or service with the goal of improving customer proximity (Rieß et al. 2016, Horlach et al. 2016, 2017), customer engagement (Haffke et al. 2016, Andersson and Rosenqvist 2018), and customer experience (Chanias and Hess 2016, Corso et al. 2018, Weingarth et al. 2019).

In general, firms seek to reduce the time to market to stay competitive in the dynamic environment (Adersberger and Siedersleben 2018, Urbach and Röglinger 2018) through the rapid co-exploration of innovative approaches in collaboration with the customer (Haffke et al. 2016, Haffke et al. 2017).

Related sub-targets include organizational development (Westerman et al. 2014, Haffke 2017, Tumbas et al. 2018) via improved business-IT relations (Westerman et al. 2014, Hansen 2015, Hansen and Kien 2015, Drews et al. 2017, Tumbas et al. 2017, Yeow et al. 2018). Such improved alignment enables synergies across functions (Westerman et al. 2014) based on knowledge development, transfer, and sharing (Westerman et al. 2014, Haffke et al. 2016, Tumbas et al. 2018, Weingarth et al. 2019), with the ultimate goal of developing digital skills and capabilities (Westerman et al. 2014, Bekkhus 2017, Haffke 2017, Tumbas et al. 2018).

The achievement of these targets is of high strategic importance and is commonly associated with internal disruption as a result of the establishment of an innovative mindset and culture in combination with the adoption of new working methodologies (Haffke et al. 2017; see also Cianni and Steckler 2017). Despite the training of existing skills in digital universities (Böhmann et al. 2015) or digital academies (Weingarth et al. 2019), companies are additionally recommended to attract new digital talents (see Wade 2015 in Bekkhus 2017). In some cases, firms consider the acquisition of start-ups and other forms of corporate transactions (see Hess et al. 2016, Cianni and Steckler 2017, Swaminathan and Meffert 2017) and even support these acquisitions with the creation of start-up incubators (see Hess et al. 2016).

Ramping up the digitally savvy headcount is reasonable for a quick scaling of digital initiatives (see Westerman et al. 2014, Cianni and Steckler 2017, Swaminathan and Meffert 2017, Duerr et al. 2018, Åkesson et al. 2018, Weingarth et al. 2019) but this approach has its limits when applied within the context of traditional structures. Integrating such initiatives within existing organizational units can result in conflicts due to the inertia of the established structures (see Åkesson et al. 2018) and is likely to suffocate the anticipated effect (Wokurka et al. 2017), as traditional structures can impede cross-functional collaboration (Dremel et al. 2017) by being too bureaucratic (Urbach et al. 2017). Hence, new constellations of rights and resources are required to overcome such potential impediments.

DIUs represent an alternative to traditional constellations of rights and resources, as these units represent an alternative for pooling digitally savvy talent around new structures in a dedicated organizational setting (Galbraith 2014). DIUs can be used to attract digital talent in the first place (see Hess et al. 2016) and enable forms of business-IT collaboration on new levels due to their interdisciplinary nature (Drews et al. 2017, Duerr et al. 2018). A DIU as a whole brings business and IT together and forms interdisciplinary teams as primary structures, which can overcome any silo mentality that may have been established. To support breaking away from established behavior, DIUs are spatially separated from the underlying functions and may even be located at new sites (see Hess et al. 2016, Weingarth et al. 2019).

The new constellations of rights and resources in DIUs should support the establishment of an entrepreneurial (Westerman et al. 2014) or start-up way of working (Tumbas et al. 2018) and facilitate a shift towards a culture that encourages experimenting (Cianni and Steckler 2017, Haffke 2017), sometimes also referred to as start-up culture (Weingarth et al. 2019).

Overall, DIUs are positioned as transformative organizational vehicles in the context of digital transformation to incubate new interdisciplinary and collaborative business-IT structures to in turn enable the development of new digital capabilities. Such a departure from the existing structures involves utilizing NWoW that enable high degrees of customer and user engagement and facilitate the creation and adoption of an entrepreneurial culture. DIUs can be a means for both by engaging the customer and user in new ways and attracting digital talent with which to nurture an innovative mindset and culture. The departure from established structures affects various levels in a firm and commonly goes hand in hand with carving out space for new roles that can drive the new mindset.

2.1.3. Digital Innovation Units in the Context of New Roles and New Models of Cross-Functional Collaboration

Digital Innovation Units and the Role of the Chief Digital Officer

Companies institutionalize resources on various levels and employ new roles within the context of their digital transformation. Roles related to the term *digital* are integrative by nature and communicate and coordinate between business and IT as well as between an organization and external stakeholders such as the customer (see Hansen 2015, Singh and Hess 2017, Tumbas et al. 2017, Yeow et al. 2018). These roles can address specific requirements, such as eCommerce specialists, copywriters for digital brand communication and marketing campaigns, and dedicated customer service representatives (see Hansen 2015, Yeow et al. 2018), or adopt a more generalized perspective on the digital mobilization needs of a company. In this case, companies appoint chief digital officers (CDOs; see Galbraith 2014, Westerman et al. 2014, Hansen and Kien 2015, Kaufmann and Horton 2015, Haffke et al. 2016, Horlach et al. 2016, Haffke 2017, Legner et al. 2017, Singh and Hess 2017, Tumbas et al.

2017, Gimpel et al. 2018, Duerr et al. 2018, Jacobi and Brenner 2018, Tumbas et al. 2018, Weingarth et al. 2019).

Even though a CDO is often viewed as being pivotal to a company's digital transformation, the role is still nascent (Singh and Hess 2017, Tumbas et al. 2017). The role of the CDO is often appointed as a board-level function and tasked with the development of a digital strategy. Related duties are broadly defined and interpreted differently across various companies.

Results of Two Recent CDO Studies

Singh and Hess (2017) conducted 10 interviews to define six CDO cases. They identified three different types of CDOs: 1) the entrepreneur, who explores digital innovations and establishes a digital transformation strategy; 2) the digital evangelist, who drives a cultural and mindset change across all levels and departments; and 3) the coordinator, who designs a "[…] controlled organizational shift from decoupled silos to cross-functional cooperation" (Singh and Hess 2017).

Tumbas et al. (2017) interviewed 35 CDOs and also identified three general types of CDOs: 1) the digital accelerator, which drives innovation via extended degrees of freedom and a mandate to experiment and who typically complements existing IT leaders focused on architecture and infrastructure transformation; 2) the digital marketer, who drives customer engagement and data analytics; and 3) the digital harmonizer, who coordinates all digital initiatives across a company's functions.

In summary, CDOs are tasked with promoting 1) digital innovation, 2) digital literacy and culture, 3) data analytics, and/or 4) the coordination of digital initiatives across all functions in a company. Obviously, these four areas of activity are broad and have synergistic relations with each other. In practice, it can be observed that the activities of CDOs intended to drive the transformation of a company can fall into more than one category (see also Haffke et al. 2016), meaning that the role is often associated with substantial challenges.

CDO Support and Resources

CDOs do not have to cope with this challenge alone, as they are not necessarily a unique phenomenon within a company. It can be observed that firms employ more than one CDO, either in parallel or sequentially, to pursue different targets. Wokurka et al. (2017) found that requirements with regard to leadership change with organizational maturity. Westerman et al. (2014) show that companies hire seasoned senior executives to drive their digital transformations. Williams and Scott (2012) and Westerman et al. (2014) proposed a two-in-a-box leadership model to bridge and unify perspectives.

A globally active company installed both a group-level CDO and local CDOs to reflect the needs of its decentralized corporate structure and to drive its transformation globally (see ibid.).

The provision and institutionalization of resources can further enrich the role of a CDO. For instance, the installation of a digital office can support a CDO in pursuing a company's digital agenda (Caudron and Peteghem 2018). Digital committees are implemented for joint decision-making and the coordination of digital initiatives across silos (see Westerman et al. 2014). Companies can create digital universities (Böhmann et al. 2015) or digital academies (Weingarth et al. 2019) for training and improving the digital literacy of co-workers across all hierarchical levels. Some companies establish incubators and digital accelerators to acquire or support startups (see Hess et al. 2016, Swaminathan and Meffert 2017). Innovative approaches are explored in interdisciplinary digital labs (Haffke et al. 2016, 2017, Weingarth et al. 2019) and brought to scale in DIUs, which seems to be the most frequently adopted and effective approach.

In summary, the creation of DIUs and the appointing of a CDO are observed as going hand in hand (Weingarth et al. 2019). DIUs are seen as the organizational units of CDOs (Tumbas et al. 2018). More specifically, CDOs are responsible for designing and building the DIU of a firm (see Westerman et al. 2014, Haffke et al. 2016). DIUs can support CDOs in carving out a space for establishing a mindset and culture around entrepreneurial NWoW that engage business and IT through cross-disciplinary structures (see Rieß et al. 2016, Drews et al. 2017) and the customer and user through a co-exploration of innovative approaches and analytics without struggling with the inertia of established structures (cf. Wokurka et al. 2017, Åkesson et al. 2018). This makes DIUs a core resource for driving the transformation agendas of CDOs.

New Models for Cross-Functional Collaboration

Approaches towards achieving and sustaining a digitally capable status quo are manifold. In general, improved cross-functional business-IT collaboration leads to the support and development of a firm's digital capabilities. A key concern of firms is the positioning of the development of said digital capabilities (Hess et al. 2016).

I identified two prevailing perspectives on developing digital capabilities: One perspective views the development of digital capabilities as a matter of concern for business functions, whereas the other focuses on the development of digital capabilities through the lens of the existing IT function. In the following, new models of cross-functional business-IT collaboration for developing digital capabilities are presented, starting with articles focused on the development of digitial capabilities through the lens of the existing IT function.

Studies on New Models for Cross-Functional Collaboration

In their IT-centric study, Haffke et al. (2017) conducted 22 interviews on the IT side and 19 interviews on the business side with the goal of exploring the adoption of a bimodal IT approach "[…] for a more agile IT function, capable of exploring innovative uses of IT in a digital business context" (Haffke et al. 2017). The interviews were mainly conducted on the executive level, specifically, on the c-level.

The authors identified three modes for enabling a bimodal IT function, that is, an IT that embraces both traditional and innovative IT structures, the latter of which are also referred to as digital IT and are said to be faster by comparison. The three modes are 1) management of slow and fast IT on a project-by-project basis, that is, the management of slow and fast IT projects by a single IT function; 2) management of slow and fast IT in two subdivisions, that is, the division of a single IT function into slow and fast subdivisions; and 3) management of slow and fast IT in two separate organizational divisions, that is, the creation of a digital division in addition to the traditional IT function. It is notable that Haffke et al. (2017) describe these three modes as transitional stages that aim towards a unimodal mode.

Horlach et al. (2016) adopted the perspective of IT units that transform towards improved customer and business alignment. They conducted nine interviews at the level of department heads and identified "[…] five different types of bimodal IT […]" (Horlach et al. 2016) that show "[…] that specific mechanisms are applied to enhance the (business) IT alignment in the respective organizational settings of each type" (ibid.).

The five types of bimodal IT are 1) the establishment of bimodal development capabilities in an existing IT department, that is, an attempt to undertake both traditional slow software development and fast, customer- and user-oriented software development in the same organizational unit; 2) agile IT outsourcing, that is, the reliance on external service providers for fast, customer-oriented development; 3) a bimodal sourcing IT function, that is, the reduction of the internal IT department's role to project management alone, with outsourcing being relied on for slow and fast development; 4) bimodal IT, that is, the in-house development of fast, customer-oriented development capabilities in a separate agile IT unit; in addition, business-IT alignment can be supported by the creation of DIUs at the boundaries between the agile IT unit and business departments; and 5) an agile IT unit, that is, a unimodal fast, customer-oriented IT that additionally creates DIUs at the boundaries with business functions.

Tumbas et al. (2018) adopted a more holistic perspective on enterprises and interviewed CDOs from 35 companies. They identified three approaches for aligning the development of digital capabilities: 1) grafting, that is, the infusion of digital capabilities into existing business structures; 2) bridging, that is, the integration of two or more functions to "[…] achieve a new digital initiative […]" (ibid.) and overcome silos by the involvement of reconciling logics, for instance, by bridging business and IT; and 3) decoupling, that is, the creation of digital initiatives that are separate from the established functional units.

Andersson and Rosenqvist (2018) reviewed a report from the ICT company Ericsson and identified three approaches: 1) the transformation of existing business processes, that is, digitalization efforts are driven by various parts of the company; 2) the creation of a DIU that starts on an organizational and technological greenfield; and 3) the creation of a parallel digital business, that is, the creation of a start-up initiative decoupled from existing structures for exploring new digital business models.

Böhmann et al. (2015) conducted a cross-industry mixed methods study involving 17 c-level interviews and, based on the results of the interviews, developed a questionnaire with 120 items that yielded 90 responses. They identified three general approaches: 1) fragmented transformations, that is, parts of an organization have identified the importance of developing digital capabilities and autonomously initiate transformation initiatives within their boundaries; 2) encompassing transformations, that is, digital transformation efforts are controlled and coordinated with the goal of transforming a company as a whole; and 3) digital ventures, that is, a company creates digital start-ups intended to nurture the development of digital capabilities in a shielded and decoupled environment and the establish knowledge backflows to established structures. **Table 4** summarizes the findings of the five studies.

In summary, the prevailing perspective is the transformation from *an IT perspective*, for instance, by enhancing an existing IT function by means of agile IT outsourcing (Horlach et al. 2016), adding a bimodal development approach and a project-by-project bimodal management in the IT function (ibid., Haffke et al. 2017), implementing bimodal divisions and subdivisions (ibid.), and establishing a digital IT (Horlach et al. 2016). An alternative perspective is the transformation from a *business perspective*, that is, a fragmented transformation or the grafting of individual business structures (Böhmann et al. 2015, Andersson and Rosenqvist 2018, Tumbas et al. 2018).

What the IT and the business perspectives on transformation have in common is that they apparently focus on transforming existing structures within a company. In contrast to this *internal orientation* on transformation, an *external orientation* is adopted when transformational efforts are pooled by starting digital ventures (Böhmann et al. 2015), for instance, by founding start-ups for establishing new digital businesses (Andersson and Rosenqvist 2018).

The interrelation of *internal* and *external* orientations with the *business* and *IT* perspectives on transformation creates a field of tension that describes at what boundaries transformational efforts are focused and who is driving the transformation of a firm. In the center of this field of tension the institutionalization of merged interests can be found: the joint development of DIUs, driven by both business and IT, to establish new ways of working and design engaging digital products and services.

Authors	Perspective	Approaches for Creating Digital Capabilities
Böhmann et al. (2015)	Whole company	1) fragmented transformation 2) encompassing transformation 3) digital ventures
Horlach et al. (2016)	IT focus	1) bimodal development 2) agile IT outsourcing 3) bimodal IT outsourcing 4) bimodal IT with DIUs 5) digital IT with DIUs
Haffke et al. (2017)	IT focus	1) project-by-project bimodal management 2) bimodal subdivisions 3) bimodal divisions
Andersson and Rosenqvist (2018)	Whole company	1) transformation of business processes 2) DIUs 3) start-up digital business
Tumbas et al. (2018)	Whole company	1) grafting 2) bridging 3) decoupling

Table 4. Approaches for developing digital disciplines (own depiction).

2.1.4. Organizational Positioning of Digital Innovation Units

The design, creation, and operation of DIUs is a challenging task. A new organizational unit driven by a new role claims new ground. Resources are provided and drawn with high priority. The status quo of existing structures might be threatened. Being aware of the impact of integrating DIUs in an existing organizational setting and how an existing organizational setting might impact the growth of DIUs is important when it comes to balancing expectations.

DIUs enable and leverage synergies across a company (Westerman et al. 2014) and can enable business-IT collaboration on a new level (Horlach et al. 2016, Drews et al. 2017). This new model of collaboration is dependent on yet decoupled from the existing structures of an organization. Instead of viewing a DIU as another organizational unit, it should rather be seen as the center of "[…] a digital innovation widespread network […]" (Corso et al. 2018) that provides opportunities for expanding the boundaries of internals functions but also of a company as a whole to provide engaging digital products and services at the boundaries. DIUs enable existing functions to create fundamental synergies based on a centralized pool of resources and talents with which to drive the digital transformation of a company.

Still, established executives can view DIUs as a threat to their autonomy (see Westerman et al. 2014). Departments that interpret the opportunities of DIUs as a threat tend to contribute little to the new initiative (see Hansen 2015). Traditional structures can impede cross-functional collaboration (Dremel et al. 2017), as traditional processes at the interfaces are contrasted by the lean and agile way of working and the organization of a DIU (Weingarth et al. 2019). The reconciliation of different ways of working can be cumbersome and might take longer than expected (see Urbach and Röglinger 2018). The lack of appreciation can permeate various organizational levels.

A new DIU is vulnerable and has to establish its own structures to "[…] prove itself to others while earning credibility" (Galbraith 2014). This development process requires management support and might include experiments intended to distinguish between successful and unsuccessful approaches (ibid.).

A tight coupling between established and new structures can lead to the suffocation of a DIU (Wokurka et al. 2017). DIUs are intended to work at a different speed but will ultimately re-align with established habits if coupled too tightly with traditional structures. The new units require independence and degrees of freedom during their early development stages to reach their potential.

The organizational positioning of institutionalized digital innovation is not trivial and can derail an organization if done incorrectly, as shown by the example of Kodak. Kodak is known for inventing the digital camera and held patent for this innovation until 2007. The company soon recognized the need for new organizational structures to create a product based on the new digital technology. Beginning in 1994, Kodak made several attempts at creating separate digital departments, similar to DIUs, around the new technology (see Lucas and Goh 2009). However, the attempts made were not sufficiently separated, which led to infighting between the old and new departments (ibid.). Kodak was thus not able to leverage the patent.

While insufficient separation can lead to suffocation, DIUs that are excessively detached from the existing structures of a company may create a different challenge. DIUs can adopt an inward perspective (Westerman et al. 2014). In this case, instead of overcoming an existing silo mentality, the new unit can contribute to it by creating another silo (Jacobi and Brenner 2018), which in turn diminishes the acceptance of the new unit and can render it ineffective in terms of achieving its goals.

DIUs are interdependent with other units (Galbraith 2014), as the latter can provide resources. Other units can in turn profit from the increased digital literacy, methodological knowledge, and customer and user insights provided by a DIU. However, drawing on the existing resources involves drawing on established organizational structures; thus, power can shift from the new unit to existing functions.

The literature has no specific answer to the question of how exactly DIUs should be positioned. Thus, the question remains as to how DIUs can be positioned in such a manner that they are provided with the required degrees of freedom with without losing touch with the established structures of a company. While relying on existing resources may appear sound for scaling a DIU quickly, such a reliance can impede the development of new structures.

DIUs need time, dedicated resources, and high degrees of freedom to exhibit healthy growth. At the interfaces with other functions, the direction of flow of organizational impact has to be monitored to ensure that established behaviors do not propagate and supersede the creation of new structures in the new unit. Instead, established structures at the interfaces of a DIU must be adapted to the new structures to not only support the NWoW but also to drive transformation concentrically from a DIU across the other functions of a company.

2.1.5. Developing Digital Innovation Units

DIUs represent a departure from established structures. They draw on joint business and IT efforts to yield new and fundamentally different ways of working. NWoW are pivotal for DIUs, as they provide a process that supports two kinds of collaboration; first, within a DIU, NWoW integrate business and IT forces into a common customer- and user-centric way of working, and, second, at the boundaries of a DIU (and thus at the boundaries of a company), NWoW enable the joint forces to collaborate with the customer and user.

The following section provides a brief introduction to the pivotal methods of a DIU, that is, NWoW (see **Chapter 2.1.5.1**). Specifically, I first introduce design thinking (DT) and the lean startup methodology (LS). Thereafter, I present my findings regarding changing organizational and technological structures by introducing DevOps and BizDevOps. As opposed to DT and LS, DevOps is not a method for developing a product or service but can support such methods through the organizational and technological structures it recommends (see Airaj et al. 2017).

I continue my review of NWoW by summarizing and delineating DT, LS, and DevOps and show that these approaches are not exclusive but rather synergistic. Afterward, I highlight once more the importance of what emerged as the common denominator of all three approaches, that is, interdisciplinary teams, changed responsibility and autonomy schemes, and technology that supports the teams' new responsibility and autonomy (see **Chapter 2.1.5.2**).

Finally, I close my view on developing DIUs with new leadership approaches. New approaches to leadership are required in innovative settings as traditional work-breakdown approaches impede the adoption of new responsibility and autonomy schemes (see **Chapter 2.1.5.3**).

2.1.5.1. New Ways of Working

NWoW represent a departure from the established structures in enterprises. Their establishment aim for exploring, developing, and operating innovative digital product or services in a lean and agile way (Drews et al. 2017, Corso et al. 2018, Weingarth et al. 2019; see also Rieß et al. 2016) with the goal of achieving faster times to market (Weingarth et al. 2019; see also Adersberger and Siedersleben 2018, Urbach and Röglinger 2019). Frequently identified areas for exploring innovations are *improved customer proximity* (see Rieß et al. 2016, Horlach et al. 2016, 2017), *customer engagement* (see Haffke et al. 2016, Andersson and Rosenqvist 2018), and *customer experience* (see Chanias and Hess 2016, Corso et al. 2018, Weingarth et al. 2019).

NWoW can be described as entrepreneurial (Westerman et al. 2014) or as start-up way of working (Tumbas et al. 2018). This way of working emphasizes exploration of customers' needs (Haffke 2017). NWoW can also substitute for existing development approaches (see Clarke 2017) but are mainly deployed in new dedicated organizational settings such as DIUs (see i.a. Westerman et al. 2014, Rieß et al. 2016, Horlach et al. 2016, Drews et al. 2017, Haffke 2017, Corso et al. 2018, Tumbas et al. 2018, Weingarth et al. 2019). NWoW are said to require a different mindset (Haffke 2017) and a culture (Cianni and Steckler 2017) towards a start-up culture (Weingarth et al. 2019).

Commonly named representatives of NWoW include DT (see Kohnke 2017, Clarke 2017, Trautmann 2017, Jacobi and Brenner 2018, Weingarth et al. 2019), the successor of Blank's (2006) customer development, that is, LS (see Denner 2017, Chanias 2017, Sauberschwarz and Weiss 2018, Weingarth et al. 2019), and DevOps (see Horlach et al. 2016, Drews et al. 2017, Weingarth et al. 2019). DevOps differs from DT and lean startup in that DevOps does not present a specific process but rather provides a set of practices that can effectively support the operation of methods such as DT and LS at scale.

In the following, I briefly introduce each of these three approaches. The following introductions are intended to provide the reader with a foundational understanding of each approach. As the complexity of the concepts behind the presented ways of working increases from DT to over LS to DevOps, the sections dedicated to each of these topics may vary in terms of level of detail. The information presented in this chapter is based on the findings of the literature review and are selectively complemented by the author's own experiences of applying and teaching these approaches in various workshops and lectures over several years.

Design Thinking: Exploring Customer and User Needs

DT is a human-centered approach to leveraging a designer's creativity to solve issues that are originally not interpreted as design problems (Brown 2008). Solutions are explored, developed, and refined in response to direct customer and user feedback.

The foundation of all DT-driven developments is a high degree of customer and user empathy to understand how, when, and why the proposed solutions are used. Therefore, instead of presenting customers and users with final solutions, these parties become part of the early development stages.

The early involvement of customers and users ensures a fit between their actual needs and the functionality offered by solution approach (ibid.). This fit is not achieved by a waterfall-like process but through a multitude of rapid iterations that guide the overall process of exploring the problem and developing a suitable solution.

DT is intended to be applied by interdisciplinary teams. It is crucial that teams be interdisciplinary in nature to ensure that the functions required to support rapid prototyping over short cycles are available.

Design Thinking: Comparison of the Five- and Six-Mode DT Processes

DT provides a large set of methods that can be utilized to leverage customer and user insights. The proposed methods are matched with different modes of DT (see **Figure 5**). The modes constitute the core process of DT and structure the process of developing a solution from the initial identification of the problem to be solve to the creation and testing of actual prototypes.

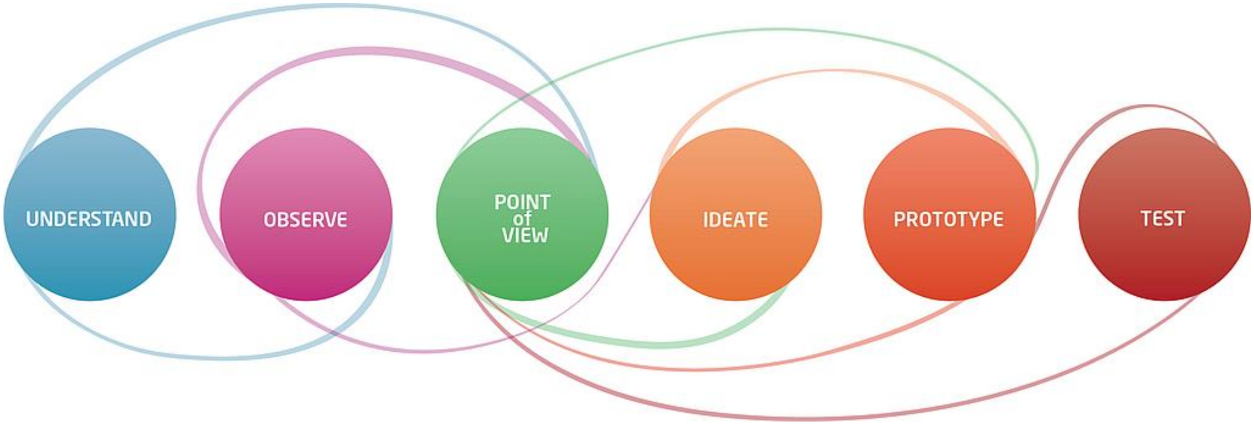

Figure 5. The six modes of design thinking (HPI School of Design 2018).

There exist similar but different versions of the DT process. Two versions prevail in the general literature and daily use of DT. Even though both versions are very similar, I decided to briefly introduce both because users of DT may encounter both in daily use.

Both versions are published by the Hasso Plattner Institute (HPI) of Design, which is also known as the Stanford School. Each version proposes different modes. The term *modes* is used to emphasize the need to adopt different ways of thinking.

The first version of the process proposes five modes. The five modes of the first version are as follows:

1) Empathize,
2) Define,
3) Ideate,
4) Prototype, and
5) Test.

The second version of the process proposes six modes. The modes of the second version are as follows:

1) Understand,
2) Observe,
3) Point of view,
4) Ideate,
5) Prototype, and
6) Test.

The last three modes of both versions of the process are equal. The modes *define* and *point of view* are named differently but are equal, as the activities behind them are the same.

The differences between the five- and the six-mode processes emerge in the *empathize* mode of the first version and the *understand* and *observe* modes of the second. Specifically, the mode *empathize* has been split to the modes *understand* and observe to structure further the activities behind.

Thus, it can be stated that both process versions are very similar, but feature minor differences. While applying and teaching DT, I realized that the six-mode process is more easily adopted. Hence, I present the six-mode process in more detail.

Design Thinking: The Six-Mode DT Process

The six-mode DT process has a normative order (see **Figure 5**) but can be highly iterative during its execution. The process allows one to take steps forward or backward at any time. For instance, forward or backward steps may be required to gather more data concerning the problem faced by the customer or user or to create different versions of a prototype. Whether or not these additional steps are required will depend on the individual process that a DT team employs and has to be determined individually. In either case, the process starts with the first mode, that is, *understand*. The following information is based on DT course material (see HPI School of Design 2009, 2018).

The *understand* mode enables a team to empathize with the customer and user, thus making it possible to obtain an improved understanding of the problem faced by the latter groups. The results of the *understand* mode are two-fold: 1) needs, in the form of the activities that the customer and user engages in, and 2) insights, in the form of the perspectives and feelings of the customer and user. Common approaches for producing results in the *understand* mode are the derivation of ideas based on the own experiences of team members, reviewing existing solutions, market research, reviewing statistics and facts, or interviews with experts and potential customers and users.

The second mode, *observe*, enables a team to view the customer and user in a problem-specific context to understand how the latter groups act in certain situations and why they do so. A typical result is a customer journey map delineating the observed behavior. Common approaches for producing results include adopting a beginner’s mindset, asking what-how-why questions, engaging in camera studies, and conducting interviews.

The third mode, *point of view*, focuses on reframing insights that may have been gained by applying the first two modes. Typical results are problem statements, defined personas, and a design vision.

Common approaches for producing results are story share-and-capture, empathy mapping, or the definition of personas.

The first two modes are used to open the problem space, while the third mode is used to close it. The next mode, *ideation*, is used to open the solution space before it is closed in the last two modes, *prototype* and *test*.

The *ideation* mode is used to explore possible solutions and results among a large number of ideas and the diversity among these ideas. Common approaches for producing results are powers of 10, asking how-might-we questions, and brainstorming and selection.

The *prototyping* mode focusses on transforming the ideas identified in the earlier modes into tangible solution approaches. The focus is on low-fidelity prototyping, with the goal being to discuss and solve disagreements among the team early and with little effort. Applicable approaches are role-playing, paper prototypes and sketches, mockups, and click dummies.

The *testing* mode aims for receiving feedback on the prototypical artifacts to learn more about the customer and user and the team's ideas and prototypes; this feedback is also used to iteratively refine prototypes. The testing approaches used depend on the individual form of a prototype. The testing approach chosen should enable the customers and users to experience the prototype, as doing so allows them to provide rich feedback.

Design Thinking: Summary

DT is executed by interdisciplinary teams to ensure quick iterations. DT emphasizes exploration and market research in its early modes and the exploration of customer and user problems with low-fidelity prototypes that usually do not rely on sophisticated technological implementations in later modes.

Testing is done qualitatively and in direct collaboration with the potential customer and user of a solution to obtain rich and instant feedback. The instant feedback, in combination with having all necessary functions within an interdisciplinary team, further supports the execution of quick iterations. DT is a suitable approach for generating and testing potential innovations with limited effort.

As DT lacks a focus on technical implementation and the development of a business model, approaches for integrating DT and LS have been proposed in the literature (see Müller and Thoring 2012, Ximenes et al. 2015).

Lean Startup: Experimentation towards Growth

LS (Ries 2011) is an approach for exploring and developing solutions from initial ideas to working business models via rapid iterative steps with direct customer feedback. As the name suggests, it can be used for guiding the growth of a start-up, but it can also be applied in established enterprises (see Ries 2011, Blank 2013a).

Lean Startup: The Origins of the Lean Startup Method

LS has its intellectual roots in Blank's customer development (Blank 2006, 2013a, 2013b). Analogous to Blank's saying "Startups don't fail because they lack a product; they fail because they lack customers" (Blank 2006), customer development focuses on identifying suitable customers and their problems, as opposed to focusing exclusively on the development of a product or service. The process behind customer development is divided into four phases:

1) Customer discovery,
2) Customer validation,
3) Customer creation, and
4) Company building.

The first phase, *customer discovery*, focuses on understanding the specific needs that potential customers and users may have (ibid.). The next phase, *customer validation*, focuses on the validation of early adopters (see also Rogers 2003) by achieving commitment (e.g., by establishing a repeatable sales model). The third phase, *customer creation*, focuses on enlarging the customer base by crossing the chasm (see also ibid.). Finally, *company building* involved the transition of an organization by scaling from start-up to company status.

Lean Startup: The Three Phases

The phases of LS are comparable to the phases of customer development. The phases of LS (see Maurya 2012, 2016) are:

1) Problem-solution fit,
2) Product-market fit, and
3) Scale.

The *problem-solution fit* phase addresses the questions of whether there is a problem worth solving from a customer's perspective, whether there is a substantial target group, and whether it is feasible to solve the problem. The first phase is comparable with *customer discovery* from the customer development process and culminates in the creation of a *minimum viable product* (MVP), that is, a working solution with a minimum set of features for addressing identified problems worth solving.

The second phase, *product-market fit*, elaborates on how well a proposed solution will be accepted by the market. This phase focuses on creating traction and cash flows and is comparable with the *customer validation* and *customer creation* phases from customer development. Finally, the *scale* phase focuses on the growth of the business and is comparable with *company building*.

Lean Startup: The Foundational Principles

The phases of LS are driven by five foundational principles (Ries 2011). These five principles are as follows:

1) Entrepreneurs are everywhere,
2) Entrepreneurship is management,
3) Validated learning,
4) Build-measure-learn, and
5) Innovation accounting.

Entrepreneurs are everywhere emphasizes that the LS approach can work in every industry and in enterprises of any size.

Entrepreneurship is management indicates that a startup is not just a product but an institution that requires a managerial style geared towards handling extreme uncertainty.

Validated learning highlights that building a sustainable business is a learning process that can be validated by conducting experiments.

Build-measure-learn (BML) introduces the central process in the LS approach. BML is an iterative development process based on experiments (see **Figure 6**). Each iteration yields customer insights and provides instant customer feedback by measuring customers' responses using various methods.

Finally, *innovation accounting* involves using various models and methods for measuring progress and prioritizing work, for instance, a business model canvas (Osterwalder and Pigneur 2010), a lean canvas (Maurya 2012), or a customer factory (Maurya 2016). The accounted units are validated learnings and insights into the overall business model (as opposed to measuring a product's stage of completion).

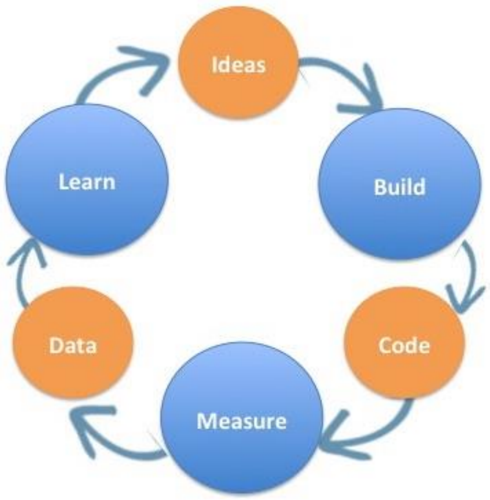

Figure 6. The BML loop (Blank 2015).

Lean Startup: Build-Measure-Learn in Detail

The core process behind LS, BML, is a hypothesis-driven approach. The way of thinking behind the preparation of a BML loop is the inverse of that used to execute the process (see Maurya 2012).

First, the team identifies what it wants to learn about the customers and users and their needs or problems and formulates a hypothesis. This process may include the exploration of unknown problems or the elaboration of known problems.

Thereafter, the measurement approach determined. If the problem is rather unexplored or unknown, a qualitative approach is suitable. In the other case, that is, if a problem is already well-known but there is room for improvement, it is more likely that a quantitative approach will be chosen.

Based on the decision regarding whether customer needs should be explored or existing services should be improved, the data to be measured to explore the problem is determined. The process of identifying the data can range from broad (e.g. discussing the challenges faced by customers in their daily lives) to more specific (e.g. discussing ideas that may lead to solution concepts or monitoring specific activities). In the latter case, choosing a quantitative approach is appropriate.

To support the generation of insights from quantitative data, measures must be differentiated from metrics (Lee 2013), and actionable metrics must be differentiated from vanity metrics (Ries 2011).

Measures describe absolute specific values, while metrics are derivatives of quantitative data. For example, *costs* and *units* are measures, but *costs per unit* is a metric (see Lee 2013). Actionable and vanity metrics are distinguished in a similar (yet slightly different) way (see Ries 2011). For instance, *total users per service* is a vanity metric, as it may also include users who have not been active for a long period of time and thus distort the given impression; in contrast, *total active users per service* is an actionable metric, as it provides an undistorted impression that can be used for testing a hypothesis. However, how *actionable* is defined depends on the context and service considered. To give a rough example, active users could be users who have logged in to their accounts at least once during the last 30 days.

Based on the defined learning objectives, the way of measuring user behavior, and the behavior to be measured, the team continues and ideates what could actually be built to measure the behavior. Here, the rule of thumb of *speed over perfection* applies (Ries 2011). This process focuses on yielding solutions that have the primary purpose of generating insights (as opposed to building high-fidelity deliverables). Therefore, the term *prototype* is used to communicate the unfinished nature of the to-be-built instantiation of a concept.

The process of developing prototypes is initially very open in order to allow for problem exploration and becomes more specific when fine-tuning a digital product or service. Examples of the different shapes that a prototype can take are paper sketches, mockups, click dummies, or fake door tests. Fake door tests advertise a certain digital product or service, but, instead of providing real functionality, they only provide a user interface and measure whether or not a potential customer and user would be activated by the promised (but non-existent) functionality.

Minimum viable products are another commonly used approach for testing hypotheses with prototypes. MVPs are vertical slices of fully functioning features that deliver core functionality in an appealing way. MVPs do not feature unnecessary functions (e.g., the integration of a service with other services or other desirable but nonessential functions). MVPs are particularly suitable for testing new value propositions.

Another popular means of conducting quantitative experiments is A/B testing, also called split testing. A/B tests describe the implementation of two competing versions of a site or feature that are both seen as promising. The versions are measured by redirecting digital traffic towards version A and version B and comparing the results. This comparison can be made using two completely new versions or by comparing the current version of a site or feature with a new version. It is worth noting that A/B testing should be used for testing structural changes (e.g., navigation) instead of considering cosmetic changes as, otherwise, the likelihood that the insights obtained will not justify the effort will increase (Maurya 2012).

Each executed BML loop brings about a decision. Ries (2011) proposes that one chooses between making a *pivot* or persevering with a current solution approach. A *pivot* means choosing a different approach based on new ideas, while *persevering* refers to elaborating on the current idea via further iterations. Either way, Ries (2011) recommends that decisions should be made on the data obtained to prevent biased decision-making. The targets of a BML iteration (i.e., the thresholds that have to be crossed in order to validate or invalidate a hypothesis) should be defined ex ante. The ex ante definition of thresholds is intended to further reducing the risk of making biased decisions.

The insights gained from an iteration are used to determine whether a hypothesis has been validated or invalidated. In addition, Croll and Yoskowitz (2013) and Maurya (2016) recommend that the definition of a macro target should drive a sequence of experiments. In the context of a macro target, Maurya (2016) adds two more options in addition to *pivot* and *persevere*. The first option is to *retire* a product or service; that is, the macro target has been successfully achieved, and the next idea for a different product or service should be developed. The second option is to *reset* a product or service; that is, the macro target has not been successfully reached, and the insights obtained indicate that the basic idea has been invalidated and that all implementations related to the idea should be removed.

All decisions should be made by an interdisciplinary team. LS is fundamentally based on interdisciplinary teams having all of the functions required for swift BML executions available (Ries 2011). Additionally, Maurya (2012) emphasizes that the "[…] one thing you should never outsource is learning about customers" (ibid.). Therefore, team members should not be sourced from service providers, as the effects of learning would perish with personnel turnover.

DevOps: Organizational and Technological Structures Towards Scale

The concept of *DevOps* made its first appearance at the *DevOpsDays* conference in 2009 (Debois 2009). DevOps is considered to be "[…] the natural next step of the agile movement, which emphasized working software, collaboration, speed, and responding to change" (from the Agile Manifesto in Christensen 2016). While the adoption of DevOps has gained momentum among practitioners (Forsgren et al. 2017), the term is still "[…] ambiguous, difficult to define and multifaceted […]" (Clear 2017). It has been described as a set of engineering process disciplines (Smeds et al. 2015), principles and practices (Zhu et al. 2016, Bass 2018), a framework (Erich et al. 2014, Diel et al. 2016), an approach (Artač et al. 2017), a movement (de França et al. 2016), a method (Airaj 2016), and an extension of agile methodology (Banica et al. 2017).

The main goals of DevOps are to "[…] bridge the gap between development and operations […]" (Barna et al. 2017), to develop higher-quality software (Perera et al. 2016), to increase software stability (Betz et al. 2016), to decrease risk (Lwakatare et al. 2016), to improve scalability (Spinellis 2016), to improve responsiveness, and to enable faster times to market (Soni 2015, Ebert et al. 2016).

Targets are achieved by interdisciplinary collaboration, deploying software in small batches (Callanan and Spillane 2016), the automation of build, test, and deployment activities (Clear 2017), and through "[…] quick flow of changes to a production environment […]" (Gottesheim 2015). These approaches are intended to be applied throughout the entire lifecycle of a product the whole product lifecycle to "[…] reduce the time between committing a change to a system and the change being placed into normal production […]" (Zhu et al. 2016).

DevOps: Organizational Aspects

Interdisciplinary collaboration demands the adoption of a new culture (Chung and Bang 2016, Perera et al. 2017), which has been referred to as a *culture of collaboration* (ibid.), the *DevOps culture* (Airaj 2016), or the *DevOps mindset* (Chen et al. 2015). Such a cultural change demands increased communication among the disciplines involved (Waller et al. 2015).

The adoption of a DevOps culture or mindset may cultivate a "[…] holistic or systemic view […]" (de França et al. 2016), that resembles the lean thinking approach (Fitzgerald and Stol 2017). This lean or systemic view fosters "[…] self-organization and empowerment of people in an organization […]" (ibid.). Increased self-organization and empowerment enable autonomy, which in turn enables teams to continuously experiment and learn (Clear 2017) guided by a philosophy based on the view that the "[…] faster you fail, [the] faster you recover […]" (Soni 2015).

DevOps is intended to change established responsibility schemes (de Bayser et al. 2015) and to overcome the prevailing silo mentality between development and operations (Furfaro et al. 2016, de França et al. 2016). This gap is bridged by the creation of cross-disciplinary team structures that include the *development* and *operations* functions (Airaj 2016) and can also include all functions that are involved in product design (Lwakatare et al. 2016). The resulting interdisciplinary team enables what is called *BizDevOps* (Drews et al. 2017, Fitzgerald and Stol 2017, Luz et al. 2018). Having interdisciplinary teams in place enables a transfer of responsibility. In fact, it is recommended that teams' responsibility be expanded to cover a product or service's whole lifecycle (McCarthy et al. 2015, Christensen 2016).

DevOps relies on a supportive culture of experimentation and learning (Clear 2017). DevOps builds on "[…] lean and agile practices […]" (Ebert et al. 2016) that are often viewed in relation to the lean startup method. The lean startup approach emphasizes experimenting and learning in interdisciplinary teams. A lean approach continuously provides feedback for improvement (de França et al. 2016, Balalaie et al. 2016), making LS – or more specifically, its BML approach – a suitable process for being used in combination with DevOps.

A high degree of autonomy, the broad responsibility, and rapid customer feedback (Jabbari et al. 2016) enable a team to continuously plan and adapt a digital product or service, which is referred to as *continuous planning*. *Continuous delivery* complements *continuous planning* by facilitating swift re-orientation (see de Bayser et al. 2015).

Continuous delivery refers to a continuous stream of small-batch deployments (de França et al. 2016). Deployment in small batches reduces risks related to each deployment and increases the speed of iterations. The automation of build, tests, and deployments enables rapid recovery in the event of failure (Laukkarinen et al. 2017). Overall, a shift in the approach to deployment can enable a team to release often and with confidence (Lwakatare et al. 2016). *Continuous delivery* and *continuous planning* support a continuous process of creating improvements, also called *continuous improvement*.

A *continuous improvement* process is at the heart of the DevOps approach, but the approach does not prescribe a specific process. DevOps does not provide an agile development method, but agile development methods are part of DevOps (Airaj 2016). A traditional waterfall approach is an unsuitable solution, as it describes a linear, non-continuous process (Roche 2013). Scrum may be used in combination with DevOps but its adoption can lead to conflicts, as the expansion of existing Scrum teams as a result of adding an operations function can lead to members not being treated equally (Erich et al. 2014). The performance of a *continuous improvement* approach is influenced by the chosen base development process and, furthermore, by the underlying technological infrastructure.

DevOps: Technological Aspects

The notion *DevOps* was coined by practitioners and created in response to the need for an "[…] agile infrastructure […]" (Debois 2008). The implementation of a microservices architecture is recommended to delineate and support the autonomy of interdisciplinary teams (Ebert et al. 2016, Drews et al. 2017). This fine-granular and modular architecture enables teams to continually develop, deploy, and operate their respective services without being slowed down by technological interdependencies created by the shared use of a tightly coupled infrastructure (Balalaie et al. 2016).

While the architecture should enable a decoupling of the teams' workflows, a coupling of the teams' communication is explicitly recommended (Artač et al. 2017). To ensure a smooth flow of communication, the co-location of team members is highly recommended (ibid., Luz et al. 2018), as communication via digital means can be unsuitable in certain situations, such as conflict resolution (ibid.). Nevertheless, inter- and intra-team communication can be complemented by tool-sharing (Perera et al. 2017), for example by using Yammer, FlowDock, or Confluence (Senapathi et al. 2018). Tool sharing improves collaboration on various levels (de Bayser et al. 2015, Woods 2016).

Tools can enable teams to interact with infrastructure via software, a practice that is also referred to *infrastructure as code* (de Bayser et al. 2015). Examples of such tools are code-versioning and code revision management tools (Artač et al. 2017) or team-spanning communication tools that are hybrid in nature in the sense that posts can be created both by teams and by automated infrastructure, for example in the case of deployments (Callanan and Spillane 2016).

Tool sharing is intended to promote knowledge sharing (Artač et al. 2017; see also MacCarthy et al. 2015). Knowledge sharing is intended to promote the exchange of general project information and personal learning experiences (de França et al. 2016). Improved knowledge sharing further supports a cultural change, as finger-pointing between functions is reduced as a result of access to well-documented and transparent information. The avoidance of finger-pointing is further supported by shared metrics, as they provide a shared language that all involved parties can understand and create a common focus on *continuous improvement* (Gottesheim 2015). Shared metrics should cover various aspects, for example business and technology-related metrics (Fitzgerald and Stol 2017).

Another intended purpose of tool use is automation. Automation plays an important role in DevOps (Perera et al. 2017) and supports *continuous deployment* by automating what is called the *deployment pipeline* (Soni 2015), the *DevOps toolchain* (Callanan and Spillane 2016), or the *DevOps pipeline* (Miglierina and Tamburri 2017). The DevOps pipeline can be further divided into *continuous integration* and *continuous delivery*, with the establishment of *continuous integration* being a prerequisite for *continuous delivery* (Balalaie et al. 2016).

Continuous integration involves merging code in a central version control repository multiple times a day (de França et al. 2016). This practice avoids keeping code local and reduces potential integration errors (Virmani 2015). Additional tools can be used to automate the build and packaging process and to run unit tests (Airaj 2016). Ideally, this process should be triggered by code commits (Virmani 2015). The tested builds are then handed over to the *deployment pipeline* of a *continuous delivery* (Bass 2018).

Continuous delivery function automatically deploys the builds (in the form of packages) to one or more stage environments with the goal to simulate deployment in a production environment and identify potential errors upfront (Airaj 2016). The environments are configured and managed with the help of domain-specific languages (DSLs). The use of DSLs allows for the elimination of the manual configuration of the environments from the process and is considered to be part of the *infrastructure as code* concept (de Bayser et al. 2015). A further advantage of the automated configuration of environments is the ability to transfer the underlying scripts, which are also called recipes, to cloud environments (Power 2014). Moving recipes to the cloud enables an on-demand infrastructure provision (McCarthy et al. 2015). A functioning *continuous deployment* function can accelerate *continuous planning* cycles, as it enables the provision of continuous feedback based on the deployments (see Agarwal et al. 2018). The time to deploy is reduced; thus, the time that would potentially be required to receive feedback from the customer and user is reduced as well (de Bayser et al. 2015).

Commonly used tools used for automating the DevOps Pipeline are code repositories and version control management software, for instance, Git, Subversion, or Mercurial (de França et al. 2016). Such software can also be used for managing infrastructure configurations (de Bayser et al. 2016). Automating builds can be enabled by using continuous integration software such as Bamboo, Jenkins, or TeamCity (Ebert et al. 2016). Preparing deployments by providing packages can be automated using Maven, Ant, or Gradle (Airaj 2016). The automated configuration of test environments for enabling automated deployments can be achieved by drawing on the concept of containerization (Balalaie et al. 2016). Containerization is a lightweight alternative to virtualization (Ebert et al. 2016). A suitable tool for containerization is Docker (Callanan and Spillane 2016, Agarwal et al. 2018). Configurations of packages, for example for the purpose of uniform deployment across various instances or for testing various configurations, can be handled with orchestration tools. Examples of orchestration tools are Kubernetes (Barna et al. 2017), UrbanCode Deploy by IBM (Oliveira et al. 2016), Rundeck, ControlTier, Capistrano, and Fabric (Airaj 2016).

The available body of knowledge concerning DevOps provides elaborate guidance for designing the technological foundations required to operate NWoW with high degrees of efficiency at scale. As NWoW are pivotal to DIUs, DevOps is crucial for operating a DIU at scale.

New Ways of Working: Summary

The three approaches discussed above share commonalities, but there are also differences. DT (Brown 2009) emphasizes qualitative methods for co-exploration of a potential product or service with the customer and user and provides elaborate guidance throughout the early stages of solution development. LS (Ries 2011) distinguishes itself from DT by its use of quantitative experimentation and its growth perspective, which manifests in the implementation of solutions and the development of business model plans (see Ries 2011, Maurya 2012).

Both DT and lean startup feature a strong customer orientation due to their emphasis on prototyping (see Duerr et al. 2018) and instant customer feedback (Weingarth et al. 2019). In comparison, DevOps does not explicitly stipulate the early integration of the customer and user in the development process but emphasizes the importance of continuous feedback for enabling *continuous planning* and achieving the overall target of DevOps, namely *continuous improvement*.

DevOps does not define a specific process for implementing *continuous improvement,* but the literature suggests that LS appears to be preferred over Scrum or waterfall approaches. Compared to DT and LS, DevOps figures prominently for developing and operating a digital product or service at scale as it is the only approach of the three to put explicit emphasis on the actual operation of a digital product or service. Beyond that, DevOps covers further topics that are important for scaling, such as automation (see Weingarth et al. 2019).

All three approaches are united by their iterative nature, the fact that they are fundamentally based on the use of interdisciplinary teams, their focus on shortening times to market, and their requirements with regard to culture. Deciding among the three approaches appears to be less of an either-or choice and more a question of timing. Various sources highlight the compatibility between DT and LS (see Müller and Thoring 2012, Ximenes et al. 2015) as well as between LS and DevOps (see Balalaie et al. 2016, Ebert et al. 2016, de França et al. 2016, Laukkarinen et al. 2017).

The different foci of these approaches and their compatibility suggest that DT is suitable for an early exploration of customer and user needs, LS is suitable for growing a business based on identified needs, and DevOps is suitable for scaling and exploiting a grown business.

2.1.5.2. Interdisciplinary Teams, Autonomy, and Responsibility

Interdisciplinary teams are pivotal to the adoption of NWoW. An interdisciplinary team, also referred to as *squad*, should consist of five to seven individuals but can also consist of up to nine (see ING in Corso et al. 2018). The teams are responsible for their domain (e.g., a digital product or service or a module of a product or service).

Teams consist of individuals with skills from both the business and IT functions. Thus, the teams are not confronted with the traditional silo mentality and can contribute to business-IT alignment in established enterprises on a different level (Drews et al. 2017, Duerr et al. 2018). This becomes increasingly important in times that require new forms of collaboration between business and IT to allow a firm to move forward in its digitalization journey (Urbach and Ahlemann in Legner et al. 2017).

Interdisciplinary teams can feature various roles (see **Table 5**). Developers and designers are commonly viewed as pivotal roles in interdisciplinary teams.[4] Further commonly identified roles in interdisciplinary teams are product owners, concept/UX, and test managers. The roles *operations* and *analysts* appear to be less frequently identified as being pivotal to the composition of interdisciplinary teams. Considering LS and DevOps (see above), I argue that the roles *operations* and *analysts* are frequently required in interdisciplinary teams to ensure provision of a high-quality digital product or service and to facilitate rapid iterations based on quick and purposeful customer and user feedback.

Additional roles, including *method coach*, *architect*, *database expert*, *security expert*, *technology expert*, *marketing expert*, and *quality manager*, have been identified as being relevant in certain situations. Their importance for the daily business of an interdisciplinary team may depend on the individual product or service that a team develops. These roles can be part of interdisciplinary teams or made available on-demand, for example through expert pools. It should be noted that the sources (see **Table 5**) do not specify exact numbers of individuals for certain roles within teams. For instance, it can be reasonable to employ more than one developer or developers with different specializations in an interdisciplinary team.

The provision of high degrees of autonomy is fundamental for establishing interdisciplinary teams (Drews et al. 2017; see also Corso et al. 2018). Autonomy can largely be provided by a transfer of decision rights regarding the scope of development from the leadership to interdisciplinary teams (Corso et al. 2018). In practice, this translates to the internalization of all of the skills required to conceptualize, develop, and operate digital services from cradle to grave and end to end in interdisciplinary teams (Drews et al. 2017, Adersberger and Siedersleben 2018, Corso et al. 2018).

Teams must be endowed with a mandate to experiment to enable exploration (see Haffke 2017). The transfer of responsibility enables swift experimentation at the interface with the customer and user, as scope decisions are primarily made by the team and reconcilement efforts can be kept to a

[4] Strikingly, Brown (2009; Design Thinking) does not share the view that the role of developer is mandatory in an interdisciplinary team.

minimum. Such exploration provides teams with instant feedback and leads to faster times to market (Weingarth et al. 2019).

#	Source	Product Owner	Designer	Concept / UX	Developer	Operations	Analyst	Test Manager	Method Coach	Architect	Database Expert	Security Expert	Technology Expert	Marketing Expert	Quality Manager (QA)
1	Oestereich and Weiss (2008)	X			X				X	X		X	X		X
2	Brown (2009)		X	X			X							X	
3	Davies and Sedley (2010)	X	X	X	X		X	X	X					X	
4	Maurya (2012)		X	X	X									X	
5	Kniberg and Ivarsson (2012)	X	X		X	X		X	X				X		
6	Canty (2015)				X			X			X				
7	Humble et al. (2015)	X	X	X	X			X		X	X			X	
8	Olsen (2015)		X	X	X	X									X
9	Virgenschow (2015)	X			X		X	X	X	X					X
10	Wolf (2015)	X	X	X	X		X	X	X					X	

Table 5. Functions in interdisciplinary teams (own depiction).

Swift cycles require teams to be co-located. Co-location facilitates communication, increases internal awareness, reduces barriers and dependencies (Weingarth et al. 2019), and provides easy access not only to skills in teams but also to pooled skills available across teams (de Kare-Silver 2011).

A further aspect of achieving autonomy is the definition and creation of clear boundaries. A low number of dependencies enables teams to sustain a lean and agile way of working without being dependent. Clear boundaries are defined by clear responsibilities for a certain part of a digital product or service. Clear responsibilities should be defined on the technological level. Establishing micro-services (see Drews et al. 2017, Weingarth et al. 2019) that are owned by a particular team eventually enables the desired shift in the accountability paradigm from a technological point of view as teams can release independently and with confidence within their own boundaries.

The shift in the accountability paradigm is not limited to transferring rights and re-arranging structures. Teams are also encouraged to build with the goal of learning without being tied to the necessity of completing and polishing digital products and services (see Duerr et al. 2018). Such a state of affairs can be achieved by adopting concepts such as prototyping or creating MVPs (Weingarth et al. 2019). The experimenting approach implies the establishment of a *failure culture* or *experimenting culture*, which in turn motivates teams to become venturesome (see Duerr et al. 2018) and fosters innovation (see Weingarth et al. 2019).

The autonomous experimenting of teams can present challenges to leadership. It must be emphasized that a shift in the accountability paradigm also means a shift in the type of deliverables. The scope that a team autonomously determines for itself enables a focus on learning rather than on delivering within a fixed scope determined in a top-down manner. Fixed scopes negatively impact agility and promote inertia, as ex post facto adjustments require tedious change requests. Therefore, relying on traditional leadership approaches is unsuitable for coordinating DIUs.

2.1.5.3. New Approaches to Leadership

The role of traditional leadership changes with the adoption of new structures in DIUs. A growing number of small interdisciplinary teams and an autonomous way of working supersede a monolithic organization and top-down coordination (see Drews et al. 2017, Corso et al. 2018). Traditional software planning (e.g., by utilizing roadmaps and work-breakdown approaches) leads to diminishing returns (Gruver 2015) in light of constant change and a growing number of teams.

The new leadership has to create and maintain a platform to support teams in supporting the customer and user. In addition, requirements with regard to leadership may change with the degree of maturity of a digital product or service (Révészová 2015). The activities behind the exploration, growth, and exploitation (see DT, LS, and DevOps in **Chapter 2.1.5.1**) of a business model present various challenges to their incubating environment and thus the leadership of a DIU.

A new approach to leadership can provide the required organizational flexibility and autonomy from a structural point of view. These options should be considered by the leadership of a DIU when attempting to create, organize, and coordinate platforms for interdisciplinary teams.

Organize Team Structures at Scale

Traditionally, the development of digital products or services has been handled within functionally oriented structures. Interdisciplinary teams break with this functional orientation by pooling different disciplines. While the new structures formed by such teams emphasize interdisciplinarity, knowledge exchange between functions is still considered to be a vital aspect of scaling a well-functioning DIU. Therefore, it can be beneficial to adopt a matrix organization in DIUs (see Weingarth et al. 2019).

The organizational engineers at Spotify have proposed a matrix model that combines interdisciplinary and functional structures (see Kniberg and Ivarsson 2012). The Spotify matrix is a suitable approach for organizing interdisciplinary teams while preserving organizational flexibility and economies of scale, and the matrix has been increasingly adopted among practitioners (see Schimera 2017, Corso et al. 2018).

The Spotify matrix (see **Figure 7**) defines core structures on several levels. Squads are the centerpiece of the Spotify matrix. Squads represent interdisciplinary teams (see also **Chapter 2.1.5.2**) and "[…] are designed to feel like a mini-startup […]" (Kniberg and Ivarsson 2012), as this approach provides teams with the necessary degrees of freedom and promotes an autonomous way of working (see also **Chapter 2.1.5.1**). Squads are functionally integrated via chapters. Chapters are designed to preserve knowledge exchange within functions and across teams to enable economies of scale. In addition to chapters, structures around common interests can be defined. Each chapter has a designated chapter lead. These structures are called guilds. Guilds are similar to chapters in that they aim for the same targets, that is, knowledge exchange and economies of scale, and that each guild has a designated guild lead. The difference lies in the scope: while chapters focus on the exchange within functions, guilds are viewed as "[…] communities of interest […]" (ibid.). Examples of guilds are "[…] the web technology guild, the tester guild, the agile coach guild […]" (ibid.). Another difference between chapters and guilds lies in their reach: Chapters are usually defined in the context of a tribe, while guilds can be defined across tribes.

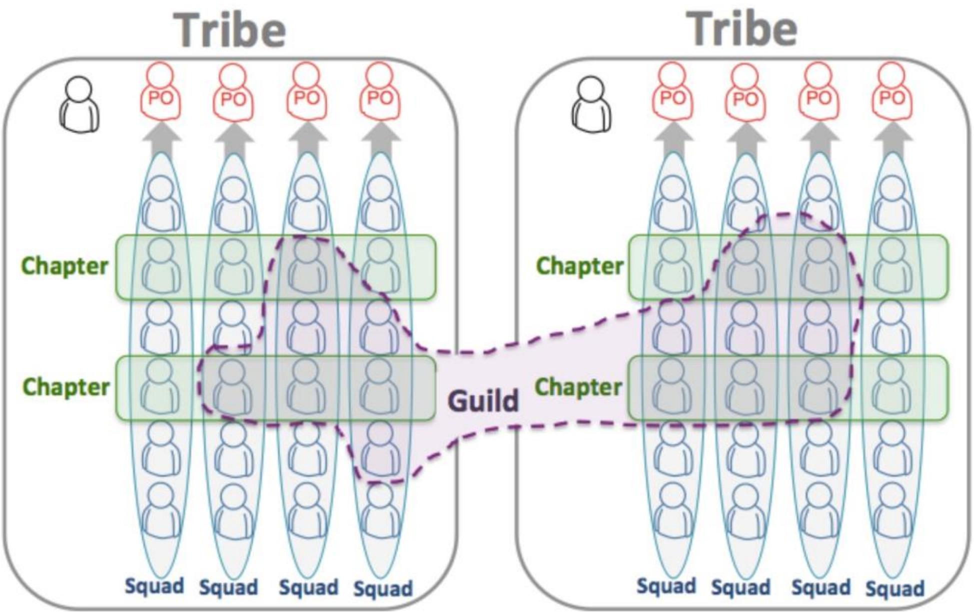

Figure 7. The Spotify matrix for organizing teams at scale (Kniberg and Ivarsson 2012).

A tribe contains and incubates squads and delineates work-related areas, "[…] such as the music player, or backend infrastructure" (Kniberg and Ivarsson 2012). Each tribe has a tribe lead, which ensures that a tribe and squads within a tribe are provided with the necessary degrees of freedom. Squads in a tribe are co-located in the same office. The size of a tribe is based on the Dunbar number. The Dunbar number has been defined by Dunbar (1992) and suggests that the maximum number of stable social relationships that an individual can maintain ranges from 100 (Kniberg and Ivarsson 2012) to 150 (Hernando et al. 2010), depending on source consulted. This limitation is set to avoid the emergence of "[…] restrictive rules, bureaucracy, politics, extra layers of management, and other waste" (Kniberg and Ivarsson 2012). Tribes rely on regular gatherings to facilitate informal communication and coordination with regard to current topics. These gatherings can cover work in progress, delivered software, live demos, hack days or hackathons, challenges, and learnings.

Overall, the structures defined by the Spotify matrix are oriented towards creating and maintaining organizational platforms for managing interdisciplinary teams while preserving a certain degree of organizational flexibility with which to respond to changing circumstances. Tribes are defined for co-locating interdisciplinary teams around work-related areas with fewer than 100 members.

I argue that a DIU is suitable for incubating at least one tribe, as tribes create a platform for teams around a common purpose and because the common purposes of a DIU include, inter alia, to design, develop, and operate a digital product or service.

Coordinate Autonomous Teams at Scale

Traditional top-down work-breakdown structures such as the definition of roadmaps scale poorly with a rising number of teams and limit autonomy. Bi-directional coordination methods can reduce the costs of control and maintain autonomy (see also **Chapter 2.1.5.2**). Google OKR and Spotify Rhythm can enable macro-coordination of squads and tribes towards common targets in innovative environments.

Both Google OKR and Spotify Rhythm distinguish between overarching company goals and team goals. While overarching company goals may be set, teams are motivated to autonomously co-align their goals in accordance with their leadership. Google OKR, which has been adopted by various companies (see Steiber 2014), is a dynamic system for coordinating continuous innovation (see Steiber and Alänge 2013); thus, it matches well with the ongoing nature of the development of NWoW (see **Chapter 2.1.5.1**).

Spotify adopted Google OKR before abandoning it for Spotify Rhythm (see Kniberg 2016). In the following, I introduce Google OKR to provide a foundation before I turn to Spotify Rhythm as an advanced method for coordinating and strategically aligning a company by means of a mixed top-down and bottom-up approach.

Google OKR

The OKR in Google OKR stands for *objectives and key results*. Google OKR was introduced within Google by John Doerr in 1999 and has been used since 2000 to coordinate objectives and key results (Klau 2013). Objectives and key results are used to define a hierarchy of goals and measurable targets to align strategies across a company (Steiber 2014). OKRs are defined by setting ambitious objectives (Klau 2013), also referred to as *stretch goals* (Rework 2016). Objectives are intentionally designed to be "[…] beyond the threshold of what seems possible […]" (ibid.) to motivate and attract talented individuals (ibid.). Objectives are not defined as a continuous activity (e.g., *keep hiring*) but rather as certain states or goals that should be reached (e.g., *hire 50 developers*). Objectives are further defined and measured with reference to key results. Key results are quantifiable targets that are designed to be achievable (see **Figure 8** for an example of OKRs).

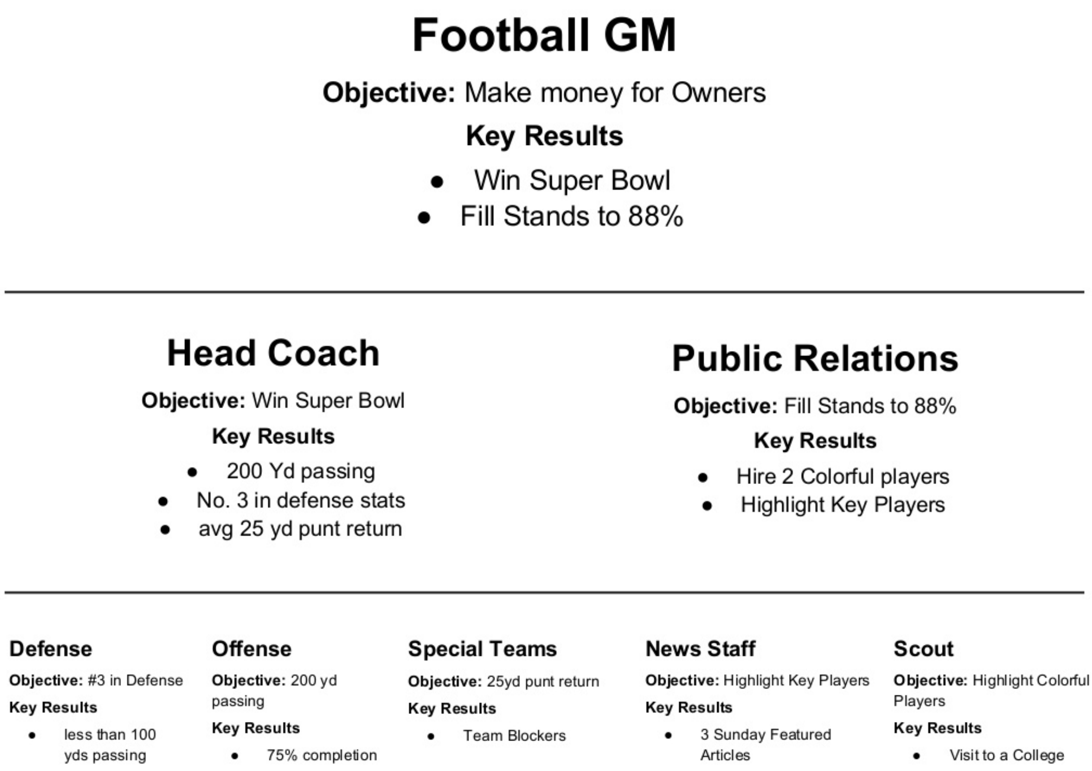

Figure 8. An example of an OKR setup (Doerr in Klau 2013).

Each node in a company should not define more than five objectives and four key results. More than 60% of the objectives should be defined from bottom up, and all involved parties must agree on the objectives. As objectives are designed to be stretch goals, the means of evaluation the degree to which an objective has been achieved should be designed accordingly. Achieving 60–70% of an objective is considered *good*, while anything above is considered exceptional. Constantly achieving above 70% suggests that objectives may be ill-designed. It must be emphasized that the degree to which OKRs are achieved should not be used to evaluate the performance of employees (Doerr in Klau 2013).

OKRs are defined on all levels of a company. The initial stage of the general OKR definition process starts with corporate objectives and ripples down to the department, group, and individual level. As more than 60% of the objectives should be defined from bottom up, this process is not considered to be unidirectional. Staff meetings and one-on-ones are used to communicate and negotiate OKRs. Staff meetings are used to develop and negotiate objectives and evaluate group performance, while one-on-ones are used to develop and negotiate key results and monitor progress. OKRs are monitored and re-evaluated on a regular basis. OKRs are defined annually and quarterly, whereas annual OKRs set a broad direction and can be redefined based on learnings (Doerr in Klau 2013).

OKRs align a strategy across a company (Steiber 2014); in addition, they focus efforts and make them measurable (Klau 2013). In comparison to traditional approaches, OKRs are defined by a combination of "[…] top-down and bottom-up suggestions […]" (Rework 2016) and are visible to everyone in a company (Klau 2013). This level of transparency enables efficient communication within a company, as employees gain information which they can use for pitching ideas and approaches for achieving their goals. The information obtained will enable them to judge upfront whether their ideas or approaches will resonate with other objectives; thus, they can avoid unnecessary communication (Klau 2013). The bottom-up communication of targets that have been identified as being important can promote reflections on what a company should be working on and uncover unleveraged development potentials (Doerr 2018).

Spotify Rhythm

Spotify Rhythm is similar yet different to Google OKR. As only limited material on Spotify Rhythm is available, I limit my introduction to Spotify Rhythm to a relative perspective on the differences between Spotify Rhythm and Google OKR.

The name *Spotify Rhythm* refers to this approach's planning cadences. Spotify uses different rhythms to stimulate planning and coordination on different levels. The top level is formed by *company beliefs*.

Company beliefs reflect the current market environment and describe how this environment should be shaped over a horizon of three to five years. Company beliefs are identified based on data and insights.

The next level is *north stars*. North stars are ambitious goals with a two-year horizon. They are based on company beliefs and used to derive further goals, specifically *company bets*. Company bets are "[…] large projects or cross-organization initiatives […]" (Kniberg 2016) with a horizon of six to 12 months that drive towards north stars. They are planned and re-evaluated by the strategy team on a quarterly basis. Company bets are the result of bottom-up and top-down planning.

The level below *company bets* includes *functional bets* and *market bets*. Functional and market bets are iterated on a six-weekly basis. Functional bets are "[…] large projects that generally take place within single functions and are set by functional leads […]" (ibid.). Like company bets, functional bets are created through a combination of top-down and bottom-up planning. Examples of functional bets categories are *marketing* or *tech-product-design*. Market bets are investments and initiatives on the same level as functional bets. Market bets can be defined in relation to company or functional bets or can be "[…] guided by their market categorization […]" (ibid.). Functional bets can be further broken down into *tribe bets*. In tribe bets, a function, for example *tech-product-design*, is further broken down into its related work areas, for instance, front-end services or infrastructure (Kniberg 2016).

The main difference between Spotify Rhythm and Google OKR lies in Spotify's definition of DIBBs. Spotify defines DIBBs instead of OKRs. DIBB stands for *data-insights-beliefs-bets* and is an iterative approach for linking coordination with data-driven experimentation (see **Figure 9**).

Spotify defines DIBB as "[…] an argument framework […]" (ibid.). The arguments are based on *data* and derived *insights*. Based on data and insights, hypotheses in the form of *beliefs*, that aim for improvements based on said data and insights are formulated. Beliefs are further broken down into specific measures in the form of bets. Achieving bets creates new data, which then can serve as the basis for another DIBB iteration on the same topic. By its DIBB framework, Spotify Rhythm closes the feedback loop. As opposed to Google OKR's objectives, beliefs must be backed with data.

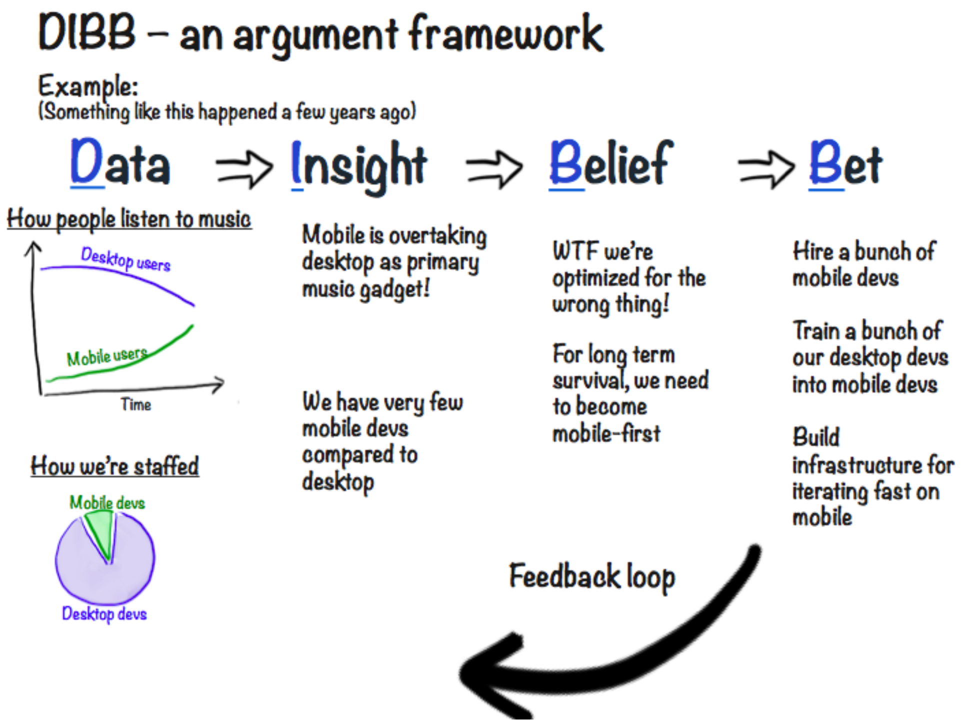

Figure 9. Spotify DIBB (Kniberg 2016).

There is an uncanny resemblance between the DIBB approach and BML in LS. Similar to DIBBs, BML is a hypothesis-driven approach based on data and insights. The DIBB approach names BML's learnings insights. Insights and learnings are both the result of an experiment (see BML) or a bet (see DIBBs). Both experiments and bets lead to the creation of data that can be interpreted to learnings or learnings, respectively, fueling the next feedback loop of both approaches. This similarity enables linking BML's experimentation process with an overall company coordination process such as Spotify Rhythm.

Due to the possibility of linking Spotify Rhythm with ways of working that are fundamentally based on data-driven experimentation, Spotify Rhythm presents itself as a suitable approach for coordinating a DIU and, furthermore, aligning a DIUs with the goals of a company. The defined levels of Spotify Rhythm further provide evidence on the size of a DIU; based on the information provided above concerning tribes (see **above**). I assume that a DIU should consist of at least one tribe. Spotify Rhythm introduces functional bets as a level above that of tribe bets to coordinate several tribes towards a common goal within a work-related area, for instance, *tech-product-design*. DIUs are tasked with the exploration, design, development, and operation of digital products and services. Based on the fact that functional bets describe a coordination mechanism that can be used to unite tribes towards making progress on a specific digital product or service, it is reasonable to assume that DIUs should consist of at least one tribe but can consist of as many tribes as necessary for the exploration, design, development, and operation of a work-related area, such as the tech-product design of a digital product or service.

2.1.6. Benefits and Risks of Digital Innovation Units

DIUs support establishing an innovative mindset and culture through a shift from existing structures towards new structures, such as NWoW (Westerman et al. 2014, Haffke et al. 2017, Tumbas et al. 2018, Weingarth et al. 2019, cf. also Urbach et al. 2017; see also Cianni and Steckler 2017). DIUs can be utilized to drive synergies across functions (Westerman et al. 2014, cf. Dremel et al. 2017) by enabling business-IT alignment on new levels (see Duerr et al. 2018). In particular, the core organizational elements of DIUs, that is, interdisciplinary teams, are not confronted with the traditional silo mentality and can contribute to business-IT alignment on a new level (Drews et al. 2017). Furthermore, interdisciplinary teams, supported by the high degrees of freedom of their surrounding DIUs, can engage with the customer and user in new ways to co-explore, develop, and operate innovative digital products and services (see Horlach et al. 2016) to shorten the time-to-market (see Weingarth et al. 2019; see also Adersberger and Siedersleben 2018, Urbach and Röglinger 2019) and produce new insights for driving a firm's analytics disciplines (see Galbraith 2014).

DIUs are a suitable means for pooling existing knowledge, driving knowledge development, and enabling knowledge sharing within a DIU and across organizational boundaries (Westerman et al. 2014, Haffke et al. 2016, Tumbas et al. 2018, Weingarth et al. 2019). Thus, DIUs can support the development of digital skills and capabilities (Westerman et al. 2014, Bekkhus 2017, Haffke 2017, Tumbas et al. 2018) and can furthermore be used as a means to attract and pool talents (Galbraith 2014; see also Hess et al. 2016).

The increasing demand for speed presents the underlying technological structures of a DIU with challenges (Weingarth et al. 2019). The main advantage of DIUs is the ability to selectively rely on legacy systems (see ibid.) or even the opportunity to start on a technological greenfield (Swaminathan and Meffert 2017). However, creating the technological platform underlying a DIU from scratch can increase the time required for a DIU to become effective and can require significant investments (see Cianni and Steckler 2017).

DIUs are a means for carving out space for new roles; thus, they can provide significant support for the establishment of new roles within an existing organizational setting (Haffke et al. 2016, Tumbas et al. 2018). Specifically, DIUs are a core asset for driving the digital agendas of CDOs (Tumbas et al. 2018, Weingarth et al. 2019; see also Westerman et al. 2014, Haffke et al. 2016).

The process of designing, creating, and operating DIUs is challenging. A new organizational unit claims new ground and drives fundamental changes throughout a company. Resources are allocated to such a new unit as a matter of priority. Employees on various existing levels might feel that the status quo is threatened. The perceived threat can create an acceptance problem. Nevertheless, at the intersection between business and IT and the internal and external stakeholders of a company, DIUs can provide an impactful lever for driving the digital transformation of a firm.

The creation of DIUs goes hand in hand with a spatial separation between new and established structures. DIUs nurture the development of a new culture and mindset, and the adoption of NWoW (see Hess et al. 2016, Weingarth et al. 2019) but often require separate spaces. DIUs are a resource-intensive but effective mechanism for driving the digital transformation of a firm (Westerman et al. 2014).

Correctly positioning DIUs in established enterprises is a challenging task. A newly created DIU is vulnerable and must prove itself to other departments. Adopting NWoW can be a cumbersome process (see Urbach and Röglinger 2018). Management support can help to shield a DIU (Galbraith 2014).

Spatial and structural separation of DIUs can provide protection. However, positioning a DIU too far from existing structures can create acceptance problems and prevent knowledge exchange, thus impeding the creation of synergies, and can ultimately lead to the creation of another silo.

Excessively close integration with existing structures, in contrast, can impede the organizational development of DIUs (Åkesson et al. 2018) and can ultimately suffocate the establishment of a new culture and structures (Wokurka et al. 2017; see also Dremel et al. 2017).

Coordination methods such as Google OKR or Spotify Rhythm can help to co-align company targets with the targets of DIUs and those of other functions in a combined top-down and bottom-up approach. However, the direction of impact at the interfaces between new and established structures must be monitored and, if necessary, corrected to drive change concentrically from DIUs through established structures to the boundaries of a firm.

2.1.7. A Research Agenda for Digital Innovation Units

DIUs are a new phenomenon that has been widely accepted as a strategy for the digital transformation of firms (see Simon 2014, Westerman et al. 2014, Galbraith 2014, Amberti 2015, Hearn 2016, Hess et al. 2016, Kaufmann and Horton 2015, Chanias and Hess 2016, Rieß et al. 2016, Drews et al. 2017, Swaminathan and Meffert 2017, vom Brocke et al. 2017, Åkesson et al. 2018, Duerr et al. 2018, Gimpel et al. 2018, Harpham 2018, Miyazaki and Sato 2018, Osmundsen et al. 2018, Ross et al. 2018, Fortmann et al. 2019, Weingarth et al. 2019). DIUs represent a departure from existing structures that involves the amalgamation of business and IT capabilities into novel interdisciplinary organizational structures. The process of designing and developing DIUs requires the implementation of new structures, but how these structures should be designed is currently unclear.

While the current literature concerning DIUs views this topic in the light of strategic measures (see Westerman et al. 2014), the role of the CDO (see Haffke et al. 2016, Tumbas et al. 2018), or in the context of business-IT collaboration (see Horlach et al. 2016, Andersson and Rosenqvist 2018), guidelines for actually designing and developing DIUs are lacking.

Guidelines for creating DIUs could support the communication of a DIU's requirements in order to align internal stakeholders and manage expectations. Thus, guidelines for creating DIUs could be used to promote the development of newly founded DIUs and could also provide guidance as to how established DIUs could be further developed. However, designing such guidelines for developing DIUs would require profound knowledge of *digital* structures, that is, aligned organizational and technological structures that enable and support the new way of working of DIUs.

A defining trait of DIUs is that DIUs employ interdisciplinary teams in combination with microservices to enable swift development cycles. This hybrid bundling of organizational and technological structures reduces dependencies and enables teams to take responsibility for the services they provide with the ultimate goal of shaping innovative digital products and services. It may not be a coincidence that new organizational and technological structures are required to produce innovative digital products and services.

Future research in the field of DIUs should follow a two-fold strategy: First, the relationship between organizational and technological structures, as well as the relationship between these hybrid structures and their impact on product design, must be understood. There is a theory concerning socio-technical design that examines the relationship between organizational structures and their impact on product design, namely *Conway's law*. A literature review on the scholarly legacy of Conway's law could uncover valuable knowledge that could serve as a foundation for creating guidelines for the development of DIUs.

Second, at the time of writing, in-depth empirical reflections on instantiated DIUs are practically non-existent. Guidelines for designing and developing DIUs could be used to empirically assess and plan the development of DIUs and would make them comparable, thus enabling in-depth empirically based reflections. In addition, empirical research at the boundaries between DIUs and surrounding organizational structures (e.g., other functions) or at the intersections among existing governance and coordination mechanisms is required. Empirical insights concerning both could provide further details concerning how the internal structures of DIUs should be designed and could also support the correct positioning of DIUs in existing organizational settings.

2.2. The Relationship between Organization and Technology in Technology Development

DIUs represent a departure from existing structures that involves the amalgamation of business and IT capabilities into novel interdisciplinary organizational structures. The process of designing and developing DIUs requires the implementation of new structures, but how these structures should be designed is currently unclear.

There is a theory concerning socio-technical organizational design that examines the relationship between organizational structures and their impact on product design. The theory in question is called Conway's law, which was described by Melvin E. Conway in his article "How do Committees Invent?" (1968). The law states that

> *[…] organizations which design systems (in the broad sense used here) are constrained to produce designs which are copies of the communication structures of these organizations.* (Conway 1968)

This implies that organizational structures should be designed should be designed considering the type of products that they will produce. As revealed by a search on Slideshare, Conway's law has been recently rediscovered in practitioner communities.[5]

I picked up on the traces of Conway and conducted a literature review to identify theories and concepts based on the law to ultimately apply the descriptive and prescriptive knowledge provided to the design of DIUs.

2.2.1. Approach

The review process is based on the suggestions of Webster and Watson (2002) and vom Brocke et al. (2009) concerning how literature reviews should be conducted. Specifically, vom Brocke et al. (2009) propose a five-step process that consists of

1) definition of scope,
2) conceptualization of the topic,
3) literature search
4) literature analysis and synthesis, and
5) research agenda.

[5] The Google search "site:www.slideshare.net +conway +agile" yielded 2,480 hits on the 26th of March 2019.

The scope of this review (see Brocke et al. 2009) was determined based on Cooper's taxonomy of literature reviews (see **Table 6**). The focus (1) is on identifying theories that emerged from Conway's law and the extraction of relevant organizational design knowledge that might impact the design of a digital product. The goal (2) is the integration of the knowledge obtained to render it applicable to designing DIUs. The organization of the findings (3) is conceptually arranged around the identified design variables and mechanisms, that is, general causal relations between system designs and their outcomes, types of dependencies that might impact an outcome, the identification of specific dependencies, organizational levels that should be considered when designing a system, and generic approaches for improving cross-boundary integration endeavors. Similar findings provided by different research streams are conceptually integrated. My perspective (4) is the neutral representation of the findings. The target audience (5) consists of specialized scholars and practitioners who research or develop DIUs. The coverage of this literature review (6) can be characterized as being central as it focusses on design variables and mechanisms for designing DIUS.

	Characteristic	Categories			
(1)	focus	research outcomes	research methods	theories	applications
(2)	goal	integration	criticism	central issues	
(3)	organization	historical	conceptual	methodological	
(4)	perspective	neutral representation	espousal of position		
(5)	audience	specialized scholars	general scholars	practitioners	general public
(6)	coverage	exhaustive	exhaustive and selective	representative	central/pivotal

Table 6. Classification of the hybrid resonance literature review (adapted from Cooper 1988 in vom Brocke et al. 2009).

The conceptualization of the topic (see Brocke et al. 2009), that is, leveraging design variables and mechanisms for designing DIUs, draws on Conway's law as a starting point. Conway's law postulates that an organizational design impacts the design of the products that that organization produces. This implies that an organization should consider the products that that organization wants to offer when designing organizational structures.

Leveraging Conway's law for organizational design requires knowledge of the core causal relationship described by the law, organizational structures relevant to the law, the behavior of these structures (as differently behaving structures must be considered differently), the system levels that should be considered within a design (as "[…] systems […] can be viewed at different levels of complication" (Conway 1968), and, insofar as they are available, existing approaches to designing the interfaces between two systems, for instance, that between business and IT or between an organization and its customer and user.

The search process can be characterized as what Webster and Watson (2002) describe as a forward search; the search itself began with the article "How do Committees Invent?" by Conway (1968). Webster and Watson (2002) propose using the Web of Science to identify further articles in the context of a forward search. I tapped into the Web of Science and identified 199 articles[6] that cited the initial article; I also found that there was an increasing trend in terms of rediscovering Conway's law in the scholarly community (see **Figure 10**).

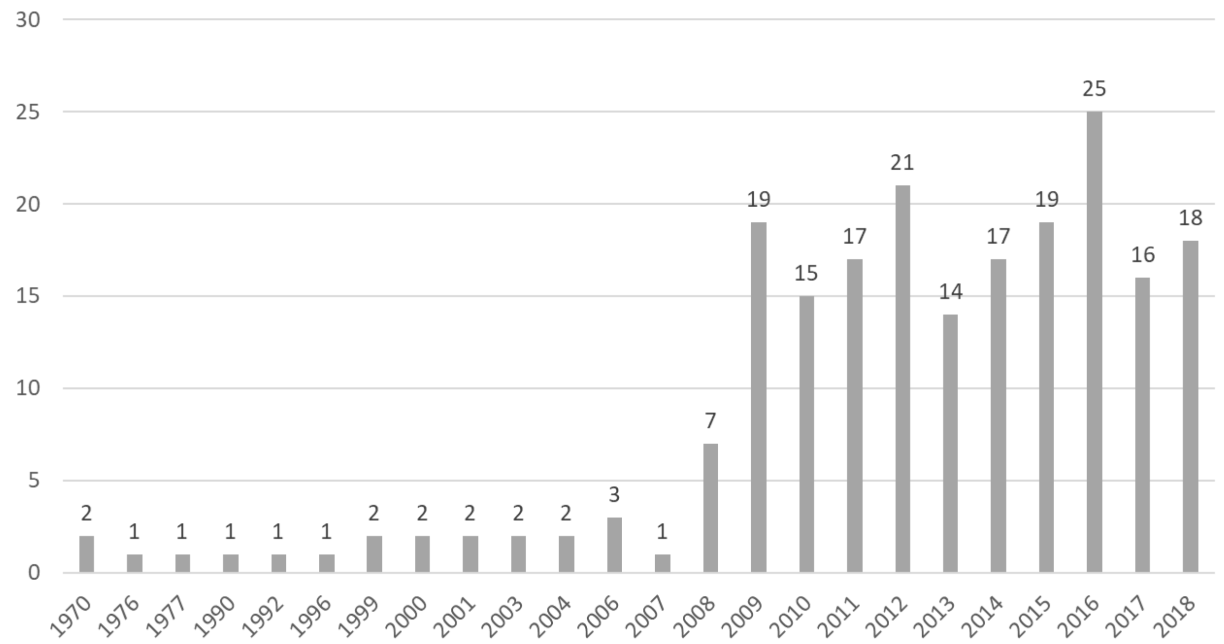

Figure 10. Web of Science search results from Conway (1968) to the 31st of December 2018 (own depiction).

I aimed to identify articles that utilize Conway's law as a pivotal theoretical construct or are based on an advanced theory emerging from the law. As further theories were unknown at this point, I conducted a pre-analysis by coding the abstracts of the 199 articles, which resulted in 284 codes. I selected the codes (16) that implied a theory of relations between architectural constructs and reduced these codes to stems (9) (see **Table 7** for stems and related codes). Subsequently, I conducted a tool-supported backward matching using SQL to match the stems with the abstracts of all articles (as opposed to selecting the articles that led to the identification of stems or codes). I opted for this approach to reduce the risk of human error in the form of false negatives during the initial coding procedure.

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[6] The forward search was conducted on the 30th of June, 2018.

The resulting sample accounted for 72 articles (see **Table 8** for the numbers). I reviewed the full texts of the 72 articles to check whether Conway's law was directly or indirectly pivotal to each of the articles, that is, whether the articles used Conway's law as a core theory or an advanced theory that draws on Conway's law. If Conway's law or an advanced theory was pivotal to an article, the article was included in the sample for later analysis (20). These articles were then categorized according to their main theory. The categorization was followed by analyses for each research stream.

Codes	Related Stems
congruence, congruent	congruen*
conway's law	conway*
duality	dual*
hybrid organization	hybrid*
isomorphic pressure, technical isomorphism	isomorph*
mirroring, mirroring hypothesis	mirror*
socio-technical congruence, socio-technical coordination	socio-technical*
stigmergic, stigmergy	stigmerg*
theory, theories	theor*

Table 7. Stems used for the backward matching (own depiction).

Stage / Status	0. distinct hits from search	1. articles after backward matching	2. articles filtered by full-text	**final results**
relevant		1	19	**20**
ambiguous	199	72	1 (unavailable)	1 (unavailable)
irrelevant		127	52	178

Table 8. Results of the literature filtering process (own depiction).

2.2.2. Conway's Law and Beyond

The literature review uncovered four emergent theoretical research streams that share commonalities but also differ in their perspectives with regard to level of abstraction and system focus; while one research stream may focus on the implications of team management and its impact on technology development, others may focus on an organization as a whole or even industry structures. **Table 9** provides an overview of the different research streams and their focal theory.

In the following sections, I provide a more detailed overview of each research stream through the lens of my literature review; that is, I focus on the replicating nature between organizational and technological structures as described in Conway's law.

Theory	Description
Conway's law	" […] organizations which design systems (in the broad sense used here) are constrained to produce designs which are copies of the communication structures of these organizations" (Conway 1968).
Socio-technical coordination and congruence	"Coordination achieved through the alignment of organisational structures and products is referred to as socio-technical coordination (Herbsleb 2007) and the extent of alignment is referred to as socio-technical congruence (Cataldo et al. 2008)" (Le and Panchal 2012).
Technical isomorphism	"When software is deployed in user organizations, inscribed organizational procedures can surface. If this happens, homogenization occurs as a result of enacting software-embedded standards. Because this has not yet been recognized as an isomorphic pressure, we coined the term technical isomorphism for it" (Benders et al. 2006).
The mirroring hypothesis	"Ever since the topic of modularity emerged in management science and innovation studies (Henderson and Clark, 1990; Langlois and Robertson, 1992; Ulrich, 1995), a central hypothesis holds that a modular product architecture is likely to be reflected in a modular organization design (Sanchez and Mahoney, 1996; Baldwin and Clark, 2000). This hypothesis later became known as the 'mirroring hypothesis' (Colfer and Baldwin, 2016)" (Querbes and Frenken 2018).

Table 9. Identified theories (own depiction).

2.2.2.1. Conway's Law

The *Conway's law* research stream comprises the initial article considered in this review, "How do Committees Invent?", as well as later works that draw on this article (see **Table 10** for an overview).

Conway (1968) describes the basic relationship between the internal communication structures of an organization and the product that that organization produces, that is, the internal communication structures imprint within the product or products, which thus reproduce the internal communication structures of an organization.

Conway elucidates on the impact of this relationship with regards to different communication mechanisms, such as architecture, delegation, design groups or teams, and organizations. While he argues that "[…] full-blown design activity cannot proceed until […] [an] understanding of the boundaries, both on the design activity and on the system to be designed […] [and a] preliminary notion of the system's organization […]" (ibid.) are achieved, Conway also emphasizes the need for a "[…] lean and flexible organization […]" (ibid.) to enable lean and flexible system development.

#	Source	Title	Focus
1	Conway (1968)	How do Committees Invent?	Conway (1968) shows how various static and dynamic communication structures across various levels in an organization impact product design.
2	Herbsleb and Grinter (1999)	Architectures, Coordination, and Distance: Conway' s Law and Beyond	Herbsleb and Grinter (1999) highlight the importance of informal communication and reflect on the impact of communication in co-located development settings against geographically dispersed development settings.
3	Kwan et al. (2012)	Conway's Law Revisited: The Evidence for a Task-Based Perspective	Kwan et al. (2012) emphasize that adopting a task-based view as opposed to adopting an architecture-based view is important to understand the needs of developers.
4	Imtiaz and Ikram (2013)	Dynamics of Task Allocation in Global Software Development	Imtiaz and Ikram (2013) examine the dynamics of task allocation in geographically dispersed development settings and find that interdependent modules should not be distributed across various sites.
5	Bano et al. (2016)	Empirical Study of Communication Structures and Barriers in Geographically Distributed Teams	Bano et al. (2016) identify barriers and challenges in geographically dispersed development settings.

Table 10. Articles from the *Conway's law* research stream (own depiction).

Conway (1968):
"How do Committees Invent?"

The rationale behind the need for a lean and flexible organization is grounded in the facts that organizational structures pre-determine communication, communication predetermines the availability of the design choices that a design group can draw on, and communication requirements shift as system and product requirements change over time.

Herbsleb and Grinter (1999):
"Architectures, Coordination, and Distance: Conway' s Law and Beyond"

Herbsleb and Grinter (1999) draw on Conway's law and stress the importance of informal communication due to the fact that unforeseen dependencies are likely to emerge during the course of product design.

The authors argue that informal communication is capable of revealing these emerging dependencies efficiently. They specifically demonstrate the need for informal communication by reflecting on the communication of geographically dispersed and co-located teams and show how the absence of informal communication impairs trust, information exchange, charitable interpretations of behavior, issue resolution, process alignment, and organizational knowledge distribution and thus impairs product design, development, operation, and testing. Collaborative technologies are found to compensate for the lack of informal communication only when it comes to very specific and straightforward issues.

Kwan et al. (2012):
"Conway's Law Revisited: The Evidence for a Task-Based Perspective"

Kwan et al. (2012) equate Conway's law with an architecture-based view. This is an obvious assumption as, early in his article, Conway draws on the concept of a modular system design for assigning responsibility. However, the rationale, that is, that the products of an organization replicate its internal communication structures, is not limited to an architecture-based view.

In fact, Conway also addressed the delegation of tasks, the arrangement of design efforts according to communication needs, the impact of team and organization size on communication, and the importance of organizational flexibility (as communication needs are prone to change). The architecture-based view is merely an example and perhaps the most intuitive perspective. Conway's law refers to communication structures in general, including static and dynamic communication structures and several levels of abstraction.

Kwan et al. (2012) elaborate on Conway's law from a task-based perspective. Specifically, they emphasize that making changes to software can be complicated by a loss of tacit knowledge related to personnel turnover and that congruence between coordination and task dependencies significantly reduces the time required to resolve development tasks. They further elucidate that an architectural view barely matches the view of developers who rely on certain tasks to fulfill targets. Thus, while the architect should "[…] serve as the long-term keeper of architectural style […]," the developer should control the process (James Coplien in Kwan et al. 2012).

Imtiaz and Ikram (2013):
"Dynamics of Task Allocation in Global Software Development"

and

Bano et al. (2016):
"Empirical Study of Communication Structures and Barriers in Geographically Distributed Teams"

Imtiaz and Ikram (2013) found that experienced managers do not geographically distribute interdependent modules. In line with Imtiaz and Ikram (2013) and similarly to Herbsleb and Grinter (1999), Bano et al. (2016) recognized the negative impact of geographic dispersion on informal communication and question the competitiveness of geographically dispersed organizational constellations in general. They further identify the positive effect of informal communication on enhanced product development, which ultimately leads to "[…] greater speed-to-market, faster revenue and satisfied clients" (ibid.). Similarly to Kwan et al. (2012), they find that an end-to-end process view can be utilized to identify constraints in a process; thus, it can be utilized to ameliorate the effects of poor communication.

Intermediate Summary

Overall, it can be stated that Conway's article (1968) addresses various dependencies between organizational and product structures on several levels. The articles that draw on Conway's law focus on a development team's perspective and related topics, such as the geographic dispersion of teams or informal communication between teams, or adopt a task- and process-centric perspective.

2.2.2.2. Socio-Technical Coordination and Congruence

This research stream examines a kind of coordination that is achieved by aligning organizational and technological structures, known as *socio-technical coordination* (STCd), and the degree to which this bipartite relation is aligned, known as *socio-technical congruence* (STCg, Le and Panchal 2012). **Table 11** provides an overview of the articles identified in this research stream.

#	Source	Title	Focus
1	Kwan et al. (2011)	Does Socio-Technical Congruence Have an Effect on Software Build Success? A Study of Coordination in a Software Project	Kwan et al. (2011) focus on measuring socio-technical congruence and its effect on build success.
2	Le and Panchal (2012)	Analysis of the Interdependent Co-Evolution of Product Structures and Community Structures Using Dependency Modelling Techniques	Le and Panchal (2012) propose and apply an approach for measuring socio-technical coordination in OSS for analyzing the interdependent co-evolution of community and product structures
3	Rytsareva et al. (2012)	Evaluating Socio-Technical Coordination in Open-Source Communities: a Cluster-Based Approach	Rytsareva et al. (2012) argue that previous studies on socio-technical coordination do not consider indirect communication and thus report low levels of socio-technical coordination. The authors propose an approach that accounts for indirect communication when measuring socio-technical coordination.
4	Cataldo and Herbsleb (2013)	Coordination Breakdowns and Their Impact on Development Productivity and Software Failures	Cataldo and Herbsleb (2013) highlight the importance of volatile dependencies in coordination.
5	Sierra et al. (2017)	A Systematic Mapping Study about Socio-Technical Congruence	Sierra et al. (2017) review the state of the art of socio-technical congruence with a focus on definitions, measurements, ways of measuring, areas of application, benefits, and case studies.
6	Datta (2017)	How Does Developer Interaction Relate to Software Quality? An Examination of Product Development Data	Datta (2017) examines social characteristics against STC measures in the context of global software development settings.

Table 11. Articles from the *socio-technical coordination and congruence* research stream (own depiction).

Kwan et al. (2011):
"Does Socio-Technical Congruence Have an Effect on Software Build Success?
A Study of Coordination in a Software Project"

Kwan et al. (2011) conducted a case study within an enterprise-grade software development setting that "[…] consists of 151 developers over seven geographically distributed sites […]" (ibid.). They measured the socio-technical congruence in this setting over time and found that the correlation between congruence and build success changed over time and by setting. The authors note that the socio-technical congruence measurements used in different studies are difficult to compare because studies use different measures.

Le and Panchal (2012):
"Analysis of the Interdependent Co-Evolution of Product Structures and Community Structures Using Dependency Modelling Techniques"
and
Rytsareva et al. (2012):
"Evaluating Socio-Technical Coordination in Open-Source Communities: a Cluster-Based Approach"

Le and Panchal (2012) examine the relationship between community structures and product structures based on publicly available information from the development of the open-source software Drupal. The authors determined that prior measures for measuring socio-technical congruence are inadequate, as they do not take informal and indirect communication into account. Within the examination of their case, the authors found that product structures significantly influence community structures but that the impact of community structures on product structures is rather weak. Rytsareva et al. (2012) present a different version of the study presented by Le and Panchal (2012), who are co-authors of the first-mentioned article.

The reflections of both articles suggest that traditional organizations rely on an organization-first approach to coordination, while open-sources projects rely on a product-first approach; that is, open-source projects adapt their coordination to the needs that arise while manufacturing a product on an ad hoc manner basis and rely heavily on implicit coordination, whereas traditional organizations define an explicit structure ex ante based on initial assumptions regarding future coordination needs and then produce the product.

Cataldo and Herbsleb (2013):
"Coordination Breakdowns and Their Impact on Development Productivity and Software Failures"

Cataldo and Herbsleb (2013) found that a static view on dependencies is insufficient to capture all relevant dependencies when measuring socio-technical congruence. Thus, they employed a dynamic view on coordination and found that incongruence between coordination requirements and actual coordination increased software failures and that congruence is positively associated with improved development productivity. In particular, they found congruence to be important for both novel and mature development contexts.

Sierra et al. (2017):
"A Systematic Mapping Study about Socio-Technical Congruence"

Sierra et al. (2017) reviewed 40 articles on socio-technical congruence. They extracted and summarized the properties, benefits, risks, and measures for measuring STCg and tools for taking measurements from these articles and found that all currently used approaches and scales differ and are barely comparable. Furthermore, they noted that only a single study explained the underlying properties of STCg; in addition, Sierra et al. noted the importance of researching the effects of overloading employees with coordination-related tasks and the costs of acquiring the information required for measuring STCg.

Datta (2017):
"How Does Developer Interaction Relate to Software Quality?
An Examination of Product Development Data"

Datta (2017) used data from a collaborative development environment to measure variables that are known to express the degree of informal communication within (e.g., spatial distribution). While Datta (ibid.) could not prove his hypotheses, he also could not disprove them. This ambiguous result stands to reason considering prior articles highlighting the challenges related to measuring STCg. Datta puts it as follows: "[…] we recognize that not every detail of developer interaction may have been captured in the data we analysed. […] These limitations of what we learned from this study come from the non-exhaustive nature of the data" (ibid.).

Datta's hypotheses are based on a theoretical elaboration that, inter alia, highlights the relations among software defects and the degree of task parallelism, team size, task familiarity, spatial dispersion, degree of coupling, and developer experience. While he was not able to definitively prove his hypotheses, Datta still provided valuable information about relevant socio-technical structures.

Intermediate Summary

Overall, it can be stated that this research stream continues Conway's legacy. The articles provide more detailed insights into the relationships between organizational and technological structures. While this research field has not yet finally concluded how the degree of socio-technical coordination should be measured, it provides valuable insights concerning socio-technical structures that matter for the design of an organization.

2.2.2.3. Technical Isomorphism

The *technical isomorphism* stream concerns how the organizational structures of a software-producing firm are inscribed in its products and how these structures are replicated within organizations that implement that product. **Table 12** provides an overview of the articles identified in this research stream.

#	Source	Title	Focus
1	Benders et al. (2005)	Sticking to Standards; Technical and other Isomorphic Pressures in Deploying ERP-Systems	Benders et al. (2005) review the standardizing effect within and across companies implementing standard software based on the concept of technical isomorphism.
2	Batenburg et al. (2008)	Technical Isomorphism at Work: ERP-Embedded Similarity-Enhancing Mechanisms	Batenburg et al. (2008) have a similar focus to that of Benders et al. (2005).

Table 12. Articles from the *technical isomorphism* research stream (own depiction).

Benders et al. (2005):
"Sticking to Standards; Technical and other Isomorphic Pressures in Deploying ERP-Systems"

Benders et al. (2005) introduce and describe the standardizing effect within and across companies of implementing standard software such as an ERP system. The authors refer to this effect as *technical isomorphism*. Technical isomorphism is based on the concept of isomorphism, which refers to "[…] the phenomenon that practices and processes are quite similar across organizations" (ibid.).

Proponents of isomorphism adopt the view that competitive forces shape organizations to become similar. Later, the concept of institutional isomorphism was introduced. Institutional isomorphism describes three mechanisms: 1) coercive forces, that is, the dependence of a company on other organizations, such as governmental agencies, and cultural expectations; 2) imitative or mimetic forces, that is, standard responses to uncertainty as observed by other companies; and 3) normative pressures, that is, norms related to certain professions.

Technical isomorphism describes the diffusion of standards and organizational processes embedded within technology, for example ERP software that has been widely adopted within and across industries. This phenomenon goes back to Conway's law and its observation that "[…] organizations will stamp out an image of itself in every design it produces" (Conway 1968 in Benders et al. 2005). Later, it was discovered that this phenomenon also falls under the notion of *inscription*, which refers to "[…] how software designers developed software to support their own preferred working habits" (ibid.).

The example of Lotus Notes shows how a non-hierarchical organization and high levels of cooperation distributed across time and space led to the creation of software that supports these ways of working. Technical isomorphism describes the effect of the emergence and adoption of inscribed organizational procedures when implementing software in various organizational contexts.

Batenburg et al. (2008):
"Technical Isomorphism at Work:
ERP-Embedded Similarity-Enhancing Mechanisms"

Batenburg et al. (2008) examine the introduction of an ERP system in a firm and the distribution of this system's embedded organizational procedures through the lens of technical isomorphism. Specifically, they found that the firm adopted the policies, principles, and procedures inscribed within and proposed by the ERP system.

Intermediate Summary

Overall, the presented articles focus on the effect of implementing standard software in organizations. The articles highlight an important effect, namely that software can change the behavior of an entity that utilizes it, for instance, the customer and user of a digital product or service.

2.2.2.4. The Mirroring Hypothesis

The *mirroring hypothesis* stream has its roots in the field of modularity and describes the bi-directional influence of organizational and technological structures. The focus of the *mirroring hypothesis* goes beyond the boundaries of a firm. **Table 13** provides an overview of the articles identified in this research stream.

#	Source	Title	Focus
1	MacCormack et al. (2012)	Exploring the Duality between Product and Organizational Architectures: A Test of the "Mirroring" Hypothesis	MacCormack et al. (2012) compare loosely and tightly coupled organizational settings and the products that these settings produced.
2	Müller et al. (2014)	Strong Ties Despite Decentralized Network Design	Müller et al. (2014) propose an approach for measuring organizational and technological ties.
3	Colfer and Baldwin (2016)	The Mirroring Hypothesis: Theory, Evidence, and Exceptions	Colfer and Baldwin (2016) review 142 empirical studies regarding intra- and interfirm correspondence between organizational ties and technological structures and organizational performance.
4	Moon (2016)	Do Open Projects "Break the Mirror"?	Moon (2016) adopts an episodic view on product development in free/libre open-source projects and finds that the degree of mirroring varies among the different episodes.
5	Moon and Howison (2016)	Do Open Projects "Break the Mirror"?: Re-Conceptualization of Organizational Configurations in Open Source Software (OSS) Production	Moon and Howison (2016) build on the article of Moon (2016) and present similar findings.
6	Querbes and Frenken (2018)	Grounding the "Mirroring Hypothesis": Towards a General Theory of Organization Design in New Product Development	Querbes and Frenken (2018) present a theoretical model and demonstrate it in simulations of varying degrees of correspondence between organizational ties and technological structures.

Table 13. Articles from the research stream *mirroring hypothesis* (own depiction).

Müller et al. (2014):
"Strong Ties Despite Decentralized Network Design"

Müller et al. (2014) propose and elaborate a measuring approach to measure the strength of technological and organizational ties. The authors base their approach on the mirroring hypothesis and theories on organizational research. The theoretical foundation of this article indicates that innovation occurs at the boundaries where different mindsets meet. They further suggest that the success of their project is based on new ways of collaboration, for instance, the establishment of conceptual transparency at the interfaces of network partners, and that knowledge transfer across interfaces can improve an organization's degree of environmental and task embeddedness and can thus improve organizational performance.

Colfer and Baldwin (2016):
"The Mirroring Hypothesis: Theory, Evidence, and Exceptions"

Colfer and Baldwin (2016) reviewed 142 empirical studies and examined whether each study either supported, partially supported, or did not support the mirroring hypothesis. The 142 studies take different perspectives, ranging from organizations to industries to open collaboration settings.

The authors found that most studies support the mirroring hypothesis in the sense that settings with mirrored organizational and technological structures within or across company boundaries perform well. However, Colfer and Baldwin also identified mirrored settings that performed poorly. In this case, the authors warn of the mirroring trap, which describes how firms focus on their current structures without considering architectural innovations outside of their boundaries. The authors further state that firms could avoid the mirroring trap by adopting *partial mirroring*.

Partial mirroring has performed well in all identified studies and describes an organizational configuration in which firms "[…] define their knowledge boundaries more broadly than their task boundaries" (ibid.). Colfer and Baldwin also propose an approach that seems to lead to the state of partial mirroring. They call this approach *breaking the mirror*.

Breaking the mirror can be achieved by "[…] implementing modular partitions within the own boundaries; and […] building relational contracts that support high levels of technical interdependency across their boundaries" (ibid.), that is, through collaboration of two systems that draw knowledge boundaries wider than task boundaries.

Even though the authors do not specifically identify the relationship between *partial mirroring* and *breaking the mirror*, I interpret the process of *breaking the mirror* as leading to the state of *partial mirroring*, as the described resulting state of *breaking the mirror* appears to be similar to the state of *partial mirroring* and, metaphorically speaking, a broken mirror can partially reflect.

Moon (2016):
“Do Open Projects “Break the Mirror”?”
and
Moon and Howison (2016):
“Do Open Projects “Break the Mirror”?: Re-Conceptualization of Organizational Configurations in Open Source Software (OSS) Production”

Moon (2016) and Moon and Howison (2016) build upon the statement of Colfer and Baldwin (2010, 2016) that open projects *break the mirror*. To shed more light on open projects from the perspective of the mirroring hypothesis, they studied the degree of coupling in free/libre open-source projects from an episodic perspective. They found that different companies employ different degrees of organizational coupling while in different episodes and thus develop software with different degrees of coupling.

Querbes and Frenken (2018):
“Grounding the “Mirroring Hypothesis”:
Towards a General Theory of Organization Design in New Product Development”

Querbes and Frenken (2018) use a NK model for simulating and measuring varying degrees of mirroring. Overall, they found that perfectly mirrored organizational settings perform well “[…] in designing products with many components and low complexity, while imperfectly mirroring organizations do better in designing products with few components and high complexity” (ibid.).

They further found that coordination efforts increase with the number of components in a product, that a decentralized organization reduces overhead costs due to less coordination being required, and that mirroring in general performs particularly well in core-periphery architectures.

They also propose that governance leave room for improvement; instead of nurturing teams to achieve the highest conceivable goals, emphasizing a focus on small and explorative steps increases team satisfaction and thus team performance and lead to the creation of an overall better product. The authors further note that a modular structure supports this approach. In fact, modular product organizations tend to renew their components constantly.

Intermediate Summary

Overall, the mirroring hypothesis is similar to yet different from STCd and STCg. The mirroring hypothesis aims to solve the same challenge as that addressed by STCg, that is, measuring the degree of mirroring, respectively, socio-technical congruence with mathematical precision. A difference lies in the general perspective on the world; the mirroring hypothesis adopts an inherently modular perspective. A further difference lies in the levels of abstraction: While STCd and STCg focus on the socio-technical relationships within organizations, the mirroring hypothesis often crosses the boundaries of an organization and adopts an inter-organizational or even industrial perspective.

2.2.2.5. Summary

All research streams are similar in that they are fundamentally based on empirical research. While some articles focus on theoretical constructs for taking measurements, the majority thereof rely on one or more cases and discuss the underlying mechanisms that impact the relationships between organizational and technological structures.

The articles of the *Conway's law* stream highlight how communication and alignment mechanisms impact software design. Some of the authors who wrote articles in the context of the *Conway's law* stream moved to *socio-technical coordination* and *socio-technical congruence* stream. This might suggest that their research studies are descendants of *Conway's law*. Analogously, the STCd and STCg stream also examines how communication and alignment mechanisms impact the design of software but added two new foci: the impact of alignment between organizational and technological structures on coordination and thus the impact on productivity and product quality and measuring the degree of congruence between organizational and technological structures.

Articles that directly relate to the *Conway's law* stream and articles that relate to STCd and STCg stream have in common a focus on teams and software development. They also share the same direction of causality; that is, they investigate the impact of organizational changes on technological changes or, in short, the impact of people to technology (see **Table 14** for an overview of all research streams and their foci).

Technical isomorphism describes how the organizational structures of a software-producing firm are replicated within the produced software and how these inscribed organizational structures are replicated in the products of organizations that use that software. The articles that relate to *technical isomorphism* focus on organizations as a whole. As these articles investigate the impact of technology on the shaping of organizational structures, the causal direction that they focus on is from technology to people.

The *mirroring hypothesis* is fundamentally based on the concept of modularity. Articles of this stream draw on the same logic as that underlying the other theories but do so from a modularity perspective.

The articles belonging to the mirroring hypothesis stream discuss how technological modularity can be a means of coordination and how organizational modularity affects the products a firm produces.

In contrast to the other research streams, the *mirroring hypothesis* goes beyond the boundaries of a firm and discusses how the modularization of system interfaces and knowledge exchange across these interfaces affect inter-organizational collaboration and can even shape the structure of industries.

The focus of the articles in the *mirroring hypothesis* stream is diverse, as it researches relationships within organizations, relationships across organizations the boundaries of organizations, and the impact of such relationships on industries. As articles belonging to this stream discuss how technology affects organization and organization affects technology, the direction of causality they examine is bi-directional.

Research Stream	Main System Focus	Direction of Causality
Conway's law	teams and software development	from people to technology
Socio-technical coordination and congruence	teams and software development	from people to technology
Technical isomorphism	software implementation and its organizational impact	from technology to people
The mirroring hypothesis	organizations, boundaries of organizations, and industries	bi-directional

Table 14. The different research streams and their foci (own depiction).

2.2.3. Opportunities for Future Research

The review of articles that address the relationship between organizational and technological structures provided valuable insights. The articles belonging to each of the different research streams provide insights and food for thought for future researchers within their specific field.

Given my research targets, I analyzed the articles from a prescriptive design knowledge perspective; that is, I focused on those insights that I could use to inform the socio-technical design and development of a DIU. Following this perspective, I identified two research opportunities that could provide insights into how socio-technical knowledge could be leveraged for the design and development of a DIU. The two opportunities are

1) Continuous socio-technical inquiry, and
2) Understanding the implications of changing digital consumption patterns for socio-technical design.

Continuous Socio-Technical Inquiry

The internal structures of a DIU determine the outcome of such a unit. As market requirements change over time, the outcome of a DIU has to change as well. Embracing modularity is recommended to ensure a high degree of adaptivity. A profound architectural understanding is required to avoid the pitfalls related to premature modularization (McDuffy 2013 in Colfer and Baldwin 2016). Traditionally, firms achieve a profound architectural understanding through tedious inquiries that rely on dedicated teams and tools. The results of these inquiries are often based on a review of static architectural structures; hence, they are snapshots of reality regarding the reviewed scope and reviewed timeframe.

Communicating the insights provided by static architectural reviews can be challenging. The abstract and static view can be perceived as irrelevant to the daily business of others (see Kwan et al. 2012). Furthermore, traditional approaches often fail to capture not only transient dependencies but also implicit and informal dependencies.

The mirroring nature of organizational and technological structures opens new approaches to the continuous and efficient handling of organizational ties and technological dependencies in new organizational settings such as DIUs. In DIUs, interdisciplinary teams and microservices form a hybrid structure. Teams are responsible for their respective microservice from cradle to grave and end to end (Drews et al. 2017, Adersberger and Siedersleben 2018, Corso et al. 2018). Socio-technological theorists consider an end-to-end view to be a valuable source for understanding dependencies (Imtiaz and Ikram 2013).

The replicating nature of organizational and technological structures makes it possible to view technological dependencies and structures through an organizational perspective, as opposed to a static view on the technical architecture of a company or organizational unit. In DIUs, interdisciplinary teams can provide insights concerning the static and dynamic organizational and technological ties and dependencies that surround them while simultaneously rating the relevance of these ties and dependencies in view of the impact on their degrees of freedom. A continuous process could be used to leverage the focused and deep knowledge of interdisciplinary teams within DIUs. A design-based research approach would be suitable for designing and evaluating such a process.

Understanding the Implications of Changing Digital Consumption Patterns for Socio-Technical Design

Over the past decades, digital consumption has shifted from the use of personal computers and long periods of multi-purpose consumption over smartphones and apps to lately voice and brain interfaces. Digital consumption has shifted from lengthy and general interactions to short and specific interactions. Based on the insights provided by the literature review, this change implies that traditional organizational and technological structures have to adapt. There is currently no research that focuses on understanding the relationship between changed digital consumption patterns and related implications for organizational and technological design.

Future research on DIUs should focus on leveraging socio-technical thinking to understand the implications of changed digital consumption patterns for the design of DIUs. The digital consumption patterns of customers and users have shifted to short and specific episodes of consumption. Based on this observation, organizational and technological structures should be short and specific. For instance, short could translate to quick iterations and small teams, while specific could mean clear organizational and technological boundaries. A design-based research approach would be suitable for elaborating on these implications and proposing and evaluating a structural design for DIUs that takes them into consideration.

3. Developing Digital Innovation Units: A Longitudinal Progressive Design Research Study

At the time of writing, no dedicated research has been conducted on DIUs. However, DIUs have been peripherally covered in academic articles as a strategic measure in the greater context of firms' digital transformations. Whether it is in academic or managerial articles, knowledge on DIUs is provided in the form of ex post views on empirical events.

Prescriptive design knowledge that could be used to guide the design and development of DIUs is unavailable at the time of writing. Specifically, design principles and theoretical constructs for analyzing, explaining, and guiding the development of DIUs are lacking. This thesis presents an integrated longitudinal progressive design research (PDR) study to close this gap.

A Brief Overview

The new prototypical research approach *PDR* combines *action design research* (ADR, Sein et al. 2011) with *design science research* (DSR, Hevner et al. 2004, Peffers et al. 2007) in a three-year longitudinal research study. Beginning my research by adopting an ADR approach in a specific DIU, I was able to obtain in-depth knowledge and create a first proof of concept (see Nunamaker et al. 2015) for an artifact that supports the design and development of DIUs.

A transition to DSR would benefit both practitioners and scholars, as being unbound from the local organizational context in the later phases of the research process enables the identification and evaluation of generalized research outcomes that go beyond the challenges associated with individual needs. The research process of this thesis' progressively transitioned from ADR to DSR. The resulting artifact was used to identify future challenges that might arise within that specific DIU and served as a proof of value (see Nunamaker et al. 2015).

As proposed by DSR, the artifact has been further transferred to other organizational contexts than the above-mentioned specific DIU. Evaluations with external experts who share an interest in the same class of problem, that is, the development of a DIU, served to drive my artifact development towards achieving a proof of use (see Nunamaker et al. 2015). The resulting artifact extends the knowledge boundaries concerning DIUs among both practitioners and scholars.

Why Combining Design Research Methods?

The selection of an integrated design research approach solved research approach-related challenges. Early in my research journey, I perceived a mismatch between the requirements of my specific research process and the structures proposed by ADR. I recursively applied ADR logic to my own research process to produce insights on a meta-theoretical level. The application of ADR logic led to a deeper understanding of the problem, and I found that my challenges were not specific to my individual research process but instead were related to a class of problems.

The class of problems in question is characterized by divergent interests on the part of practitioners and scholars, the creation of generalized research outcomes, and a balance between rigor and relevance in a research process.

Based on my reflections on my own actual research process, which were guided by ADR's sixth principle, *guided emergence*, a prototype of integrated design research to address this class of problems. After discussing a proof of concept (see Nunamaker et al. 2015) with representatives of the target group, that is, researchers, I achieved a first proof of value (see ibid.) for my prototype, as it solved my research design-related problem and therefore was validated "[…] akin to the concept of instantiation validity […]" (Chandra et al. 2015). However, as I learned while designing my PDR prototype, it requires further applications in other research contexts to achieve a proof of use (see Nunamaker et al. 2015). I present my prototype for PDR and demonstrate its application demonstration to motivate other researchers to discuss, apply, and adapt my integrated approach in future research endeavors.

The Remainder of This Chapter

The contributions of this chapter are two-fold: First, I motivate and introduce my prototype for PDR; this introduction includes motivating the class of problems, a discussion of related research, and a presentation of the prototype.

Second, I present the process of conducting and the insights provided by my field research concerning the creation of an artifact intended to support the design and development of DIUs. The presentation includes a description of a specific DIU and of the intra- and inter-organizational iterations that led to the artifact's design. The second part also contributes to the first part, as my research process is framed by drawing on my prototype for PDR; thus, the second part effectively provides a demonstration.

3.1. Towards Integrated Design Research with Progressive Design Research

In this chapter, I motivate the need for an integrated design research approach in **Chapter 3.1.1**, before I introduce related research that provides a basis for the various building blocks of PDR and eventually balance the advantages and disadvantages in **Chapter 3.1.2**. The new approach for integrated design research, PDR, is presented in the subsequent **Chapter 3.2**.

3.1.1. About Balancing Instantiation and Generalization

Information systems research (ISR) must make theoretical contributions and "[…] assist in solving the current and anticipated problems of practitioners (Benbasat and Zmud 1999, Iivari 2003, Roseman and Vessey 2008)" (Sein et al. 2011). Design science research (DSR, Hevner et al. 2004, Peffers et al. 2007) seeks to provide theoretical contributions in the form of artifacts for solving organizational challenges that "[…] go beyond explanation […]" (Sein et al. 2011) and leverage the "[…] experience, creativity, intuition, and problem-solving disciplines of the researcher […] (Hevner et al. 2004) to develop […] solutions to important and relevant business problems" (ibid.).

Still, DSR is perceived to lack relevance because "[…] traditional design science does not fully recognize the role of organizational context […]" (Sein et al. 2011). To close this gap, Sein et al. (2011) introduced ADR as a design research "[…] method that simultaneously aims at building innovative […] artifacts in an organizational context and learning from the intervention while addressing a problematic situation […]" (ibid.).

ADR seeks to obtain prescriptive design knowledge through the interwoven activities of building, intervening, and evaluating artifacts in an organizational setting and reflecting on the process (Sein et al. 2011). A challenging task in ADR is the generalization of research outcomes (ibid.).

The generalization of research outcomes is intended to provide theoretical contributions to the research community by using the obtained research insights to develop the gained situated research insights towards "[…] general solution concepts for a class of field problems […]" (ibid.). Sein et al. emphasize that "Generalization is challenging because of the highly situated nature of ADR outcomes that include organizational change along with the implementation of an […] artifact" (ibid.).

ADR provides guidance for creating generalized outcomes in the form of definitions of different levels of generalization and tasks. Following the abstract nature of generalized outcomes, the provided guidance is high in meaning but low in detail. Generalization is the final step in ADR and an end in itself. The ADR process does not stipulate the further use or application of generalized outcomes for solving further problems.

The respondents in a meta-research study on ADR noted "[…] balancing expectations from the industry partners and the research community […] as [a] dichotomy between solving real-world problems and distilling design knowledge […]" (Haj-Bolouri et al. 2018). During the respondents' research process, this dichotomy was "[…] an ongoing issue to be managed […]" and "[…] manifested in a number of ways" (ibid.). In summary, the respondents described three recurring themes:

1) An *impedance mismatch* between slow academic deliberation and the fast-moving organizational setting,
2) *keeping the research team engaged*, as the multi-disciplinary composition of scholars and practitioners in a team is expressed in the ongoing need to keep practitioners motivated, and,
3) *separate but equal*, that is, the unfruitful involvement of practitioners in the discussion of research outcomes (ibid.).

It can be stated that there is a conflict of interest between the distillation of theoretical contributions and the shaping of the instantiated artifact in the current ADR process.

I also encountered this mismatch during my research. I argue that it results from the inductive nature of creating generalized outcomes based on a specific organizational setting as prescribed by ADR. My experience is that practitioners in ADR research may be more interested in a solution to their specific problem than in discussing generalized versions of already known solutions. Thus, I further argue, a transfer to other organizational settings can facilitate the generalization of an artifact, as it provides a reason for creating generalized outcomes: Practitioners from other organizational contexts who seek solutions to the same class of problem might be interested in deductively matching a generalized solution to the challenges of their specific contexts.

Peffers et al. (2007) propose a DSR method (DSRM) that enables the transfer and evaluation of an artifact in organizational contexts that have not been exposed to prior inductive theory generation. This transfer provides a reason for generalization, as it requires a sufficiently generalized artifact for deducting specific solutions with practitioners who share an interest in the related class of problem. Accordingly, DSRM can be applied as a suitable approach for determining whether an artifact is generalized enough to propose a class of solutions to a class of problems.

Furthermore, various DSR-related publications have discussed the nature and distillation of theoretical contributions (see i.a. Gregor 2006, Gregor and Jones 2007, Gregor and Hevner 2013) and thus further support a researcher in creating the desired generalized outcomes by facilitating a profound understanding of generalization and providing mental models.

An integration of ADR (Sein et al. 2011) and the DSRM (Peffers et al. 2007) could leverage the benefits of both approaches while diminishing the impact of their drawbacks. The resulting approach would align fast-moving organizational interventions with slow academic deliberation and thus would provide an artifact with high degrees of relevance (through organizational inscription) and high degrees of generalization (through cross-company design and evaluation).

An integrated approach would provide an effective means for balancing scholarly and practitioner expectations by its research design. The value of an artifact created using an integrated research design could be proven from two perspectives: first, by an in-depth instantiation and application and, second, by being transferred to other organizational contexts. Therefore, an integrated process would not only balance the creation of two-sided outcomes but could also effectively strengthen the reasoning behind the application of an artifact.

Ultimately, an integrated process can facilitate the creation of artifacts that are "[…] abstract enough to allow for generalizations and useful conclusions, but close enough to observed data to be empirically validated […]" (Hassan and Lowry 2015) and thus fall into the sweet spot of design research outcomes, that is, theories of the middle range (see Gregor and Hevner 2013; see also Merton 1968, Gregor 2006).

Artifact design should be inseparable from intervening in an organization (see Sein et al. 2011). I argue that generalizing an artifact should be inseparable from transferring it to different contexts.

3.1.2. Related Research

In the following, I review approaches that discuss different levels of theory, ranging from instantiations to generalized outcomes, in **Chapter 3.1.2.1**. Thereafter, I introduce the stages and principles of ADR (Sein et al. 2011) in **Chapter 3.1.2.2** and the process behind the DSRM (Peffers et al. 2007) in **Chapter 3.1.2.3** before summarizing and comparing the two design research (DR) approaches in **Chapter 3.1.2.4**.

3.1.2.1. From Instantiation to Generalization

ADR and the DSRM target the creation of prescriptive design knowledge in the form of artifacts. Both provide research processes intended to facilitate achieving this outcome but leave discussions regarding the progressive nature of abstraction levels and achieving generalized outcomes open to other literature. In the following, I review pertinent literature that covers different levels of abstraction in artifact design.

Different Types of Artifacts

The term artifact is commonly used in DR to refer to the pivotal outcome of a DR process. An artifact is described as "[…] something that is artificial, or constructed by humans, as opposed to something that occurs naturally […]" (Simon 1996 in Gregor and Jones 2007); however, this definition leaves room for interpretation. Therefore, Gregor and Jones (2007) further divide the concept of an *artifact* into *instantiations* or *material artifacts* and *theories* or *abstract artifacts* (see **Figure 11**).

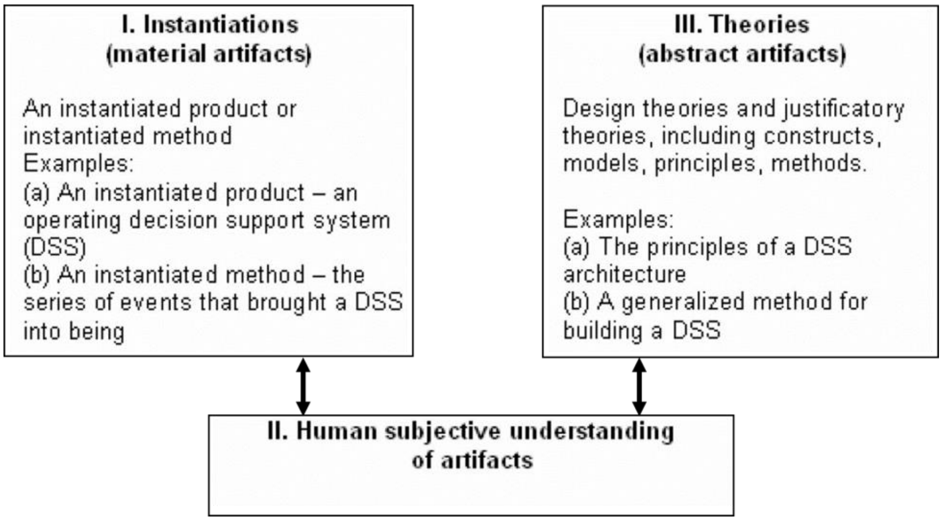

Figure 11. Relationships between different types of IS/IT artifacts (Gregor and Jones 2007).

Material artifacts, or instantiations, have "[…] a physical existence in the real world, as a piece of hardware or software, or an IS, or the series of physical actions (the processes or interventions) that lead to the existence of a piece of hardware, software, or an IS" (Gregor and Jones 2007).

In contrast, abstract artifacts, or theories, "[…] do not have a physical existence, except in that they must be communicated in words, pictures, diagrams, or some other means of representation. Constructs, methods, and models are all this type of artifact […]" (ibid.).

The human subjective understanding of artifacts relates to both types and highlights that insights provided by one type of artifact can be used to produce an artifact of the other type; for instance, "[…] design principles and theory can be extracted from observation and inference from already instantiated artifacts" (ibid.).

Different Artifact Maturity Levels

Gregor and Hevner (2013) take the definition of an artifact a step further by adding a maturity logic (see **Figure 12**).

	Contribution Types	Example Artifacts
More abstract, complete, and mature knowledge	Level 3. Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
↕ ↕ ↕ ↕	Level 2. Nascent design theory—knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules.
More specific, limited, and less mature knowledge	Level 1. Situated implementation of artifact	Instantiations (software products or implemented processes)

Figure 12. DSR contribution types (Gregor and Hevner 2013).

Instantiations represent the lowest maturity level (level one). Abstract artifacts represent levels two and three on the maturity scale. Abstract artifacts are further differentiated into nascent design theories on level two and well-developed design theories on level three.

Nascent design theories can take the form of "[…] constructs, design principles, models, methods, technological rules […]" (Gregor and Hevner 2013). Well-developed design theories can take the form of mid-range or grand theories. However, Gregor and Hevner add that it "[…] is not clear whether we have any grand theories in IS/IT design science, or even whether they would be particularly useful if they did exist" (ibid.). They further add, paraphrasing Merton, that "[…] in an applied field (such as […] IS/IT) there should be a focus, but not an exclusive focus, on theories of the middle range […]" (ibid.). Accordingly, I focus on mid-range theories in the following.

Mid-Range Theories

In his opus *Social Theory and Social Structure*, Merton shows that "[…] there is evidence enough to indicate that theories of the middle range […] have been advocated by many of our intellectual ancestors" (Merton 1968). Mid-range theories are said to have "[…] greater explicative significance […]" (Hawkins in Merton 1968) than total or grand theories. Davis describes a mid-range focus as an "[…] empirical analysis in a limited conceptual setting […]" (Davis in Merton 1968) that "[…]

appears to assure […] the necessary continuous contact with empirical variables" (ibid.). Lowe states that mid-range theories can be used to "[…] connect the economic with the social process […]" (Lowe in Merton 1968). Cuvillier adds that "[…] middle range theory deals with the comparative analysis of specified aspects of social structure [...]" (Cullivier in Merton 1968), and Riesman recommends "[…] 'working in the middle range, to [talking] less of *breakthrough* or of *basic* research and to [making] fewer claims all around'" (italics added, Riesmann in Merton 1968).

Overall, mid-range theories link theoretical deliberations with that which is empirically observable, have comparably small groups as research subjects, compare theoretic constructs against the empirical backdrop of different groups, and describe the mid-range as the sweet spot of research that can make impactful contributions to a class of empirical contexts.

According to Merton, mid-range theories "[…] build on an accumulation of artifacts all addressing the same application problem […] (Merton in Gregor and Hevner 2013); thus, a mid-range theory must be built on a variety of artifacts. The form of mid-range theories is described as an "[…] array of unconnected special theories […] consolidated into successively enlarged sets of theory […]" (Zetterberg and Malewski in Merton 1968).

Merton further describes mid-range theories as "[…] empirically grounded theories – involving sets of confirmed hypotheses – and not merely organized descriptive data or empirical generalizations or hypotheses which remain logically disparate and unconnected" (Merton 1968). Examples of sociologically oriented mid-range theories are "[…] a middle-range theory of the occupational sub-system; […] a theory of mobility into topmost positions in groups; […] an intermediate theory based on both micro- and macro-sociological data that relates patterns of deviant behavior to the structure of communities; […] consolidation of empirical uniformities in public opinion into a composite theory and […] a consolidation of demo-graphic uniformities" (ibid.).

The field of use of mid-range theories is described as being "[…] applicable to all situations exhibiting specified aspects of social phenomena […]" (Berger et al. in Merton 1968). Their use can further be demonstrated (ibid.).

Thus, mid-range theories are artifacts that are grounded on a variety of empirically developed artifacts, relate to the same phenomenon, and describe meaningful compositions of special theoretic constructs that can ultimately be used to produce a proof of use by demonstration.

Intermediate Summary

Artifacts can take different forms, ranging from instantiations to constructs, methods, models, design principles and technological rules to mid-range theories that can be interpreted as meaningful compositions, based on empirically grounded theoretical constructs that can ultimately be used to achieve a proof of use by demonstration.

While the DSR- (Gregor and Jones 2007, Gregor and Hevner 2013) and mid-range theory-related literature (Merton 1968) provides information on the definition of material artifacts, abstract artifacts, and, in particular, mid-range theories, it does not provide a path from instantiations that are highly specific to their situated organizational context to artifacts that are generalized enough to demonstrate a proof of use by demonstrating the creation of individual instantiations.

Three Types of Proofs: A Path from Instantiations to Generalized Outcomes

In their article "The Last Research Mile," Nunamaker et al. (2015) propose an approach that creates a range of artifacts, all of which address the same phenomenon. Therefore, this approach of Nunamaker et al. (ibid.) can serve as a pivotal component in a mid-range theory (see above).

The approach of Nunamaker et al. (2015) builds on three stages that create increasingly generalized and transferable outcomes (see Nunamaker et al. 2015), that resemble the maturity logic of Gregor and Hevner (2013) on the structural, logical, and substantial levels, which indicates conceptual compatibility. The three stages described in their approach are *proof of concept*, *proof of value*, and *proof of use*.

The goals of the *proof-of-concept* stage are 1) demonstrating the "[…] functional feasibility for a potential solution to an important class of unsolved problems in the field […]" (Nunamaker et al. 2015), 2) developing "[…] deeper and broader understandings of the class of problems addressed by a solution […]" (ibid.), 3) discovering "[…] the first nuggets of scholarly knowledge that may lead to future operational feasibility for a solution […]" (ibid.), and 4) initiating research "[…] on scholarly theories that explain outcomes of interest so as to better-inform design choices as research progresses" (ibid.). The outcomes of the *proof-of-concept stage* are, inter alia, prototypes. Such a prototype is "[…] usually a rudimentary solution that is not necessarily scalable, not necessarily full-featured, and not necessarily stable or optimized, but will have sufficient functionality to test functional feasibility with simple tasks" (ibid.). Prototypes are described as being "[…] quick and dirty, meant to be tried and thrown away as they engender new knowledge that suggests better design choices."

Nunamaker et al. (ibid.) give further examples of how the instantiation of prototypes in an organizational context can provide hitherto unknown insights about a problem and its context; for instance, such insights can relate to "[…] the problems and opportunities of the stakeholders, the economic, political, social, and operational constraints in the environment, and perhaps, accounts of prior dead-ends […]" (ibid.). Obtaining insights by instantiating prototypes highlights that Nunamaker et al. (ibid.) describe the instantiation and "[…] situated implementation of [an] artifact […]" (see DSR Contribution Types: Level 1 in Gregor and Hevner 2013). Other outcomes are the definition of "[…] the class of problems […]" (Nunamaker et al. 2015) and "[…] generalizable requirements […]" (ibid.).

The goals of the *proof-of-value* stage are 1) to deepen "[…] scientific understandings of the phenomena discovered during proof-of-concept research, and to discover and describe new phenomena pertinent to the problem and its potential solutions […]" (Nunamaker et al. 2015), 2) to measure "[…] the degree to which a generalizable solution meets its design goals for improving key outcomes […]" (ibid.), 3) to improve "[…] the functional quality of the solution. The functional quality means the quality of both the technological components of a solution and the processes by which the technology can be used to create value […]" (ibid.), 4) to discover and describe the "[…] unintended consequences of a solution […]" (ibid.), 5) to develop and document "[…] the processes by which, and the conditions under which, a solution can be used to create value […]" (ibid.), and 6) to obtain a better understanding […] of the technical, economic, and operational feasibility factors that might affect successful deployment of such a solution in the workplace […]" (ibid.). Key objectives of proof-of-value research are "[…] to learn which elements of the solution have what effects on the outcomes of interests; to discover and explain the independent and interaction effects of various design choices; to distinguish the solution elements that create positive value from those with neutral or negative value; to gain knowledge about ways […] components of a […] solution can be used in the field to create value" (ibid.). Fulfilling these objectives lead to the creation of a "[…] rich body of explicit and tacit knowledge about the problem and solution spaces […]" (ibid.). Outcomes of the proof-of-value stage are, inter alia, generalizable requirements, generalizable solutions, the design of processes for using a system to create value, exemplary instances, and a "[…] theoretical logic to explain observed phenomena […]" (ibid.), indicating that the maturity of the artifact being investigated has developed from instantiations into a nascent design theory, that is, "[…] constructs, methods, models, design principles, technological rules […]" (Gregor and Hevner 2013) or level two on the Gregor and Hevner (2013) DSR contribution maturity scale.

The goals of the *proof-of-use* stage are 1) the determination of “[…] whether it is possible to create self-sustaining and growing communities of practice around a new […] solution […]” (Nunamaker et al. 2015), 2) the codification of “[…] a design theory encapsulating the knowledge practitioners require to develop successfully their own instances of generalizable solution […]” (ibid.), and 3) the continuous deepening of “[…] scholarly understandings of the problem and solution spaces” (ibid.). Key objectives for proof-of-use research are “[…] to discover, describe, understand, and design to accommodate functional feasibility issues – political, social, cognitive, emotional, and physical – that would otherwise prevent people from deriving value from a new […] solution” (ibid.). Outcomes of proof-of-use research are, inter alia, the definition of “[…] key constructs, theories that inform design choices, […] principles of form and function, design methodologies for solutions, exemplary instances of the solution […]” (ibid.). These outcomes resemble the anatomy of design theory;[7] thus, it can be stated that the *proof-of-use* stage can be used to further develop an artifact from level two on the Gregor and Hevner (2013) maturity scale towards level three, that is, a well-developed design theory.

Nunamaker et al. (2015) present a high-level process for developing a series of artifacts that elaborate on and relate to the same class of problems. Beginning with exploratory instantiations of prototypes in organizational contexts, the authors implicitly describe how an artifact can be further developed into a nascent design theory and ultimately into a mid-range design theory that is “[…] abstract enough to allow for generalizations and useful conclusions, but close enough to observed data to be empirically validated […]” (Hassan and Lowry 2015).

3.1.2.2. Action Design Research

ADR is a DR method that emphasizes the relevance of considering the organizational context in artifact development. ADR views artifacts as ensembles of intended solution approaches and emphasizes the inscription of the organizational domain “[…] into the artifact during its development and use […]” (Sein et al. 2011).

The initiators of the ADR movement proposed a process for designing and building an artifact that is “[…] inseparable and inherently interwoven […]” with “[…] intervening in the organization, and evaluating it concurrently […]” (ibid.). Therefore, “[…] securing the long-term commitment from

[7] In their article “The Anatomy of a Design Theory,” Gregor and Jones (2007) elaborate on six plus two (the latter two are optional) components of an IS design theory: 1) purpose and scope, 2) constructs, 3) principle of form and function, 4) artifact mutability, 5) testable propositions, 6) justificatory knowledge, 7) principles of implementation, and 8) expository instantiation.

the participating organization […]" (ibid.) and setting "[…] up the roles and responsibilities of the research team that includes researchers and practitioners […]" (ibid.) are critical elements in ADR.

The interrelated reciprocal shaping of organizational context and an artifact in ADR is intended to ensure that the research outcomes have a high degree of relevance. To guide users of the method through the research process, ADR is based on four stages and seven principles.

The Four Stages and Seven Principles of Action Design Research

ADR consists of four stages. The first three stages propose a normative order, but the process suggests taking a step backwards or forwards should doing so be necessary to update the intermediate results of a stage (see Sein et al. 2011). The fourth stage represents the final step. This final stage does not foresee to revisit other stages once it has been entered. All stages are further guided by principles. Sein et al. (ibid.) present seven principles in total, which are distributed among the four stages (see **Figure 13**).

The first stage, *problem formulation*, describes the conceptualization of "[…] a research opportunity based on existing theories and technologies" (Sein et al. 2011).

The second stage, *building, intervention, and evaluation*, involves the iterative instantiation of theoretical constructs as solution approaches for addressing a problem in a specific organizational context and the reciprocal shaping between the artifact to be created and its context.

The third stage, *reflection and learning*, involves reflecting on "[…] the problem framing, the theories chosen, and the emerging ensemble […] (ibid.) of an artifact and its embedded instantiation in the organizational context to move conceptually from building specific solutions for specific problems "[…] to applying that learning to a broader class of problems" (ibid.).

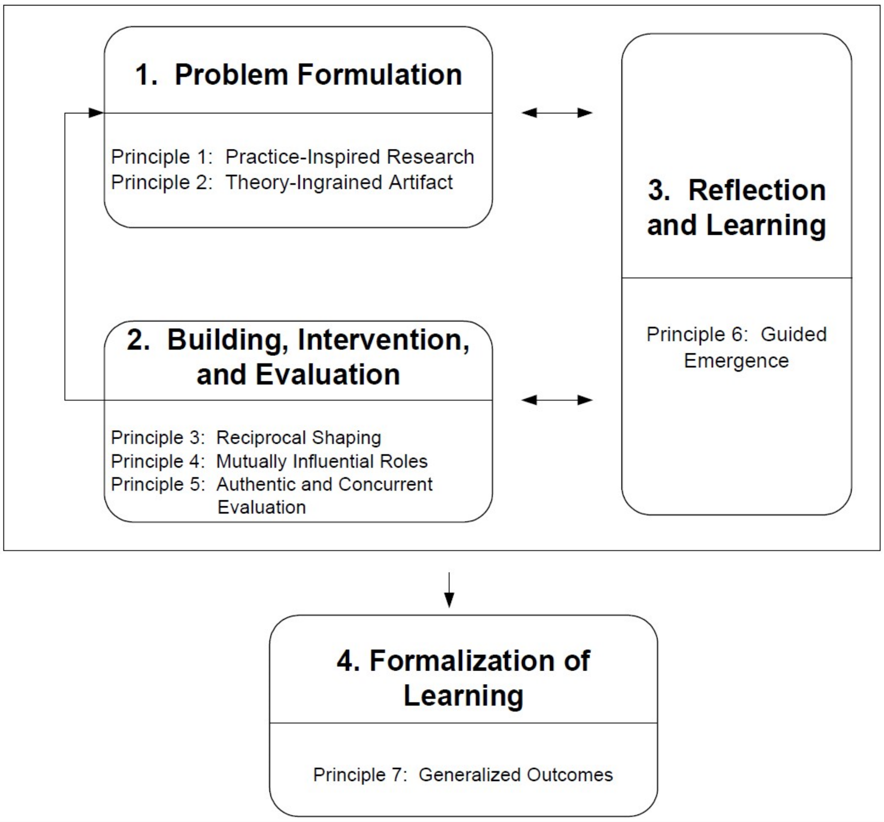

Figure 13. ADR method: stages and principles (Sein et al. 2011).

The fourth stage of ADR, *formalization of learning*, involves the generalization of the situated learning towards general solution concepts that are suitable to address a class of problems (ibid.). Each stage is further informed by principles.

The first stage, *problem formulation*, contains two principles: 1) *practice-inspired research*, that is, focusing on a field problem and the generation of knowledge that can be applied to a class of problems associated with that specific field problem, and 2) *theory-ingrained artifact*, that is, informing the artifact that is used for solving a problem by "[…] inscrib[ing] theoretical traces that reflect the socio-political context of the design situation […]" (Sein et al. 2011).

The second stage, *building, intervention, and evaluation*, contains three principles: 1) *reciprocal shaping*, that is, the instantiation of theoretical constructs in the organizational context and the examination of the reciprocal shaping between artifact and context; 2) *mutually influential roles*, that is, the exchange and cross-fertilization of scholarly and practitioners' knowledge; and 3) *authentic and concurrent evaluation*, that is, the design, shaping, and reshaping of the ensemble artifact and intervening in the organizational context while concurrently evaluating it (ibid.).

The third stage, *reflection and learning*, contains one principle, namely 1) *guided emergence*, that is, reflecting on both the anticipated and the unanticipated consequences of the reciprocal shaping (see stage 2, principle 1) and concurrent evaluation (see stage 2, principle 3) of the design of the artifact to identify design principles (ibid.)

The fourth stage, *formalization of learning*, contains one principle: 1) *generalized outcomes*, that is, the "[…] move from the specific and unique to generic-and-abstract […]" (Sein et al. 2011). Sein et al. (ibid.) propose three levels for this move: 1) *generalization of the problem instance*, that is, the casting of a specific problem into a class of problems (see also stage 1, principle 1); 2) *generalization of the solution instance*, that is, the reconceptualization of "[…] the specific solution instance into a class of solutions […]" (ibid.); and 3) *derivation of design principles*, that is, the reconceptualization of "[…] the learning from the specific solution instance into design principles for a class of solutions" (ibid.).

3.1.2.3. Design Science Research Method

The DSRM was introduced by Peffers et al. (2007) to provide a commonly accepted methodology for conducting DSR in ISR. The DSRM enables and facilitates the presentation and evaluation of any "[…] designed object with an embedded solution to an understood research problem" (Peffers et al. 2007). Such artifacts are "[…] intended to solve organizational problems […]" (ibid.) that are "[…] heretofore unsolved […]" (ibid.).

The development of solution approaches is described as a "[…] search process that draws from existing theories and knowledge to come up with a solution to a defined problem" (ibid.). Peffers et al. (2007) synthesized prior pertinent sources that contributed to DS research in IS and identified seven common key elements. Based on these seven key elements, Peffers et al. (2007) propose a process with six activities and four points of entry into the process (see **Figure 14**).

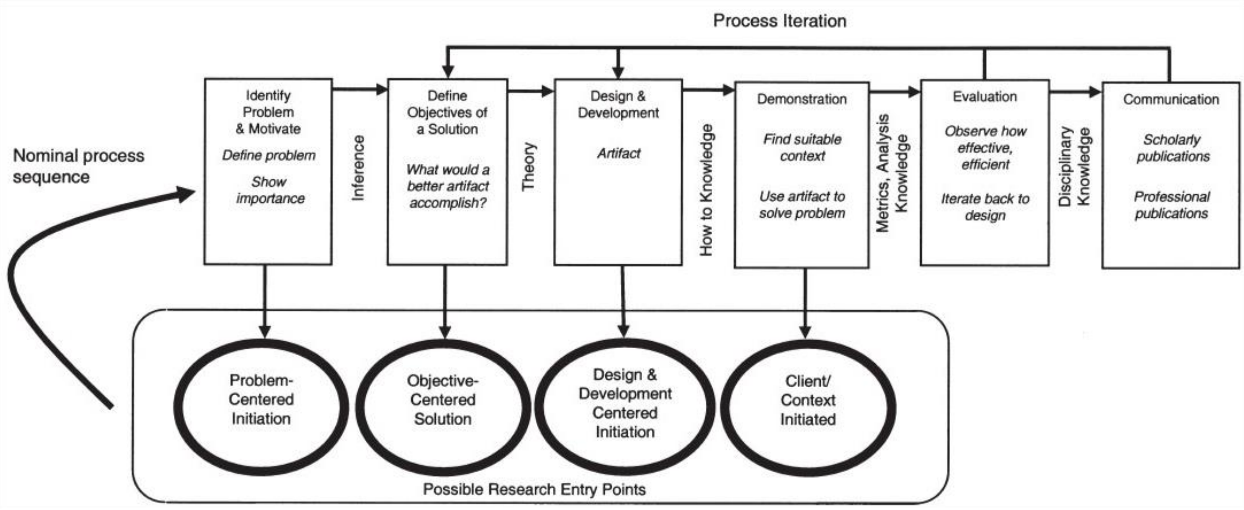

Figure 14. The DSRM process model (Peffers et al. 2007).

The Six Activities of the DSRM Process

The first activity in the DSRM process is 1) *identify problem and motivate*; it includes the definition of the specific research problem, which is necessary for an artifact to effectively solve it, and a determination of the value of solving the identified problem (ibid.).

The next activity, 2) *define objectives of a solution*, involves defining the objectives that an artifact in the light of the defined problem must meet. Such objectives can be defined qualitatively or quantitatively and can include knowledge about comparable "[…] solutions, if any, and their efficacy" (ibid.).

The following activity, 3) *design and development*, involves the design and creation of an artifact based on a pre-determined architecture and functionality; this process is further to be informed by theories.

In the subsequent activity, 4) *demonstration*, the value of the created artifact is shown by using it to solve one or more problem instances. The demonstration must include "[…] effective knowledge of how to use the artifact to solve the problem […]" (ibid.) and can be based on different approaches, for example, "[…] experimentation, simulation, case study, proof, or other appropriate […]" (ibid.) approaches.

The demonstration is followed by 5) *evaluation*. The evaluation of the artifact is based on the demonstration (see **above**) and additionally involves the identification of "[…] relevant metrics and analysis techniques" (ibid.). The evaluation of the artifact can include "[…] any appropriate empirical evidence or logical proof […]" (ibid.), such as "[…] a comparison of the artifact's functionality with the solution objectives from activity 2, objective quantitative performance measures such as budgets or items produced, the results of satisfaction surveys, client feedback, or simulations" (ibid.).

The last activity in the DSRM process, 6) *communication*, involves summarizing the insights gained from the outcomes of other activities and includes the communication of "[…] the problem and its importance, the artifact, its utility and novelty, the rigor of its design and its effectiveness to researchers and other relevant audiences such as practicing professionals, when appropriate" (ibid.). Peffers et al. (2007) propose using the structure of the DSRM process for presenting scholarly articles.

The Four Entry Points of the DSRM Process

The DSRM process defines four points of entry into the overall research process (see **Figure 14**). The first entry point, *problem-centered initiation*, starts the research process with an observed problem or a suggestion for research from an appropriate source. The second entry point, *objective-centered solution*, could focus on a research or industry need.

The third entry point, *design- and development-centered solution*, begins with an existing yet unfinished artifact, that is, a potential solution for a problem exists "[…] that has not yet been formally thought through as a solution for the explicit problem domain in which it will be used" (ibid.). The fourth entry point, the *client-/context-initiated solution*, starts from a working solution and can result in "[…] a DS solution if researchers work backward to apply rigor to the process retroactively" (ibid.).

The DSRM process describes a normative order in general but is iterative in nature. The process allows for taking steps forwards or backward from certain steps (see **Figure 14**); for example, the activity *evaluation* may initiate another *design and development* cycle or trigger a re-definition of the objectives.

3.1.2.4. Comparing the ADR and DSRM Processes

Both ADR and the DSRM initiate a research process by framing a research challenge. ADR emphasizes that the problem to be solved must be a practice-inspired problem (see Sein et al. 2011); in contrast, the DSRM simply calls it a problem (see Peffers et al. 2007). However, as the target of DSR is "[…] to develop […] solutions to important and relevant business problems […]" (Hevner et al. 2004), it can be assumed that solved problems in the DSRM are practice-inspired as well.

Research Initiation and Problem Definition

A problem definition is a vital part of justifying research efforts to "[…] motivate the researcher and the audience of the research […]" (Peffers et al. 2007). Identifying the motivation for a research endeavor requires "[…] knowledge of the state of the problem and the importance of its solution" (ibid.). ADR specifically proposes retrieving required knowledge by reviewing empirical insights to avoid solving "[…] theoretical puzzles […]" (Sein et al. 2011); however, ADR also emphasizes that problem instances should be cast to a class of problems to maintain general relevance (ibid.).

The required empirical insights could be sourced from "[…] practitioners, end-users, the researchers, existing technologies, and/or [a] review of prior research" (ibid.). DSRM continues by defining the first objectives for a solution (see Peffers et al. 2007), while ADR emphasizes the importance of solving problems in organizational contexts. In this respect, ADR proposes securing a long-term commitment with a participating organization based on a researcher-client agreement (see Sein et al. 2011).

Such an agreement "[…] can become the basis for mutual understanding of the scope, focus, and mode of inquiry […]" (ibid.); such an agreement could be enriched by including information about the underlying objectives as described in the DSRM (see above). The agreement is followed by the determination of roles and responsibilities in an ADR team, that is, those belonging to the researchers and practitioners from the pertaining organization who follow the research throughout the process.

Both ADR and the DSRM continue by creating instantiable designs based on suitable theories (see Peffers et al. 2007, Sein et al. 2011). ADR explicitly emphasizes that the initial design is preliminary in nature and that it should suit the purpose of instantiating solution approaches in an organizational setting, followed by iterations of reciprocal shaping (see Sein et al. 2011). DSRM is not specific about the *preliminary* attribute of designed artifacts, but Peffers et al. (2007) show in their DSRM examples that an initial design of an artifact is highly likely to not be a final design. Thus, it can be stated that both approaches rely on an iterative artifact design approach.

Artifact Design and Evaluation: Intra- vs. Inter-Organizational Shaping

A major difference between the two DR approaches involves the characteristics of the process behind the evaluation and the target audience of evaluation activities.

ADR views artifacts as ensembles of intended solution approaches and the inscription of an organizational domain "[…] into the artifact during its development and uses […]" (Sein et al. 2011). The initiators of the ADR movement propose a design process that is "[…] inseparable and inherently interwoven […]" with "[…] intervening in the organization, and evaluating it concurrently […]" (Sein et al. 2011). It should be noted that these interwoven nature of these design and evaluation activities limits their target audience to stakeholders in a specific organizational context.

By contrast, the DSRM views artifact design and artifact evaluation as sequentially separate but is not limited to evaluating an artifact in a specific organizational context (see Peffers et al. 2007).

Generalization in ADR and DSRM

Generalization is a crucial step in distilling design knowledge into a transferable form. A comparison of the role of generalization led to the identification of another difference between ADR and the DSRM. As a final step, ADR suggests that the researchers focus their attention on the generalization of the research outcomes after all other research has been conducted (see Sein et al. 2011). The DSRM, in contrast, is less explicit about generalization (see Peffers et al. 2007).

The generalization of outcomes in ADR encompasses three activities: "[…] (1) generalization of the problem instance […]" (Sein et al. 2011), which can also be attributed to the first stage of ADR (see stage 1: *problem formulation*); "[…] (2) generalization of the solution instance […]" (ibid.), that is, the abstraction of the organization-specific solution approaches "[…] into concepts for a class of field problems […]" (ibid; see stage 3: *reflection And Learning*); and "[…] (3) derivation of design principles […]" (ibid.). While the first activity is comparable with problem definition and motivation in the DSRM, the latter two differ from their DR counterparts.

The DSRM is not specific about the generalization of a solution instance as a class of solutions. This difference might be the result of the DSRM's focus on the design of an instantiable artifact, as opposed to the reciprocal shaping of both the instance and the instantiable artifact described by ADR. In the DSRM, the evaluation setting can be unknown at the point in time when the artifact is design. Thus, it can be assumed that the resulting artifact must be generalized by design to enable transfers to evaluation contexts, while, in ADR, the resulting artifact may feature organization-specific solution approaches that are required for an in-depth evaluation in a specific organizational setting.

The second major difference with regard to generalization in ADR and DSR constitutes the view on deduction and the definition of design principles as described by level two on the Gregor and Hevner

(2013) DR contribution maturity scale. DSR adopts an ex ante perspective on formulating design principles, while ADR takes a concurrent perspective in combination with a finalizing ex post view (see *guided emergence* in ADR). At this point, it should be noted that DSRM as described by Peffers et al. (2007) does not explicitly mention the definition of design principles. However, Chandra et al. (2015) suggest conceptualizing design principles through a lens that predominantly views DR in ISR through DSR. Thus, I base my following comparison on the insights provided by Chandra et al. (ibid.).

Chandra et al. (2015) propose a "[…] structure that is both clear and precise […]" (ibid.) for formulating design principles. Similarly to the sequential nature of the DSRM, the proposed approach for defining and evaluating design principles is sequentially separated (see Chandra et al. 2015). The validity of the formulated design principles is evaluated through their application "[…] akin to the concept of instantiation validity […]" (Chandra et al. 2015). In contrast, ADR views the generation of design principles as a process of evolutionary emergence that is observable in and indicated by substantial changes in an artifact's design (see Sein et al. 2011). Similar to ADR's process of designing an artifact, the deduction of design principles in ADR involves an interwoven interplay of design, instantiation, and emergence. Hence, design principles derived using the ADR are already evaluated by instantiation.

Communication of Outcomes

The last difference between the two DR methods that should be compared is the final process step in the DSRM, that is, *communication*. ADR does not include a dedicated step for communicating research outcomes. In contrast, the DSRM proposes communicating research outcomes to both scholars and practitioners, if reasonable.

Summary

ADR is a design research method that emphasizes the relevance of considering the organizational context during artifact design. The interrelated reciprocal shaping between an organizational context and an artifact is intended to ensure that the research outcomes are characterized by a high degree of relevance. In ADR, the evaluation of the artifact has a formative character and is concurrently executed with the implementation of organizational interventions.

This perspective is contrasted by that of the DSRM, which considers these activities as separate phases, beginning with the design of an artifact outside of an organizational context and with the resulting artifact being subsequently evaluated in the relevant organizational context. In the DSRM, the evaluation of the artifact has a summative character and is decoupled from a specific organizational context.

DSR has been criticized for valuing technical rigor over organizational relevance, as it scarcely considers the shaping of an artifact by its organizational context (see Sein et al. 2011). This statement is in line with Hevner's (2004) observation that "[…] an overemphasis on the rigor can lessen relevance."

ADR, in contrast, has been criticized for attempting to merge what are apparently divergent interests. ADR is said to create "[…] an ongoing issue […]" (Haj-Bolouri et al. 2018), as "[…] balancing expectations from the industry partners and the research community […]" (ibid.) has been described by users of the ADR approach as "[…] as [a] dichotomy between solving real-world problems and distilling design knowledge […]" (ibid.).

The pivotal point in both ADR and the DSRM is the creation of an artifact as an approach to solving a class of practice-inspired problems. Both ADR and the DSRM describe an abductive and iterative interplay of artifact design and artifact (re-)application and (re-)evaluation. While both approaches are similar to the extent that they rely on an abductive hermeneutic process, they differ in their emphasis on induction and deduction.

ADR views generalized solution design as the emergence of an artifact design from driving interventions in a specific organizational context and evaluating the instantiated artifact concurrently (see Sein et al. 2011). Thus, in ADR, the notion of an artifact can be further divided into *instantiations* or *material artifacts* (see Gregor and Jones 2007).

As, in ADR, created artifacts are first and foremost instantiations that are evaluated concurrently and reflected with the target to create generalized design knowledge, the hermeneutic emphasis in ADR with regard to theory generation is *inductive*.

The DSRM, in contrast, views artifacts as "[…] constructs, models, methods, or instantiations (each defined broadly) [20] or 'new properties of technical, social, and/or informational resources' [24, p. 49]" (Peffers et al. 2007). DSR explicitly notes that this approach includes not only "[…] instantiations […] but also the constructs, models, and methods applied in the development and use of information systems […]" (Hevner et al. 2004).

Artifacts created by an application of the DSRM can be classified as either *material* or *abstract* in nature. As opposed to material artifacts, abstract artifacts "[…] do not have a physical existence […]" (ibid.) and "[…] must be communicated in words, pictures, diagrams or some other means of representation […]" (ibid.).

With regard to theory, the hermeneutic emphasis of the DSRM can be either inductive or deductive depending on the type of artifact created. In practice, however, artifacts created with DSRM face the criticism identified by Sein et al. (2011); that is, the sequentially separated design and evaluation process required by the DSRM pays scant attention to the artifact's shaping by an organizational context. This criticized aspect of the DSRM affects the creation of different kinds of artifacts differently. Apparently, the criticism is especially relevant for creating material artifacts, as they can be autonomously used by practitioners due to their real-world existence, while this criticism is mitigated with regard to the creation of abstract artifacts, as these must be communicated after they have been designed, so there is a natural sequential separation between design and evaluation.

As the DSRM process proposed by Peffers et al. (2007) explicitly reflects this sequential separation of design and evaluation, I argue in line with Sein et al. (2011) that DSRM is particularly suitable for creating abstract artifacts. Therefore, the hermeneutic emphasis of DSRM must be *deductive*.

The one approach's advantages are the other's disadvantages and vice versa. ADR differs from the DSRM's emphasis on deductive knowledge generation in the form of transferring an instantiable artifact to other organizational contexts. While conducting in-depth research by driving interventions in a specific organizational context can yield the benefit of an early proof of value, it also brings the burden of generalizing and evaluating generalized solutions with practitioners whose specific problems have already been solved.

By contrast, in the DSRM, specific solutions are deductively created with practitioners, who can derive benefits from deducing specific solutions from an instantiable artifact. It is this transfer to that provides a reason for creating a generalized artifact design and can encourage and motivate a researcher to present a generalized solution approach to a class of problems. Finally, it can also provide a further proof, namely that of use.

The integration of DSRM into a predominantly ADR-driven approach can support researchers in nurturing, facilitating, and legitimating a focus on generalization, whereas the integration of ADR activities into a predominantly DSRM-driven approach can ensure that the designed artifact does not lose touch with the reality of the socio-political problem context.

It stands to reason that integration can benefit both approaches. Still, it remains unclear how such integration could be designed and how an integrated process would ultimately lead to the creation of a mid-range theory. Gregor and Hevner's (2013) levels of theory maturity and the article "The Last Research Mile" of Nunamaker et al. (2015) provide high-level guidance for research, beginning with the instantiation of artifacts in organizational contexts (which is distinct to ADR) and finishing with the design of a transferable abstract artifact as a class (as is typical of the DSRM). I argue that a combination of ADR and DSRM in an integrated process, guided by the levels and steps described by Gregor and Hevner (2013) and Nunamaker et al. (2015), can provide a basis for researchers who aim to design artifacts in the middle range (Merton 1968 in Gregor 2006) that are "[…] abstract enough to allow for generalizations and useful conclusions, but close enough to observed data to be empirically validated […]" (Hassan and Lowry 2015).

3.2. Integrated Design Research with Progressive Design Research

This thesis introduces a prototype for a new research method that builds on both ADR and DSRM. The new integrated research process emphasizes ADR in initial phases and the DSRM in the later stages, with the two approaches overlapping when it comes to the overall target, namely the creation of an artifact for solving a class of practitioner-relevant problems.

Drawing on ADR and DSRM makes it possible to create a progressive design perspective. Progressive design initially emphasizes the creation of an ensemble artifact in a specific organizational setting, with the emphasis shifting to the design of generalized theoretical contributions in later stages. The in-depth reciprocal shaping within a specific organizational context and the design and evaluation with the help of stakeholders who are external to the initial organizational setting ensure both rigor and relevance of the research outcomes for practitioners and scholars. Inspired by this transfer of audience and the progressive nature of artifact abstraction levels, the prototype approach is named *progressive design research* (PDR).

An integration of ADR and DSRM enables researchers to balance the expectations of both practitioners and scholars through the creation of generalized artifacts that are ingrained by a relevant socio-political reality and abstract enough to be transferred to various organizational contexts. The integration of these two DR approaches into one unified process requires making fundamental design decisions, which are discussed in **Chapter 3.2.1.1**. The presentation of the PDR prototype continues with an overview of the overall research method and its modes in **Chapter 3.2.1.2**. Finally, PDR stages that describe pivotal outcomes of the research approach are introduced in **Chapter 3.2.1.3.**

3.2.1.1. Design Decisions

The integration of the two processes is not a trivial endeavor. Based on Bleicher's (1991) approaches for reducing process cycle times and inspired by Nunamaker et al.'s (2015) high-level research stages, I made decisions concerning the research process flow characteristic, that is, whether the to-be integrated processes would be arranged in parallel, interleaved, or sequentially, and concerning the process elements that should culminate in a common process, that is, whether the new process should contain all elements of both research approaches to be integrated or just a selection of elements, which elements those would be, when they should be used, and why. In the following, I discuss my design decisions in terms of *process flow characteristics* and the *selection of process elements*.

Process Flow Characteristics

A conceptually simple form of integrating ADR and DSRM is the sequential execution of both. DSRM allows for a design- and development-centered initiation (see **Chapter 3.1.2.3**). ADR results such as an instantiable artifact and deduced design principles, could be handed over to initiate a DSRM research process. In contrast, a converse sequential integration would also be possible, as ADR research can be based on prior research outcomes (see **Chapter 3.1.2.2**).

However, a simple sequential integration of both processes would lead to an overblown research process, as it would effectively result in adding an outer hull to what apparently would cover two research projects. Furthermore, cross-fertilization based on the two approaches' benefits would hamper the engendering of "[…] new knowledge that suggests better design choices […]" (Nunamaker et al. 2015) by handing over solidified research outcomes at the processes' interfaces.

A parallel approach would arguably also result in an excessively complex research design. A parallel integration design would consider driving interventions and reciprocal shaping in a specific organizational context while also evaluating the resulting artifacts with a target audience that shares the class of problem but is external to the specific organizational context. Such a parallel approach could leverage the benefits of both ADR and DSRM and would culminate in a balanced abductive approach, but I argue that a parallel integration would lead to extreme workload peaks, especially in the early research stages; driving interventions in an organization can be work-intensive, particularly due to the efforts required to persuade a partnering company and stakeholders within it to participate.

External evaluations, in contrast, can be similarly work-intensive depending on the planned number and depth of evaluations.

This leaves the field open for an interleaved approach, that is, an approach that involves an interplay of the two to-be-integrated research processes. As described in the introduction to this chapter, switching between the two research paradigms is conceptually enabled by both the interfaces, that is, by the (iterative) problem (re-)definition based on prior research in ADR, and by the design- and development-centered initiation as describes in the DSRM. The question that arises with an interleaved approach is when to focus on which paradigm.

Beginning the overall research in an DSRM mode would lead to the creation of an artifact (or rather versions of artifacts) that does not consider the organizational context through reciprocal shaping and thus would ignore "[…] the problems and opportunities of the stakeholders, the economic, political, social, and operational constraints in the environment […]" (Nunamaker et al. 2015). This might lead the creation of early design markers that would be subject to fundamental change when exposed to in-depth scrutiny by driving interventions.

Beginning the overall research process in an ADR mode would yield in-depth insights that can sensitize a researcher to the socio-political context related to a certain class of problem. Thus, provide a wealth of not only explicit but also tacit knowledge (see also Nunamaker et al. 2015). This knowledge can inform design activities, as such knowledge would enable considering theoretic deliberations in light of a range of real-world situations and examples. This knowledge would enable researchers to consider theories against a rich empirical background and to create focused designs that also maintain a high degree of relevance of the research outcomes.

The early access to in-depth knowledge provided by an ADR approach indicates that starting the overall research process with an ADR focus would be preferable. The profound relationship between a researcher and the organizational context chosen for the implementation of interventions enables making fast-paced design decisions due to the researcher's proximity to the research context. Quick cycle times are particularly important in the early stages of designing an artifact, as early design efforts can be highly exploratory in nature. Transitioning to a DSRM-prevalent research mode towards the end of the overall research process can effectively loosen the interwoven relation between a researcher and the fast-paced organizational setting and motivate slow academic deliberations concerning the generation and evaluation of generalized outcomes.

The question of how, when, and why a transition between an ADR-prevalent initiation and a DSRM-prevalent finalization should be made remains. I discuss this issue in light of the process elements that each research paradigm can contribute to an integrated approach.

Selection of Process Elements

When integrating two processes, a decision must be made concerning which of these elements of those processes should ultimately be included in an integrated design. It must be determined whether an integrated design should contain all elements or just a selection thereof, which elements those would be, when they are required, and why. I answer this question based on the introductions to and comparison of ADR and the DSRM (see **Chapter 3.1.2**).

In design, there is a direct relationship between a problem and the solution space. The problem space regarding DSRM and ADR is described by above-mentioned critiques. The criticism indicates the potential for solutions. A solution must address any points of criticism while maintaining the benefits of both approaches.

The benefits of ADR include the reciprocal artifact shaping and the creation of in-depth knowledge about a class of problems within a socio-political context. The drawback of ADR is the interwoven relationship between researchers and their chosen organizational setting, which hampers the creation of academically deliberated solutions that can be generalized as a class of solutions.

The benefit offered by the DSRM is a design approach that enables the transfer of an artifact to various organizational contexts due to its separation of design and evaluation. Thus, designs created using DSRM are inherently generalized to the degree required to enable the required transfers. The drawback of DSRM is the scant attention it pays to the organizational context in artifact design.

The comparison shows that ADR and DSRM can complement each other. Even though they employ partially contrasting views, I was not able to identify process activities in one approach that would be in conflict with the activities of the other approach or would render the activities of the other approach obsolete. A closer look reveals that one approach's advantages are the other's disadvantages and vice versa.

Due to its process design, DSRM does not allow for a problem re-definition, which ADR does. DSRM's scant attention to the organizational context is addressed by ADR's intra-organizational research perspective, while an easing ADR's interwoven relationship between researchers and their chosen organizational settings can be achieved by DSRM's inter-organizational design and evaluation perspective. ADR generates design principles, whereas DSRM requires generated design principles for evaluation. Generalization in ADR is a challenging task, whereas DSRM is a suitable approach for creating generalized or abstract artifacts. ADR does not consider the communication of research outcomes, which DSRM does. This might be an obvious step, but it must still be considered in an overall research design.

The complementary relationship between ADR and DSRM speaks in favor of integrating all of their associated activities. However, in an integrated research approach, a selection of process activities must consider limited research resources to avoid an overblown research process. While certain activities from one approach provide details that facilitate to conduct certain activities of the other approach (for instance, the complementary relationship between objective definition as described in the DSRM an ADR problem formulation (see **Chapter 3.1.2.4**) there are also process activities that would create additional effort within an unrestricted integrative design (for instance, the concurrent design and evaluation in ADR and the sequentially separated design and evaluation in DSRM). While both design and evaluation approaches are justified by the value they provide, the somewhat redundant approaches to design and evaluation of both approaches offer opportunities to reduce the effort of a research approach that integrates both.

An integrated two-sided view on design and evaluation, that is, the combination of the induction-prevalent ADR perspective with the deduction-prevalent DSRM perspective, can provide a two-sided proof of value. As both methods are known to produce valid research outcomes, any solution involving integrating the benefits of both approaches while keeping the overall research effort required to conduct research at a manageable level must lie in a reduction of the design and evaluation efforts required by each method. I present the manner in which I solved this design challenge in the subsequent chapter.

3.2.1.2. PDR Modes

PDR integrates the processes behind ADR and the DSRM into a single theoretical construct. Instead of presenting the result in the form of a process model, I decided to present an integrative design in the form of a canvas. Canvasses can delineate a process and provide a blueprint for planning and discussing actual research processes; they are also a suitable means for presenting the underlying components of a research process. A miniaturized overview of the PDR process canvas is shown in **Figure 15** (an applied full-size canvas is presented in **Chapter 3.3.2**).

Models can have a direction of reading; for instance, the DSRM process model is meant to be read from left to right, whereas the ADR method is meant to be read from top to bottom. The general direction of reading the PDR process canvas is from left to right. The PDR canvas shows five areas which represent the five modes of PDR. The five modes canvas are *problem definition*, *intra-organizational shaping*, *artifact design*, *inter-organizational transfer*, and *communication of outcomes*. Each mode is based on one or more ADR or DSRM stages or activities (see **Table 15**).

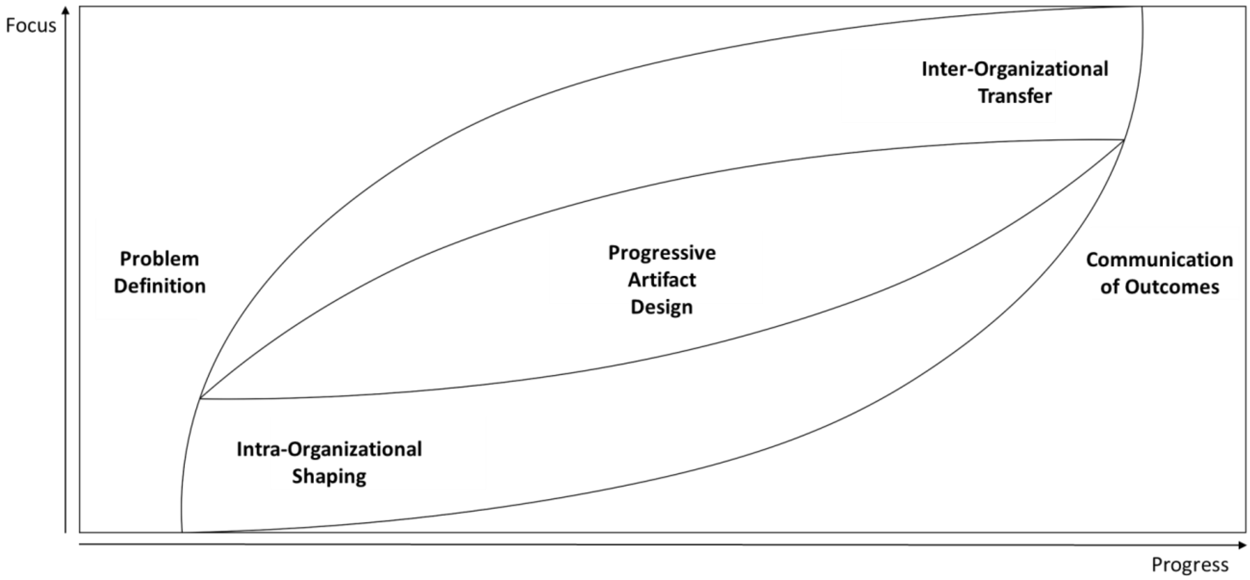

Figure 15. An overview of the PDR canvas (own depiction).

The term *modes* is used to indicate that a specific mode is not completed when entering another mode. Taking steps backward or forwards is explicitly permitted and recommended. The modes describe a nominal sequence, but the research outcomes created in one mode may initiate activities in other modes and in modes already visited. For instance, activities in the mode of *intra-organizational evaluation* may lead to new insights that are relevant for *problem definition*.

Modes underpin the iterative nature of an actual process. The PDR research approach begins by being highly ADR-oriented and then shifts to being DSRM-oriented with advancing research progress. The individual activities of a PDR mode are largely described by their relations to ADR or DSRM. Still, in the following chapter, I discuss the modes in more detail to explain the deviations from ADR and the DSRM that make PDR unique.

PDR Mode	Related ADR/DSRM Stages and Activities
Problem definition	ADR stage 1: Problem formulation
Intra-organizational shaping	ADR stage 2: Building, intervention, and evaluation
Progressive artifact design	ADR stage 3: Reflection and learning DSRM activity 3: Design and development
Inter-organizational transfer	DSRM activity 4: Demonstration, DSRM activity 5: Evaluation
Communication of outcomes	DSRM activity 6: Communication

Table 15. PDR modes and related ADR/DSRM activities (own depiction).

Problem Definition

Problem definition in PDR is fundamentally based on ADR's first stage, *problem formulation* (Sein et al. 2011). This implies that the tasks and principles related to this ADR stage apply in this mode: the research opportunity must be identified and conceptualized, initial research questions must be formulated, the problem must be cast as an instance of a class of problems, existing knowledge in the form of pertinent theoretical bases and prior technology advances must be identified, a long-term organizational commitment must be secured, and the roles and responsibilities of an ADR team must be identified (see Sein et al. 2011 for more details).

Additionally, I found that the DSRM activity *define the objectives for a solution* (see Peffers et al. 2007) can contribute to problem definition. In ADR, it is suggested that a long-term commitment be based on a researcher-client agreement. This researcher-client agreement "[…] can become the basis for mutual understanding of the scope, focus, and mode of inquiry […]" (Sein et al. 2011). Defined objectives, as required by *define the objectives for a solution* (see DSRM), can enrich a researcher-client agreement by providing a "[…] description of how a new artifact is expected to support solutions to problems not hitherto addressed" (Peffers et al. 2007). It should be noted that the PDR problem definition mode allows the problem to be iteratively redefined based on gained insights in a manner similar to that described in ADR. This opportunity for problem re-definition stands in contrast to DSRM, which does not allow for the iterative re-definition of a problem. Thus, the definition of objectives in a researcher-client agreement should leave room for interpretation, as objectives are defined on the basis of particular understanding of a problem, which can evolve over time.

The research outcomes of the PDR problem definition mode are an explicit problem understanding, explicit knowledge concerning a class of problems, the identification of theories that can contribute to either an improved problem understanding or the development of solutions, and long-term organizational commitment.

Intra-Organizational Shaping

Intra-organizational shaping is fundamentally based on ADR's second stage*, building, intervention, and evaluation* (Sein et al. 2011). The related tasks and principles as defined by ADR apply in this mode; this includes the execution of *build-intervene-evaluate* cycles, which enable an authentic and concurrent evaluation of a material artifact and the reciprocal shaping between a material artifact and the specific organizational context it is instantiated in. The reciprocal shaping is further defined by the assignment of mutually influential roles (see Sein et al. 2011).

Mutually influential roles describe the knowledge exchange that occurs between researchers and practitioners: "[…] researchers bring their knowledge of theory and technological advances [see *problem definition*], while the practitioners bring practical hypotheses and knowledge of organizational work practices" (Sein et al. 2011).

Intra-organizational shaping in PDR emphasizes in-depth interventions during the initial stages of research and a continuous reduction in the number and effort of interventions throughout the overall research process. This reduction is intended to release research resources to continuously increasing the depth of inter-organizational transfers (see below: inter-organizational transfers).

Research outcomes are rich tacit and explicit knowledge concerning a specific problem and its relevant socio-political context, first solutions in the form of instantiated artifacts, and authentic insights into the suitability of the instantiated artifacts for solving a specific problem (see Nunamaker et al. 2015) and thus a first validation of the artifact by its instantiation (see Chandra et al. 2015).

Progressive Artifact Design

The nature of artifacts in ADR differs from that of the artifacts produced by the DSRM (see **Chapter 3.1.2.4**). Build-intervene-evaluate cycles lead to the creation of instantiations or material artifacts, while artifact design in the DSRM predominantly leads to the creation of "[…] constructs, models,

[and] methods […]" (Peffers et al. 2007), also referred to as abstract artifacts (see Gregor and Jones 2007, Gregor and Hevner 2013). Progressive artifact design in PDR draws on the artifact design approaches of both ADR and the DSRM and describes a progression from material artifacts, as emphasized by ADR, to abstract artifacts, as emphasized by DSRM.

Progressive artifact design in PDR initiates artifact development with the creation of a preliminary abstract artifact design (see Sein et al. 2011) based on the current problem understanding. This prototypical artifact is used to create first material artifacts during the course of interventions within an intra-organizational context. The instantiation and the authentic and concurrent evaluation through an intra-organizational shaping (see above: inter-organizational transfers) provide insights that enable a researcher to enrich and detail a preliminary abstract artifact design, leading to the creation of an abstract yet highly specific artifact; that is, it is abstract in that it represents an abstract model of the reality, and it is highly specific in that the insights gained from interventions that are ingrained in the artifact focus on solving a specific problem as opposed to solving a class of problems. The abstract yet highly specific artifact design enables the researcher to communicate and plan further progress with organizational stakeholders of the specific organizational setting.

The early presentation of this preliminary artifact design can lead to a fundamental problem re-definition, the selection of further theories that can contribute to a solution, and eventually to a fundamental re-design of the artifact on the architectural and functional levels. The fundamental and early re-design is a desirable outcome, as it ensures that the basic scope, purpose, architecture, and functionality of an artifact are determined with sufficient certainty before the artifact undergoes further design iterations intended to generalize and polish it.

The transition from an abstract yet highly specific artifact to a generalized abstract artifact requires a demonstration (see Peffers et al. 2007) in additional organizational contexts. The transfer (see below: inter-organizational transfers) of an artifact implies a change in the target audience. Therefore, the researcher is required to create transferable artifact designs eliminating organization-specific solution approaches within the artifact or translating and extracting the underlying design knowledge, for instance, in the form of first design principles, similar to stage 3 of ADR, *reflection and learning* (see Sein et al. 2011). Thereafter, the extracted design knowledge must be exposed to other organizational contexts for validation (see also Chandra et al. 2015).

First transfers can be initiated within the initial organizational context as a first facilitated transfer if possible, but the transfers should ultimately involve experts from different organizational settings.

Transfers to other organizational settings can shed new light on an artifact's design by adding further knowledge concerning additional problem instances and can thus contribute to the researcher's understanding of the class of problems, uncover further that must be addressed by a solution, and can initiate another search for further "[…] knowledge of theory that can be brought to bear in a solution" (Peffers et al. 2007). The enriched problem understanding and a further ingraining of theory contribute to an improved representation of the class of problems and the class of solutions, that is, the generalized artifact design.

The outcome of progressive artifact design is an accumulation of artifacts addressing the same problem (see Merton in Hevner 2013) that have been validated by instantiation (see Chandra et al. 2015), demonstrated by transfers to other organizational settings (see Peffers et al. 2007), and can ultimately lead to the creation of an artifact design that incorporates various theoretical constructs and rich empirical insights and that is "[…] abstract enough to allow for generalizations and useful conclusions, but close enough to observed data to be empirically validated […]" (Hassan and Lowry 2015).

Inter-Organizational Transfers

Inter-organizational transfers focus on transferring extracted design knowledge obtained by intra-organizational shaping to other organizational settings. This mode is based on the DSRM's demonstration and evaluation activities (see Peffers et al. 2007). Inter-organizational transfers are initiated with the identification of suitable contexts for demonstration, that is, organizations or experts from organizations that share the same class of problem.

A demonstration requires "[…] effective knowledge of how to use the artifact to solve the problem" (Peffers et al. 2007). The demonstration of an artifact can be used for its evaluation. The evaluation of an artifact requires "[…] knowledge of relevant metrics and analysis techniques" (ibid.). An evaluation "[…] could take any form […]" (ibid.), for instance, "[…] a comparison of the artifact's functionality with the solution objectives […], objective quantitative performance measures such as budgets or items produced, the results of satisfaction surveys, client feedback, or simulations. […] Conceptually, such evaluation could include any appropriate empirical evidence or logical proof" (Peffers et al. 2007; see also Peffers et al. 2012 for a more detailed list of suitable evaluation approaches).

Inter-organizational transfers and related demonstration and evaluation activities in PDR continuously increase as intra-organizational shaping activities decrease. The degree of invested effort and the depth of demonstration and evaluation activities begin at a low level to gain first insights with relatively little effort. This progression is intentional, as the change from an intra-organizational to an inter-organizational perspective can induce fundamental artifact re-designs through the change in and expansion of the target audience.

First activities in the inter-organizational transfers mode focus on producing an artifact version that is abstract and generalized enough to cover a class of solutions and is therefore suitable for the initiation of later artifact-driven interventions in other organizational contexts.

Research outcomes extend the researcher's knowledge of the class of problems and, based on this expanded knowledge, enable the design of a class of solutions in the form of a generalized artifact.

Communication of Outcomes

The communication of outcomes in PDR is fundamentally based on the DSRM's last activity, *communication* (see Peffers et al. 2007). The researcher should communicate "[…] the problem and its importance, the artifact, its utility and novelty, the rigor of its design, and its effectiveness to researchers and other relevant audiences such as practicing professionals, when appropriate" (Peffers et al. 2007).

In contrast to ADR, the DSRM (and, by extension, PDR) specifically prescribes the communication of research outcomes and furthermore enables the iterative publication of outcomes that are enabled by intermediate insights (e.g., by presenting the state of the art concerning a certain topic, inquiries intended to leverage theoretical insights, or the results of intra- or inter-organizational evaluations).

3.2.1.3. PDR Stages

The purpose of the PDR stages is to connect a high-level perspective on outcomes and targets with a more specific perspective on a research process. To achieve this, PDR stages link artifact maturity levels (see Gregor and Hevner 2013) with proofs, as defined by Nunamaker et al. (2015) (see **Chapter 3.1.1** for more on how maturity levels and proofs match), specific ADR steps (Sein et al. 2011), and DSRM steps (Peffers et al. 2007), as described in PDR modes (see **Chapter 3.2.1.2**).

PDR defines three stages. The three maturity levels, as defined by Gregor and Hevner (2013), describe three different types of artifacts. Each artifact type marks the outcome of a PDR stage; that is, conducting a full pass through all three PDR stages covers the three maturity levels. The three proofs, as defined by Nunamaker et al. (2015), describe structures that are conceptually compatible with the three maturity levels of artifacts (see **Chapter 3.1.2.1**). Nunamaker et al. (2015) define targets with the intention of achieving a certain proof. Due to the strong conceptual similarity between the specific maturity levels and the specific proofs, fulfilling targets that have been defined to achieve certain proofs supports the creation of an artifact of a certain maturity level.

In combination, artifact maturity levels and proofs provide information concerning the form of the outcome and targets and are therefore suitable for answering questions concerning the *what* of a research process. PDR stages link these definitions of the *what* with specific ADR and DSRM activities (see also **Chapters 3.1.2.2** and **3.1.2.3**), as defined in PDR modes (see **Chapter 3.2.1.2**), to provide guidance for answering questions that concern the *how*.

The combination of ADR (Sein et al. 2011) and the DSRM (Peffers et al. 2007) activities in PDR modes provide elaborate guidance concerning the research process and associated activities; therefore, they are suitable for answering the question of *how*. Together, ADR and the DSRM activities ensure the emergence of an artifact that provides insights into and is shaped by a socio-political problem context and the distillation, transfer, and evaluation of different types of design knowledge that can be used to solve a class of problems.

The combination of PDR stages and modes results in an artifact design process that supports researchers in answering the questions of *what* and *how*; this combined approach initiates research with the creation of a material artifact and works its way towards the creation of a middle-range theory by providing information concerning the shape of the outcome, the definition of targets and requirements, and the provision of a combined ADR and DSRM process.

Each PDR stage can involve all PDR modes. Each stage puts a different emphasis on the different modes. To avoid redundancy in elaborating on PDR modes (see **Chapter 3.2.1.2**), the proofs described by Nunamaker et al. (2015, see **Chapter 3.1.2.1**), and the maturity level logic for categorizing artifacts defined by Gregor and Hevner et al. (2013, see **ibid.**), I limit my introduction of the three PDR stages to describing their purpose in the light of artifact creation, their outcomes and targets, their emphasis in terms of the PDR modes, and the relationships among the involved PDR modes.

PDR Stage 1: Concept Implementation

The first stage, *concept implementation*, connects the first maturity level of artifacts as defined by Gregor and Hevner (2013) with the *proof-of-concept* stage described by Nunamaker et al. (2015). Together, the level of maturity and the proof of concept define the type of outcome and targets towards achieving the outcome.

The target outcome of PDR *stage 1: concept implementation* is defined by Gregor and Hevner's (2013) maturity logic; specifically, the outcome of this stage is a material artifact. The targets towards achieving the outcome are defined by the requirements defined in Nunamaker et al.'s (2015) *proof-of-concept* stage. Therefore, the targets towards creating a material artifact are the demonstration of a solution approach "[…] to an important class of unsolved problems in the field […]" (Nunamaker et al. 2015), the development of a profound understanding of the class of problems (see ibid.), the discovery of first scholarly insights "[…] that may lead to future operational feasibility for a solution […]" (ibid.), and initial research on theories that can "[…] explain outcomes of interest so as to better inform design choices as research progresses" (ibid.).

The outcomes of achieving these targets, as defined by Nunamaker et al. (2015), are in line with Gregor and Hevner's (2013) definitions of the characteristics of a material artifact. Specifically, Nunamaker et al.'s (2015) perspective on outcomes manifests in the creation of a rudimentary "quick and dirty" prototype that is "[…] meant to be tried and thrown away […]" (ibid.), as it may "[…] engender new knowledge that suggests better design choices […]" (ibid.).

Neither Gregor and Hevner (2013) nor Nunamaker et al. (2015) provide elaborate guidance on how to achieve the overall outcome and the related targets. Therefore, I describe the complementary nature of the outcomes, targets, and requirements and present the more process-oriented view required by the PDR modes. PDR proposes achieving the abovementioned outcome and targets by emphasizing the PDR modes *problem definition* and *intra-organizational shaping*

PDR's *problem definition* emphasizes the development of a problem understanding by identifying and conceptualizing a "[…] research opportunity based on existing theories and technologies […]" (Sein et al. 2011). Therefore, the problem definition mode is aligned with Nunamaker et al.'s (2015) proposition to conduct first research on theories. The goal of this initial research is to define "[…] the problem as an instance of a class of problems" (Sein et al. 2011); therefore, the problem definition mode can further can contribute to developing a profound problem understanding, as described by Nunamaker et al. (2015). PDR further defines the creation of a preliminary design (see Sein et al. 2011: principle 2) as a starting point for iterative instantiation and evaluation.

PDR's intra-organizational shaping mode involves evaluating and shaping the preliminary design developed in the problem formulation mode to continuously shape its instantiation in an organizational setting and evaluate the problem understanding concurrently (see Sein et al. 2011); therefore this mode matches Nunamaker et al.'s (2015) proposition to iteratively instantiate prototypical artifacts.

While all involved PDR modes may play a role in completing the PDR stage *concept implementation*, the primary focus of this stage is set on the *problem definition* and *intra-organizational artifact shaping* modes, as they are crucial for developing a profound problem understanding and instantiating an artifact and thus creating a material artifact with which to gain insights into the "[…] problems and opportunities of the stakeholders, the economic, political, social, and operational constraints in the environment, and perhaps, accounts of prior dead-ends […]" (Nunamaker et al. 2015). The focus of the PDR concept implementation stage on the mentioned PDR modes is in line with my argument for emphasizing an ADR perspective during early research activities (see **Chapter 3.2.1.1**). Outcomes can be communicated by (see PDR: mode 5) publishing "[…] first scholarly insights […]" (Nunamaker et al. 2015) regarding the class of problems and a review of related theoretical constructs that might contribute to designing a solution, as well as insights gained through reciprocal shaping.

PDR Stage 2: Theory Emergence

The second stage, *theory emergence*, connects the second maturity level of artifacts as defined by Gregor and Hevner (2013) with the *proof-of-value* stage described by Nunamaker et al. (2015). Together, the level of maturity and the proof of value are used to define the type of outcome and targets towards achieving that outcome.

The target outcome of *stage 2: theory emergence* is defined by Gregor and Hevner's (2013) maturity logic; specifically, the target outcome is a *nascent design theory* that is further described as "Constructs, methods, models, design principles, [and] technological rules" (ibid.). The sub-targets towards achieving the target outcome are defined with reference to the requirements identified in Nunamaker et al.'s (2015) *proof-of-value* stage. More specifically, the sub-targets towards creating a nascent design theory are the deepening of "[…] scientific understandings of the phenomena discovered during proof-of-concept research, and to discover and describe new phenomena pertinent to the problem and its potential solutions […]" (Nunamaker et al. 2015), measurements of "[…] the degree to which a generalizable solution meets its design goals for improving key outcomes […]" (ibid.), the improvement of "[…] the functional quality of the solution, the discovery and description of […] unintended consequences of a solution […]" (ibid.), the development and documentation "[…] of the processes by which, and the conditions under which, a solution can be used to create value […]" (ibid.), and a better understanding […] of the technical, economic, and operational feasibility factors that might affect successful deployment of such a solution in the workplace […]" (ibid.).

Achieving the targets identified by Nunamaker et al. (2015) can be facilitated by focusing on the PDR modes *progressive artifact design* and *inter-organizational transfers*. *Progressive artifact design* combines the ADR and DSRM artifact design, demonstration, and evaluation approaches for the design of an artifact by leveraging different perspectives.

New phenomena pertinent to the problem (see Nunamaker et al. 2015) can be discovered through further build-intervene-evaluate cycles (see PDR mode: intra-organizational shaping). The build-intervene-evaluate cycles facilitate uncovering further in-depth knowledge in a single organizational setting. First transfers of the artifact to different organizational settings (see PDR mode: inter-organizational transfers) facilitate demonstrations of the artifact with a different target audience. Together, both intra- and inter-organizational modes shed light on artifact development from an in-depth and a generalizing perspective.

Improving the "[…] functional quality of the solution, the discovery and description of […] unintended consequences of a solution […]" (Nunamaker et al. 2015) can be achieved through reflecting on activities within PDR's progressive artifact design mode. The ongoing reflection on the development of the artifact regarding change moments (see Sein et al. 2011), that is, important decisions have been made to address unpredicted problems, can uncover initially unintended consequences of implementing a solution (see Nunamaker et al. 2015). Therefore, PDR can support identifying and describing the unintended consequences of implementing a solution.

The functional quality (see Nunamaker et al. 2015) can be evaluated using both the ADR and DSRM approaches. ADR facilitates a formative evaluation with a focus on the process of applying and using an artifact, while DSRM suggests relying on evaluation activities with summative character. Therefore, the integration of both approaches in PDR can provide insights into the functional quality of the artifact in use; in addition, they can provide insights from more distant and reflective perspective, for instance, by discussing different aspects or meta-aspects of an artifact during expert interviews.

The development and documentation "[…] of the processes by which, and the conditions under which, a solution can be used to create value […]" (Nunamaker et al. 2015) can again be supported and facilitated by following both the recommendations of Sein et al. (2011) and Peffers et al. (2007). Specifically, the in-depth knowledge obtained during build-intervene-evaluate cycles enables researchers to gain rich knowledge concerning the conditions (see Nunamaker et al. 2015) under which a solution may or may not work. With time and reflection, this knowledge can be used to identify the relevant conditions. The development and documentation of processes (see Nunamaker et al. 2015) are a pivotal step in the DSRM activity *demonstration*, as this step emphasizes the development of "[…] effective knowledge of how to use the artifact to solve the problem" (Peffers et al. 2007). Measurements of "[…] the degree to which a generalizable solution meets its design goals for improving key out-comes […]" (Nunamaker et al. 2015) are addressed by the DSRM activity *evaluation*; *evaluation* prescribes the acquisition of "[…] knowledge on relevant metrics and analysis techniques […]" (Peffers et al. 2007) and therefore can effectively inform achieving the target as described by Nunamaker et al. (2015).

The PDR mode *communication of outcomes* can benefit from the outcomes that are identified in the PDR stage *theory emergence* by the creation and publication of first generalized outcomes and all activities and results related to any kind of demonstration and formative or summative evaluation.

PDR Stage 3: Transfer of a Class of Solutions

The third stage, *transfer of a class of solutions,* connects the third maturity level of artifacts as defined by Gregor and Hevner (2013) with the *proof-of-use* stage described by Nunamaker et al. (2015). Together, the third maturity level and the proof of use define the type of outcome and targets towards achieving the outcome.

The target outcome of *stage 3: transfer of a class of solutions* is defined in Gregor and Hevner's (2013) maturity logic; specifically, the target outcome is a *mid-range theory* (see also **Chapter 3.1.1**). The sub-targets towards achieving the target outcome are defined by the requirements identified in Nunamaker et al.'s (2015) *proof-of-use* stage. More specifically, the sub-targets towards creating a mid-range theory are the determination of "[…] whether it is possible to create self-sustaining and growing communities of practice around a new […] solution […]" (Nunamaker et al. 2015), the codification of "[…] a design theory encapsulating the knowledge practitioners require to develop successfully their own instances of generalizable solution […]" (ibid.), and the continuous deepening of "[…] scholarly understandings of the problem and solution spaces" (ibid.).

Achieving the targets identified by Nunamaker et al. (2015) can be facilitated by focusing on the PDR modes *inter-organizational transfers* and *communication of outcomes*. *Inter-organizational transfers* prescribe the transfer of an artifact to organizational contexts outside of the initial context, which has been subject to a reciprocal shaping with the artifact. The *communication of outcomes* prescribes the publication of insights and outcomes via practitioner and scholarly relevant outlets.

The result of the determination of "[…] whether it is possible to create self-sustaining and growing communities of practice around a new […] solution […]" (Nunamaker et al. 2015) can be positively influenced by the PDR mode *inter-organizational transfer* and, by that, by the DSRM activity *demonstration* (see Peffers et al. 2007), as *demonstration* prescribes the creation and provision of "[…] effective knowledge of how to use the artifact to solve the problem […]" (ibid.). The provision of this knowledge will facilitate others to utilize an artifact, therefore, can be considered to be an important step in creating a self-sustaining and growing community of practice. The DSRM activity *communication* can further enable the establishment of a self-sustaining community of practices, as making practitioners and scholars aware of the artifact and its value can encourage early adoption. The codification of "[…] a design theory encapsulating the knowledge practitioners require to develop successfully their own instances of generalizable solution […]" (ibid.) can be supported in a similar way. As shown above, conducting a *demonstration* can lead to the creation of knowledge on how to use an artifact.

The continuous deepening of "[…] scholarly understandings of the problem and solution spaces […]" (ibid.) can be supported by all PDR modes, as each mode facilitates obtaining knowledge concerning either one or both. Towards the completion of the overall research process, changing perspectives by making a change in the evaluation audience, as prescribed by *inter-organizational transfers*, can bring about both a deepening of understanding of the problem and solution space. Furthermore, writing about both the problem and the solution space as described in *communication of outcomes* can facilitate reflection; therefore, it is also possible that the process of writing itself can contribute to deepening knowledge of both the problem and solution space.

3.3. Demonstrating PDR: The Research Design of this Thesis

This chapter demonstrates the application of the PDR process using the example of my research design. PDR consists of five modes. The five PDR modes (see also **Chapter 3.2.1.2**) are as follows:

1) *Problem definition*,
2) *Intra-organizational shaping*,
3) *Progressive artifact design*,
4) *Inter-organizational shaping*, and
5) *Communication of outcomes.*

This chapter is structured on the basis of these five modes. I begin my demonstration with PDR mode 1, that is, *problem definition*. **Chapter 1** describes the underlying research problem that this thesis solves. The presentation of the problem definition is briefly described in this section, as it is already described in more detail in other sections of this thesis, such as, the introduction.

After a brief reiteration of the problem definition, I provide an overview of the core process behind PDR, that is, *progressive artifact design*, in **Chapter 3.3.2**. *Progressive artifact design* connects the intra- and inter-organizational activities of PDR by providing a stream of artifacts. The stream of artifacts reflects the evolution of a research's solution approach and is the result of exposing various artifact versions to intra- and inter-organizational research activities.

I demonstrate *intra-organizational shaping* by presenting my research in **Chapter 3.3.3**. The research activities underlying an *inter-organizational transfer* are similar to the activities associated with a summative evaluation. Summative evaluation activities are commonly presented after the introduction of the core result, that is, the final artifact (see **Chapter 4**). Therefore, I demonstrate the PDR mode *inter-organizational transfer* in **Chapter 5.2**.

I close my demonstration of the PDR modes by presenting mode 5 of PDR, that is, the *communication of outcomes*, in **Chapter 6**; while this thesis as a whole serves the purpose of communication, **Chapter 6** summarizes the outcomes.

3.3.1. Problem Definition: The Challenge of Designing Digital Innovation Units

The role of the traditional IT function in established enterprises has changed (Urbach et al. 2017). In the past, business-IT collaboration was based on large-scale projects with long run times. However, increasing pressure from consumers of digital products and services has challenged the existing model. The increasingly dynamic environment and greater expectations with regard to a company's digital services on the part of customers have led to a demand of new ways of working. These NWoW tend to focus on small and agile projects (Böhmann et al. 2015, Rieß et al. 2016, Drews et al. 2017).

Small and agile projects demand organizational flexibility. Conducting these projects within the existing model, in which business and IT are separate, led to increased bureaucratic efforts and creates inflexible organizations (see Urbach et al. 2017). Thus, the existing business and IT model becomes an obstacle when attempting to strengthen a firm's digital capabilities. A business IT-collaboration on new levels is required (see Drews et al. 2017, Duerr et al. 2018). Established enterprises transform their organizational structures to overcome this hurdle; these transformations take place in DIUs.

DIUs consolidate efforts in novel interdisciplinary organizational structures that are tasked with the exploration, development, and operation of digital services to achieve higher levels of customer engagement. DIUs face a dual challenge, namely the internal interdisciplinary alignment of two subsystems (e.g., marketing and IT) into a single unit (Hearn 2016; see also Westerman 2014) and achieving closer integration with the customer at the boundaries of the company (Horlach et al. 2016, Drews et al. 2017). DIUs have become an established measure for driving a company's digital transformation (see Simon 2014, Westerman et al. 2014, Galbraith 2014, Amberti 2015, Hearn 2016, Hess et al. 2016, Kaufmann and Horton 2015, Chanias and Hess 2016, Rieß et al. 2016, Drews et al. 2017, Swaminathan and Meffert 2017, vom Brocke et al. 2017, Åkesson et al. 2018, Duerr et al. 2018, Gimpel et al. 2018, Harpham 2018, Miyazaki and Sato 2018, Osmundsen et al. 2018, Ross et al. 2018, Fortmann et al. 2019, Weingarth et al. 2019).

DIUs are widely considered to be an effective strategy (Ismail et al. 2017). However, available knowledge concerning the specifics of building DIUs is scarce. The concept has not been deeply explored in either theory or practice. A defined theoretical structure for creating DIUs, as is common for implementing methods or frameworks (e.g., Scrum, ITIL, and COBIT), is lacking. The lack of written knowledge on designing DIUs transforms a generally challenging endeavor into an ambitious goal.

We reached an agreement with a large globally active corporation called InCorp to conduct a longitudinal study. We participated in the development of the corporation's DIU over the course of three years and were provided with opportunities to intervene. We identified promising transformational approaches, and we were also able to observe the balancing act between the autonomy of the DIU and the gravitational pull of established structures.

In addition, we reached an agreement with InCorp that allowed us to adopt a dual design approach by engaging in bi-directional knowledge exchanges with other practitioners who shared an interest in solving the same class of problem. Based on both theories and intra- and inter-organizational empirical insights, we developed a model titled the *New Way of Designing Digital Innovation Units* (N2DIU).

3.3.2. Progressive Artifact Design: The Genesis of the N2DIU Model

The N2DIU model is the result of a progressive artifact design in the form of an interplay between ADR and DSRM research activities. The interplay of ADR and DSRM research activities shapes an artifact from both the intra- and an inter-organizational perspective. The different perspectives inform a solution design by providing in-depth insights into a socio-political problem context and ensure an artifact's general validity. Overall, the N2DIU is end product of six major revisions.[8]

In the following, I present an overview of the genesis of the N2DIU model. The early versions of the N2DIU enabled us to initiate an *intra-organizational shaping* process (see also **Chapter 3.3.3**) between the evolving artifact and the focal organizational setting. We were thus able to develop both the artifact and the organizational setting. The early versions of the artifact enabled us to effectively communicate change initiatives within the focal organizational setting. However, the artifact versions that resulted from early intra-organizational shaping activities were merely generalized but specific solution approaches that were only suitable for solving specific problems.

I opted to transfer and expose the artifact to experts from other organizational contexts to improve the external validity of the artifact. These *inter-organizational transfers* (see also **Chapter 5.2**) required us to create generalized artifact versions. **Figure 16** provides an overview of the process of designing the artifact. The sub-headings a1 to a6 present the artifact's progression (see **ibid.**)

[8] The six major artifact versions were the result of 68 minor artifact revisions. Each revision was the result of application and/or evaluation research activities.

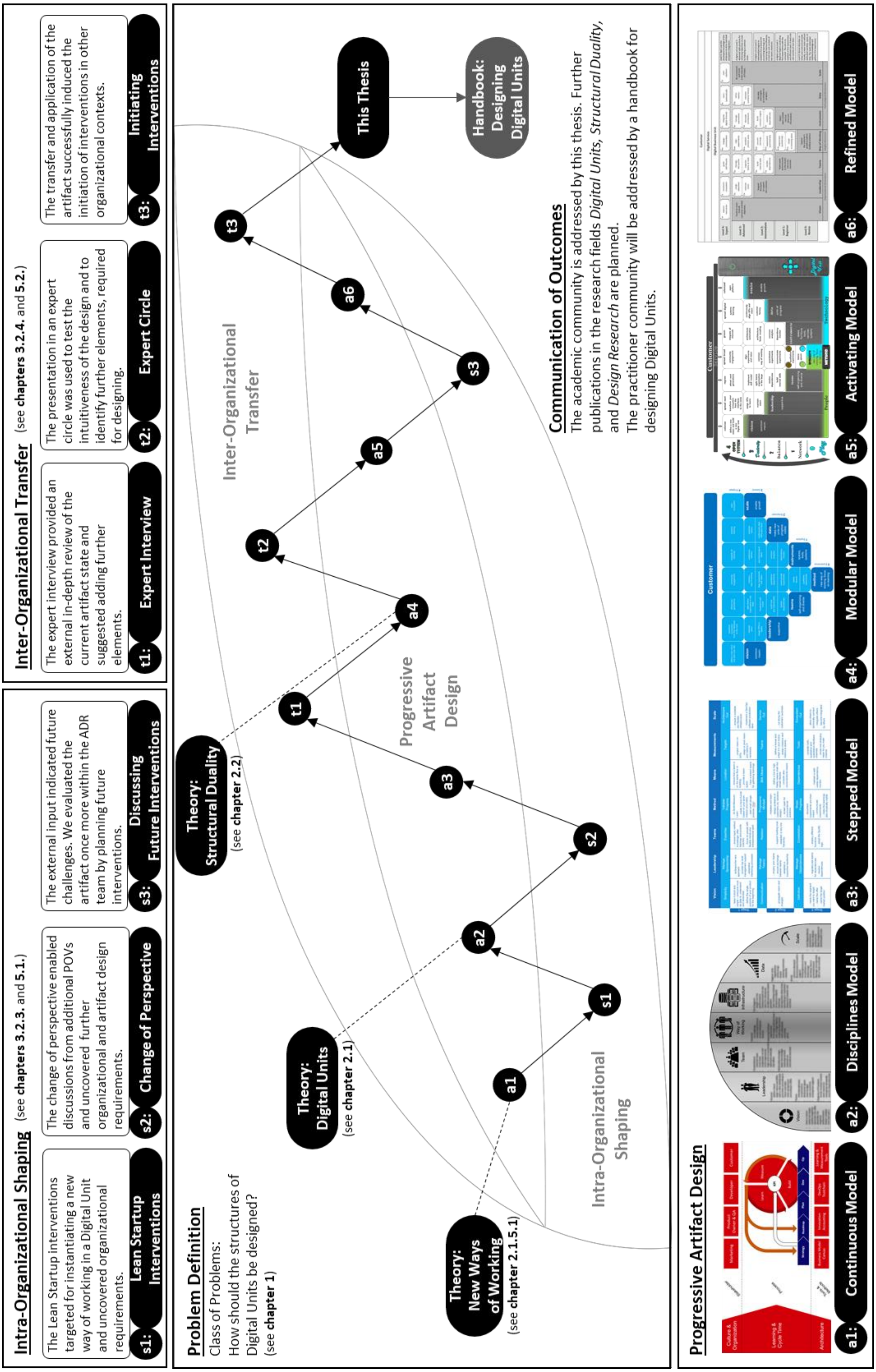

Figure 16. The PDR research design of this thesis (own depiction).

a1: The Continuous Model

DIUs are an organizational construct for establishing NWoW. We based our the design of our first preliminary artifact on interviews and analyzing information archives. The result was *the continuous model* (see **Figure 17**). The interviews and the information archive analysis were conducted with the goal of learning more about the organizational and technological context of InCorp's DIU.

The continuous model showed how NWoW (see *build-measure-learn* in **Figure 17**) iteratively inform existing decision-making processes (see the blue chevrons in **Figure 17**). The preliminary design further considered relevant stakeholders within the corporation and at its boundaries (see *culture & organization* in **Figure 17**) as well as further approaches that we identified as suitable for establishing NWoW on a larger scale (see *architecture* in **Figure 17**).

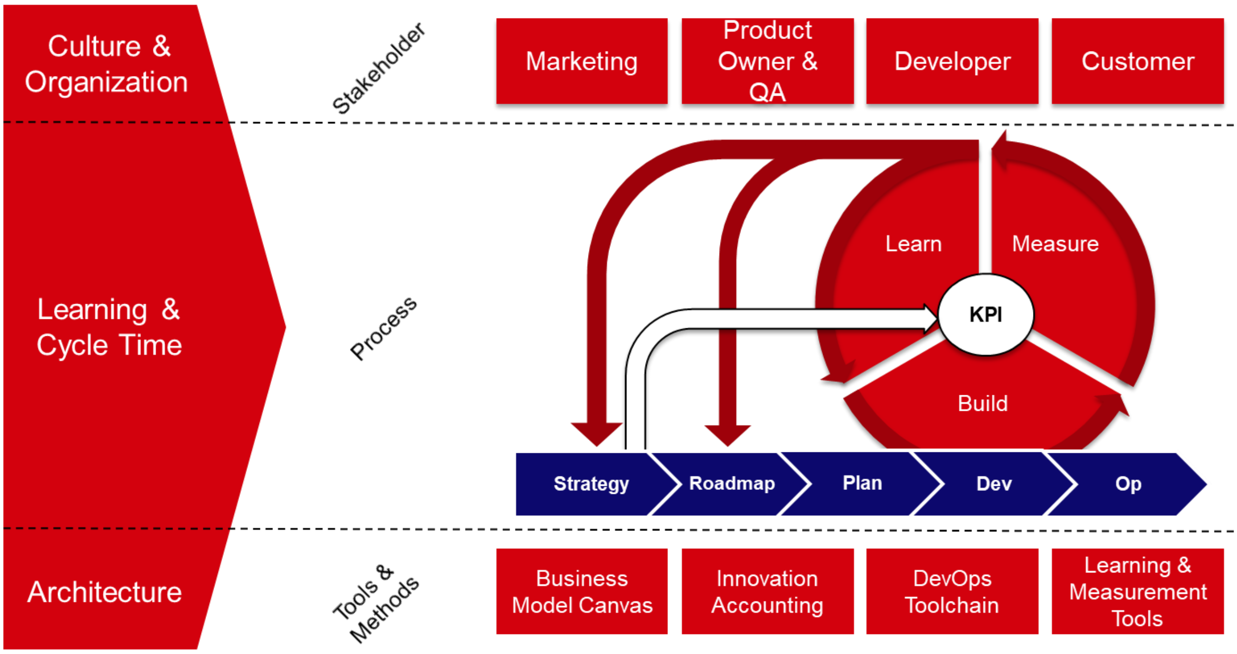

Figure 17. The continuous model (own depiction).

For instance, we argued that the implementation of a DevOps toolchain could allow developers to spend less time on code management issues. The innovation accounting approach could enable product owners to consider customer insights in decision-making and daily communication.

The continuous model facilitated the communication and discussion of research and intervention objectives within the research team. The team consisted of sponsorship of InCorp's DIU, the IT leader of said unit, three senior researchers, and a research associate. The research team agreed with the planned intervention, which indicated that the preliminary artifact design was appropriate for communicating the objectives of the planned intervention. **Chapter 3.3.3** provides more details concerning this research stage.

a2: The Disciplines Model

The continuous model paved the way for driving interventions in InCorp's DIU. Specifically, the research team agreed to implement lean startup's BML approach as a first step towards establishing an NWoW (see **above: a1**).

We formed an interdisciplinary team by regrouping existing employees with the necessary skills. We provided method training and executed several BML iterations together with the team. Executing the iterations provided us with valuable insights. NWoW are driven by bottom-up decision-making to enable quick and autonomous decisions that are closely aligned with customer and user's interests. Our BML iterations highlighted where autonomous bottom-up decision-making could conflict with top-down decision-making.

For instance, the outcomes of annual and quarterly meetings, which are attended by internal stakeholders, were used to determine roadmap items. In contrast, NWoW rely on direct customer and user insights; these insights are used to determine the next development items. A shift in power was required emphasize bottom-up decision-making. We opted to investigate further potential impediments that become visible by contrasting new with traditional ways of working.

NWoW are fundamentally different to traditional ways of working. We identified several points of contrast and decided that we had to reiterate our problem understanding. Instead of asking *how can we implement an NWoW,* the question became *what requirements must a DIU fulfill to successfully establish an NWoW*?

We extended the literature pool to address our new problem understanding. We elaborated on the state of the art with regard to developing DIUs by reviewing related practitioner and academic literature (see **Chapter 2.1**). Elaborating on state of the art sensitized us to further points that could be used to contrast new with traditional ways of working.

We ended our lean startup interventions with a summative evaluation from the perspective of the team (see **Chapter 5.1**). I then summarized the insights we obtained from implementing the interventions, the state of the art with regard to developing DIUs, and the findings of our summative evaluation. The summarized insights were taken into consideration while designing the next version of the artifact.

The new artifact, *a2: the disciplines model*, was designed to support the leaders and sponsorship of the DIU in communicating and driving change with the goal of creating and maintaining a platform for interdisciplinary teams that operate an NWoW. We structured the model into seven disciplines to facilitate the communication of change initiatives (see **Figure 18**). *The disciplines model* identified specific contrasting points within the prevailing organizational and technological structures of InCorp's DIU. We then identified practices that can be established to support NWoW.

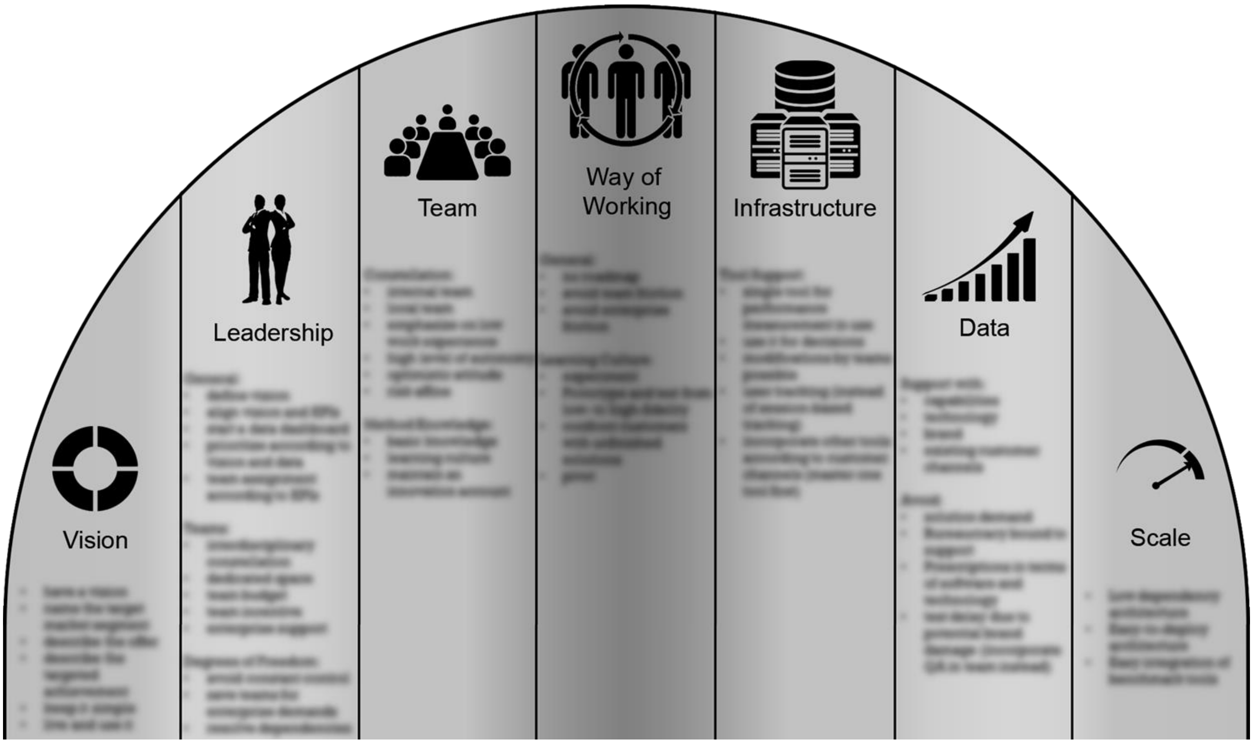

Figure 18. The disciplines model[9] (own depiction).

The disciplines model was a proof of concept; I aimed to identify a suitable means of communicating required changes within DIUs. I used *the disciplines model* to present my summarized insights and defined practices for supporting an NWoW to the sponsors and the IT leader of the DIU. We were subsequently able to observe fundamental changes within the DIU throughout the following months. *The disciplines model* provided sufficient functionality to solve the first real problem, indicating that it was not only a proof of concept but also a first proof of value.

[9] The specific propositions of the model are blurred when presented in this thesis, as they show sensitive information.

Chapter 3.3.3, specifically **s1: Instantiating a New Way of Working in InCorp's Digital Innovation Unit**, provides more details on driving lean startup interventions and the genesis of *the disciplines model*.

a3: The Stepped Model

We were able to demonstrate the value of *the disciplines model* (see **above: a2**). We designed *the disciplines model* as a specific solution approach for proposing and communicating change initiatives to high-level stakeholders in order to reshape InCorp's DIU and establish NWoW. We communicated to the sponsor- and leadership of InCorp's DIU and supported the value of the proposed change initiatives by our empirical and literary insights. However, the artifact's degree of generalization was not sufficient to address the development of DIUs as a class of problems. Hence, we opted to expose the following artifact versions to different organizational contexts. Changing the organizational context required us to design artifact versions that were not specific solution approaches for one context but could be applied to many.

Two executives in different areas in the same company sought to utilize NWoW; we contacted them both. We reached an agreement with each executive to transfer the development of our artifact to their respective organizational contexts; that is, we assessed each organizational context with the help of the artifact. The transfer of our artifact development to two similar but different contexts provided us an easy entry into and a shallow slope towards generalization.

We created interview guides based on *the disciplines model*. The semi-structured interview guides were abstracted from information that was specific to the artifact's original organizational context. We conducted semi-structured interviews with each executive, during which we identified impediments to the establishment of NWoW and developed propositions for change initiatives.

Reflecting on the two internal transfers led us to elaborate on the current model's structure. *The disciplines model* presented various practices for driving change initiatives but did not define an order in which these practices should be implemented. Interviewing the executives revealed that some practices should be implemented before others due to their scope and level of aspiration; this became apparent when the answers to some interview guide items also indicated implications for other items. We decided to develop a new artifact version to incorporate these new insights.

Based on my new insights, we developed a new version of the artifact. We decided to arrange the interview guide items in ranked order to support both an efficient assessment and the constructive development of a DIU. The result was *the stepped model* (see **Figure 19**).

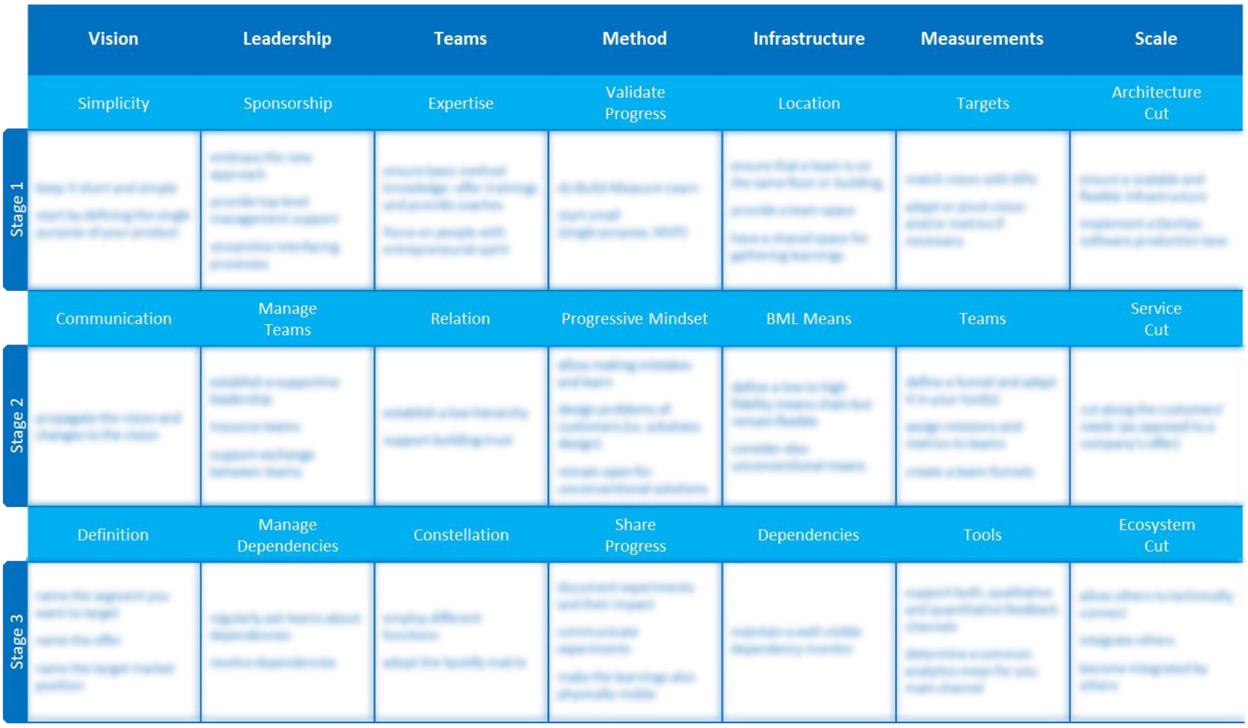

Figure 19. The stepped model[10] (own depiction).

The stepped model employed the concept of stages to structure the practices of *the disciplines model*; however, it still employs the concept of disciplines. *The stepped model* further abstracts from organization-specific information that were part of *the disciplines model*. Even though the new model was more abstract than the disciplines model, the individual items within the model still reflect various points identified during our research in the DIU. Therefore, the specific practices of *the stepped model* are blurred. A more detailed description of the internal transfers involving the two executives that guided our design decisions is provided in **Chapter 3.3.3,** under subheading **s2: Internal Transfers**.

We prepared the first external transfer based on *the stepped model*; that is, we prepared the first evaluation with an expert who was external to InCorp. We arranged a 60-minute interview with an expert from a large and globally active enterprise. The expert held the role of Head of IT in the German subsidiary of a globally active corporation in the finance sector. At the time of the interview, the company had successfully developed and operated a DIU. At the time of writing, the company plans to employ the same structures as utilized in its DIU throughout the whole organization.

[10] The specific propositions of the model are blurred when presented in this thesis, as they show sensitive information.

We initiated the interview with an introduction to *the stepped model*. We presented its purpose, architecture, disciplines, and practices. The expert quickly grasped the purpose of the model. We then went into the details of the model. The expert compared the propositions of *the stepped model* against her own experience of developing a DIU. The expert's experience ranged from an initial attempt to build a DIU over 10 years ago to the operation of a scaled DIU at the time of writing.

We recorded and transcribed the interview, which was rich in insights. The expert reflected on her journey of developing a DIU and informed us about what she would have done differently. We used these insights to redesign the model by changing the rank order of practices and adding new practices. **Chapter 5.2.1** provides more details on the expert interview.

a4: The Modular Model

The stepped model (see **above: a3**) improved on *the disciplines model* (see **above: a2**) in several ways: It abstracted from a specific organizational context, added new practices, and suggested a ranked order of practices. Still, reflecting on the prior artifact versions uncovered further requirements, which we considered in developing further artifact designs.

We iterated multiple times on the rank order and determined that the design and layout of *the stepped model* were unsuitable for reflecting our insights; we felt that the process of assessing and developing a DIU should consider implementing certain practices before others. Moreover, we also felt that a new design should consider addressing certain disciplines before others. We decided that the graphical representation of disciplines should not be even.

Our observations concerning the development of a DIU and the expert interview (see **above: a3**) both suggested that developing DIUs is a complex and lengthy endeavor that should be planned, communicated, and executed through manageable change initiatives. We decided that we should further focus on modularizing the model for improving the manageability of changes.

Reflecting on our prior designs revealed that we had purposefully arranged organizational and technological disciplines. We had arranged both in a mirroring way to support each other; for instance, *teams* collaborate on the basis of a loosely coupled *infrastructure* (see **above: a2** or **a3**), as such an infrastructure reduces organizational dependencies between teams and thus supports a high autonomy of teams and quick decision-making. We decided that we should further elaborate on the supportive relationships between organizational and technological structures on a more detailed level.

We extended our literature pool to address the abovementioned requirements. Specifically, we drew on a field of research that addresses the topics of socio-technical congruence and modularity in both software development processes and collaboration across organizational boundaries (see **Chapter 2.2**). The extension of the literature pool provided valuable insights that proved helpful in further dividing practices into manageable sizes and for understanding the relationship between organizational and technological practices.

We designed *the modular model* (see **Figure 20**) based on these new insights. *The modular model* structures the stages of *the stepped model* (see **above: a3**) into more fine granular practices. It furthermore aligned each practice with its organizational or technological counterpart to reap the benefits of socio-technical congruence (see **Chapter 2.2**).

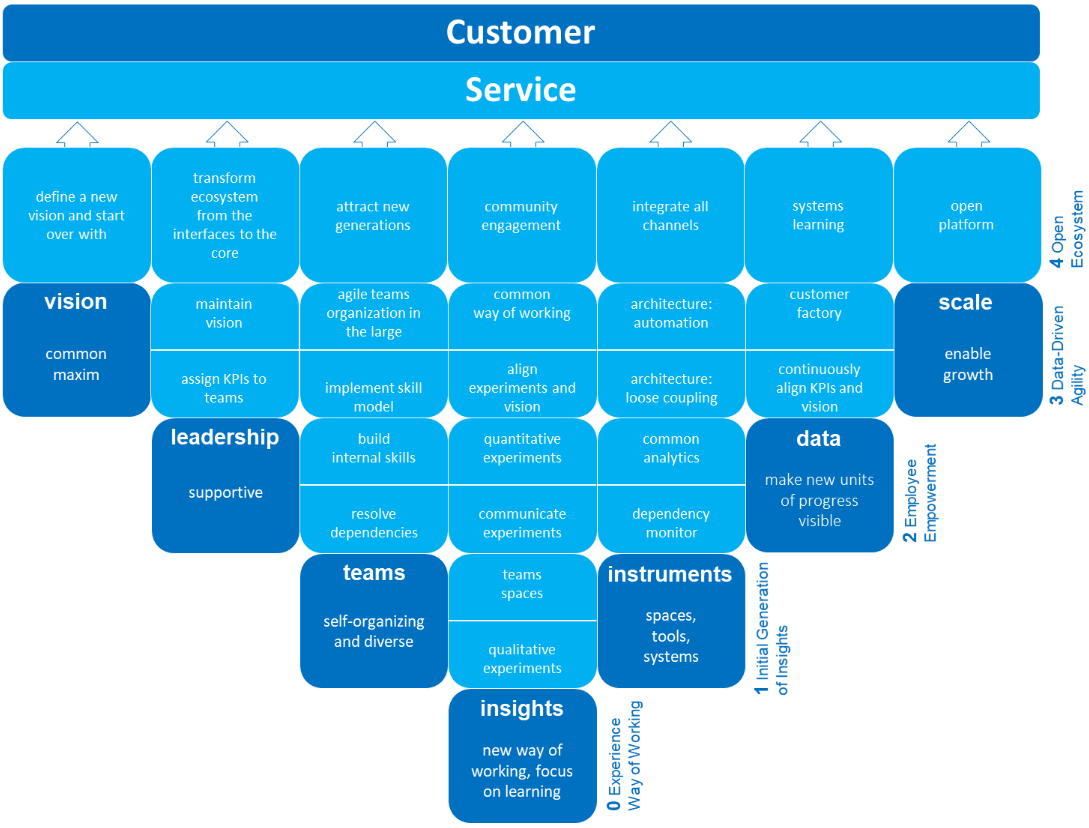

Figure 20. The modular model (own depiction).

We evaluated the modular model in collaboration with an expert circle consisting of six C-Level executives from different organizations. Presenting the artifact to six C-level executives in under 30 minutes required us to fine hone our descriptions of the purpose, structure, and content of the artifact. Everyone reported being able to easily follow the presentation of the artifact.

In general, we received positive feedback. The multi-faceted feedback provided by the members of the circle focused less on fundamental changes to the structure or content of the model and more on how to design and labeling could be further improved. This feedback indicated that the model design had reached a certain degree of maturity as the purpose was clear to the audience, the audience did not propose structural changes, and it was easy to understand in general. Furthermore, the executives from consultancy firms started to discuss licensing the model for their own purposes, which we interpreted as a further proof of value. **Chapter 5.2.2** provides more details concerning the expert circle.

a5: The Activating Model

The expert circle provided rich feedback on *the modular model* (see **above: a4**). The experts considered the purpose, architecture, and practices as being sound. The feedback indicated that we should focus on detailing specific elements of the model, for instance, by providing more details concerning the descriptions of disciplines and practices within the model and by providing detailed documentation.

In the next major iteration, we focused on describing the model in detail and creating documentation. In addition, we overhauled the artifact's visual representation to test a more engaging design. The result was *the activating model* (see **Figure 21**).

Creating a complete documentation was time intensive. We opted to once again transfer the artifact in the interim to evaluate the current design and receive further feedback. We revisited the initial starting point of our research journey, that is, InCorp's DIU. Both the unit and the artifact clearly developed. We were able to observe that the communicated propositions were considered by the sponsor- and leadership of InCorp's DIU (see **above: a2**). Our artifact evolved in terms of its form and its function as it was extended by identifying further relevant practices, structuring practices for a stepped and robust change, and presenting matched pairs of organizational and technological practices for establishing socio-technical congruence. Thus, we had to evaluate the new artifact version within the initial organizational context (see **a1** and **a2**) to test whether the generalized and extended version still provided value when re-applied in its initial organizational context.

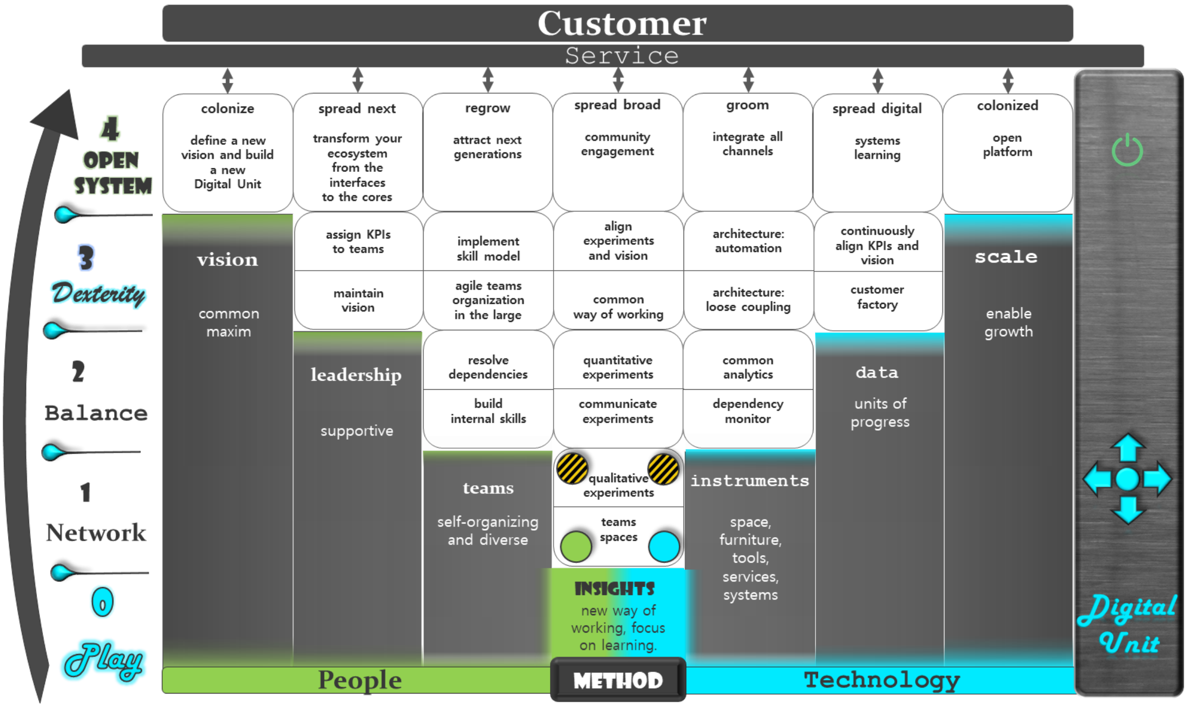

Figure 21. The activating model (own depiction).

We conducted an expert interview with the head of InCorp's DIU. Together, we were able to identify directions for further developing the DIU. The head of the DIU perceived the new structure and content of the artifact positively. The colorful design did not seem to add any value, however. The head of the DIU also asked for documentation to support autonomous use of the model. **Chapter 3.3.3** provides more detailed information.

a6: The Refined Model

We drew on the feedback we received concerning *the activating model* (see **above: a5**) and continued working on the artifact's documentation. We improved the visual clarity of the model and re-arranged practices once again to further improve the alignment of practices within the model. Furthermore, we added shortcuts to better address the model's practices within the documentation. The result was *the refined model* (see Figure 22**).**

We created documentation to prepare for a transfer to a community of practice. The documentation (see **Chapter 4**) provides background knowledge on the model's purpose, foundational structure, disciplines, levels, practices, and relations among practices. Finally, we evaluated the artifact again with experts from two further globally active companies who were also involved in the development of DIUs.

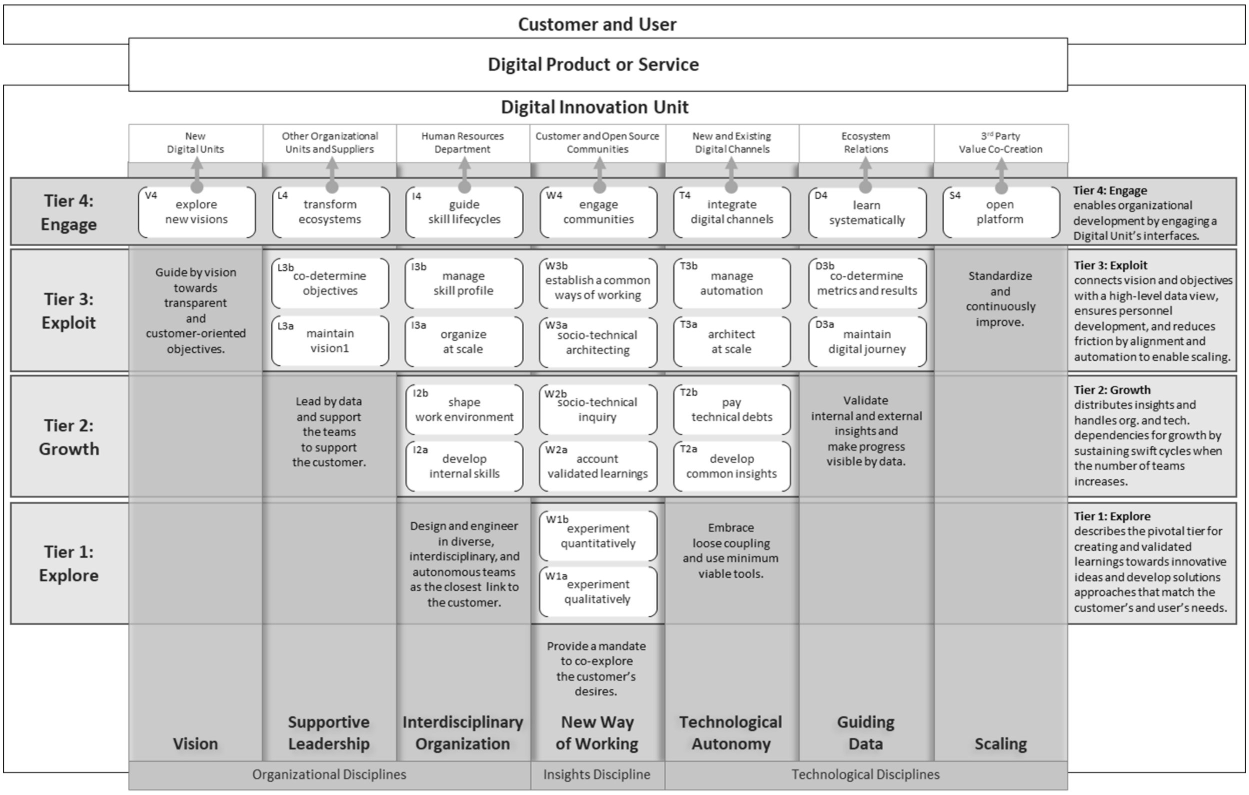

Figure 22. The refined model (own depiction).

3.3.3. Intra-Organizational Shaping

In this chapter, I present the activities behind the intra-organizational shaping in more detail. Specifically, I provide more insights concerning activities s1–s3, as introduced in **Chapter 3.3.2**.

Establishing a long-term research agreement with a company is a critical element in ADR (see Sein et al. 2011). As the development of DIUs can be lengthy, we opted for a longitudinal study and secured a three-year agreement with InCorp. Together, we drove interventions to shape the ensemble artifact, namely InCorp's DIU. The longitudinal study provided us with in-depth insights and enabled us to create prototypes of an artifact intended to guide the design and development of a DIU.

I divide the presentation of our intra-organizational research within InCorp into three segments and an introduction to the status quo. Subsequently, I present our intra-organizational research journey, based on the core activities s1-s3.

Beginning with the first core activity (**s1**), I describe how we instantiated a preliminary artifact over the course of four interventions and how the insights obtained were used to further shape both the material and the abstract artifacts. The second core activity (**s2**) describes how we extended our investigated context from InCorp's DIU by the company's IT function; two executives shared a core goal with regard to the design and development of DIUs, that is, the instantiation of an NWoW. The last activity in the intra-organizational context (**s3**) describes how we re-applied the latest versions of the artifact to the context in which it originated, that is, InCorp's DIU. We extended the scope of the early artifact versions beyond the initial insights we gained from the research conducted in the DIU; thus, we had to test whether the generalized artifact would provide value when re-applied to its original context.

3.3.3.1. The Status Quo of InCorp's Digital Innovation Unit

In 2013, InCorp decided to consolidate efforts behind developing its digital capabilities. Specifically, the B2C website of one of InCorp's core brands was identified as suitable a starting point for initiating a continuous exploration of new business opportunities.

In the same year, InCorp founded a DIU for driving this endeavor; together, the marketing and IT departments bridged their knowledge across functions to create a unified and interdisciplinary organizational unit. InCorp had chosen to pick up on entrepreneurial spirit and initiated the development of the DIU by starting it within a container on a parking lot.

The ultimate target behind developing a DIU has been the development of new and innovative digital services to improve marketing efficiency, brand equity, and sales. A centralization of digital efforts and improved customer- and user engagement by providing new and innovative digital services were identified as driving the organization towards these targets.

Over the years, the unit has grown and moved to larger facilities. The container vanished for a modern and open workspace with amenities for its co-workers. The DIU is provided with high degrees of freedom regarding the design and adoption of own organizational structures. However, there are also dependencies to existing functions and stakeholders within the enterprise.

InCorp's DIU matches core properties that define a DIU. The DIU is decoupled from existing functions to certain degrees, the unit adopts the concept of interdisciplinary collaboration, and it strives for developing an innovative digital service to achieve an improved customer and user engagement. Thus, InCorp's DIU provided us with a suitable empirical context to conduct our research.

We initiated our research journey in InCorp's DIU. The DIU develops and operates the B2C content and eCommerce platform behind one of the core brands of this globally active corporation.

Together with practitioners, we assembled a research team. From the organization's side, the team consisted of the sponsorship and IT lead. Three senior researchers and one research associate comprised the scientific side of the team. Together, we defined the first targets in terms of shaping the way of working within the DIU.

We agreed on the broad target of developing new models and methods for incorporating knowledge about the consumer into the development processes of InCorp's DIU. These models and methods describe new ways of collecting, combining, exploring, and analyzing data from different sources for improving decision-making processes and enable InCorp's DIU to test and evaluate new and innovative ideas with low effort. We initiated our research and conducted a thorough inquiry in InCorp's DIU with the goals of improving the specification of the research problem and identifying theories that that might be suitable to inform initial solution concepts.

Initial Inquiry and Results

Our initial investigations in the DIU involved expert interviews and an information archive analysis. The goal was to gather information on the target of the organizational unit, the core processes, how teams worked at the time, and the technological infrastructure. We held interviews with the product owner of the overall platform, a CRM expert, an analytics expert, a concept and UX expert, and the IT supervisor. The information archive analysis encompassed documentation concerning various topics, such as the overall target of the organizational unit, the focal decision-making process within the unit (i.e., the roadmap process), the roadmap itself, concepts for features to be released in the future, an organigram, development and deployment processes, and the technological architecture.

In total, we reviewed 450+ pages of documentation and conducted seven interviews for the initial inquiry. The initial inquiry provided substantial insights. The platform development was steered by a roadmap process. The roadmap was threefold and integrated plans for basic system development, roll-outs of new platform versions in the company's globally distributed subsidiaries, and feature development. The process of determining roadmap items was based on roadmap navigation meetings, which were held quarterly. The meetings involved up to 30 persons and included leaders from InCorp's DIU, key stakeholders from marketing and IT, the product owner of the central platform, and representatives of various countries.

The process of defining roadmap items was initiated in scope workshops. Scope workshops were used to determine requirements, specify stories, and kick off development. These workshops were held by the product owner of the platform, functional leads (e.g., the heads of UX, eBrand, eCRM, and eCommerce), the IT supervisor, the integration architect, and representatives of countries on demand.

The process of developing roadmap items was based on a development process that could be described as *ScrumBut* or *Water-Scrum-Fall*. On paper, this *Water-Scrum-Fall* process was based on consecutive iterations of six weeks each. Each iteration consisted of two weeks preparation, that is, the design of the concept and UX, two weeks of software development, one week of functional and integration testing, and one week of UAT, that is, user acceptance testing. In reality, the single phases occasionally took longer than planned may take longer than planned, effectively resulting in a six-week deployment process that published what was ready to ship at that time.

The underlying technological architecture can be described as brownfield. As opposed to a greenfield approach, the DIU chose to build on existing systems to reduce the time required to become effective. The architecture is heterogeneous and integrates several external solutions that have been customized to the needs of InCorp's DIU. Among others, InCorp's DIU builds on a customer data and marketing platform and on Sitecore and Demandware to draw on content management and eCommerce functionality. Additionally, there were dependencies on systems outside of the DIU; certain systems and modules acted as an interface to production and product communication, for instance, SAP, PIM and MAM.

The organizational structures of InCorp's DIU mirrored the unit's technological architecture. Various service providers were involved and responsible for customizing and operating certain systems or stages within the development process. For example, service provider A was the main party responsible for concept and UX, and service provider B was the main party responsible for software development. This, again, was a natural choice in light of the goal of making InCorp's DIU immediately effective. As we identified in our literature review, such a sourcing approach is adopted for enabling the quick scaling of a DIU (see **Chapter 2.1**).

Interventions: Target Agreement

Based on these insights and the intermediate results of our literature review on DIUs, the research team conducted a workshop and opted for an instantiation of *lean startup* (see Ries 2011) and its BML approach to emphasize a consumer-oriented way of working that involves the consumer as a valuable source of innovation.

Lean startup provides a core method and a plethora of inspirational approaches, but only few insights are provided concerning the architectural requirements of this method. Thus, we added other concepts (see **Figure 23**) that we considered as having the potential to support NWoW. For instance, DevOps might focus less on the end user of a digital product or service but emphasizes requirements of the toolchain to facilitate quick and efficient deployments, which can improve and reduce cycle time, which is in turn in line with BML, as, in executing BML, speed prevails over perfection. With this plan, we initiated our interventions in **s1**.

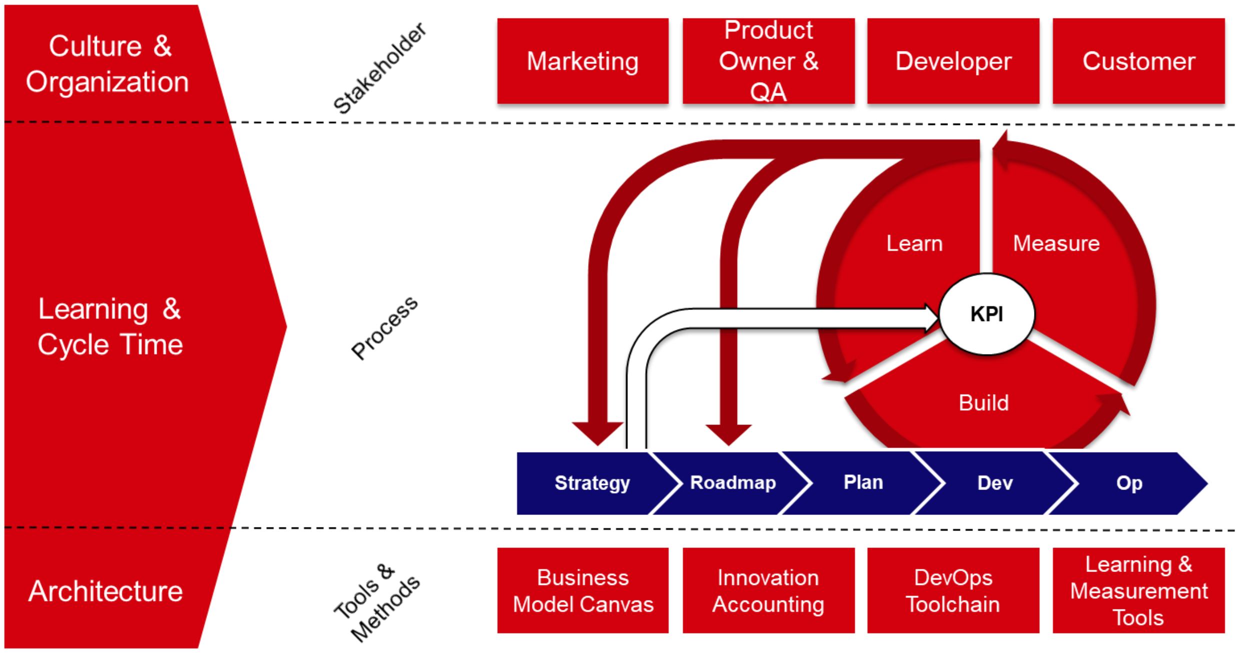

Figure 23. Kick-off slide for target agreement in the ADR team (own depiction).

3.3.3.2. s1: Instantiating a New Way of Working in InCorp's Digital Innovation Unit

The research team agreed to intervene in the DIU by instantiating lean startup's BML process (see **Chapter 2.1.5.1**) as an NWoW. The following paragraphs describes our research process and presents information concerning the evaluation of something in the form of a concurrent evaluation (see Sein et al. 2011).

We created an early prototype of an artifact for planning and communicating with stakeholders in InCorp's DIU. We identified two opposing forces that might impact the chance of instantiating lean startup's BML: first, a shift from a decentralized development approach in the subsidiaries to a central development created a gravitational pull towards the requirements of established structures, second, the lean startup's customer orientation is intended to create a gravitational pull towards the requirements of the customer and user.

This gravitational pull towards established structures affected the determination of roadmap items and the elaboration thereof in the scope workshops. New ways of working such as lean startup focus on elaborating on requirements in direct contact with the customer and user of a digital product or service. We found that these two perspectives can be in stark contrast and opted to visualize the opposing forces in the form of a figure that merges descriptive and prescriptive elements for sensitizing organizational stakeholders to a root challenge (see **Figure 24**).

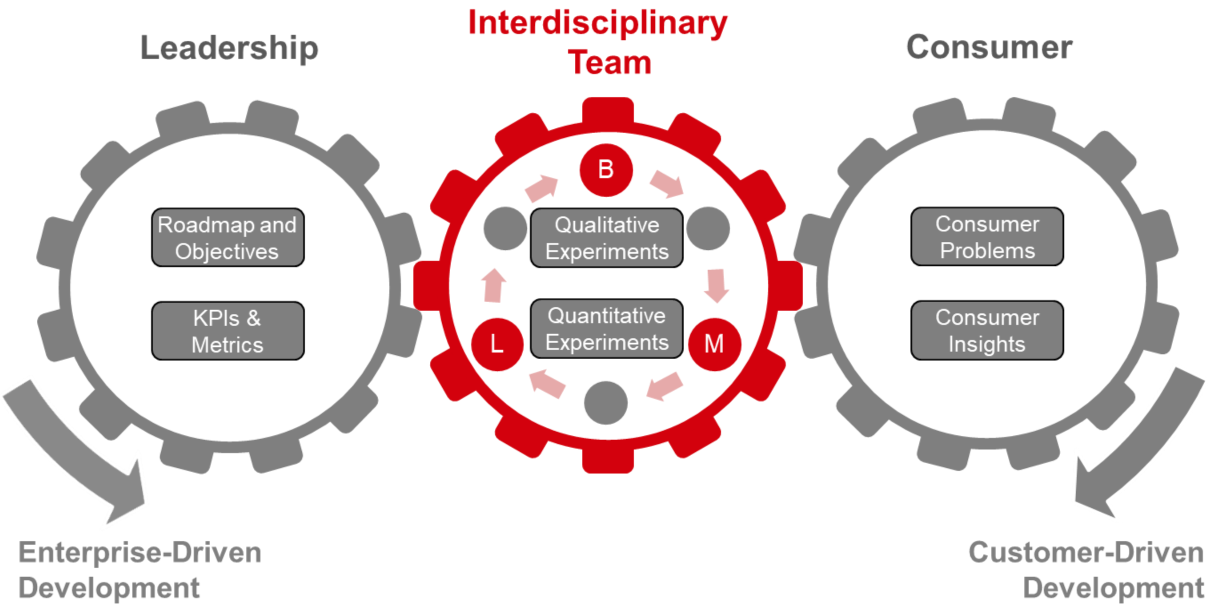

Figure 24. The *development drivers* model (own depiction).

Intervention Planning and Preparation

We moved on by planning and communicating the interventions with the relevant stakeholders in the organizational context. Specifically, we discussed our plan with the product owner of the overall platform. We introduced lean startup's BML process and its intended targets and selected an upcoming feature from the roadmap as a testbed for implementing the new process, knowing that the selection of an already internally determined feature might serve as a compromise between an enterprise- and a customer-driven development approach.

Subsequently, we focused on a core requirement of lean startup, that is, having an interdisciplinary team in place to enable quick iterations. Together, we concluded that all required functions for forming an interdisciplinary team are available within the DIU but that the organizational ties that existed at the time emphasized communication within functions instead of interdisciplinary communication. As a consequence, the product owner designated the lead concept developer of the chosen roadmap item as the leader of the team to be formed.

We met the newly chosen team leader and discussed the planned development of the new feature with him. Together, we reflected on the new approach in light of the old approach. The previous approach placed end-user testing at the end of the process. In contrast, the new approach conducts end-user testing before implementing actual software (e.g., with mock-ups or click dummies). Thereafter, we discussed how we could unite an interdisciplinary team. Ultimately, a compromise was necessary, as the core development capacity has been offshored to India, and communication was therefore impeded by distance. We settled for strengthening cross-functional ties by conducting workshops with the on-site team members, thus effectively improving cross-functional communication, and involved the off-site team members by using forms of digital communications, such as 360° video conference calls.

Before the team could engage with the actual process, it was necessary to develop basic methodological expertise. We designed appealing slides (see **Figure 25** for an example) to explain the core concept behind the lean startup approach, that is, short iterative development cycles driven by consumer insights. We presented the slides in front of the entire DIU to raise awareness of the topic.

The presentation highlighted the new process, the new team constellation, and the approach to measuring progress. As opposed to existing agile and non-agile approaches, this NWoW employs a data-driven accountability paradigm (see Maurya 2012, Ries 2017); that is, it focuses on producing end-user insights and uses these insights for future iterations instead of focusing on the development of pre-defined deliverables.

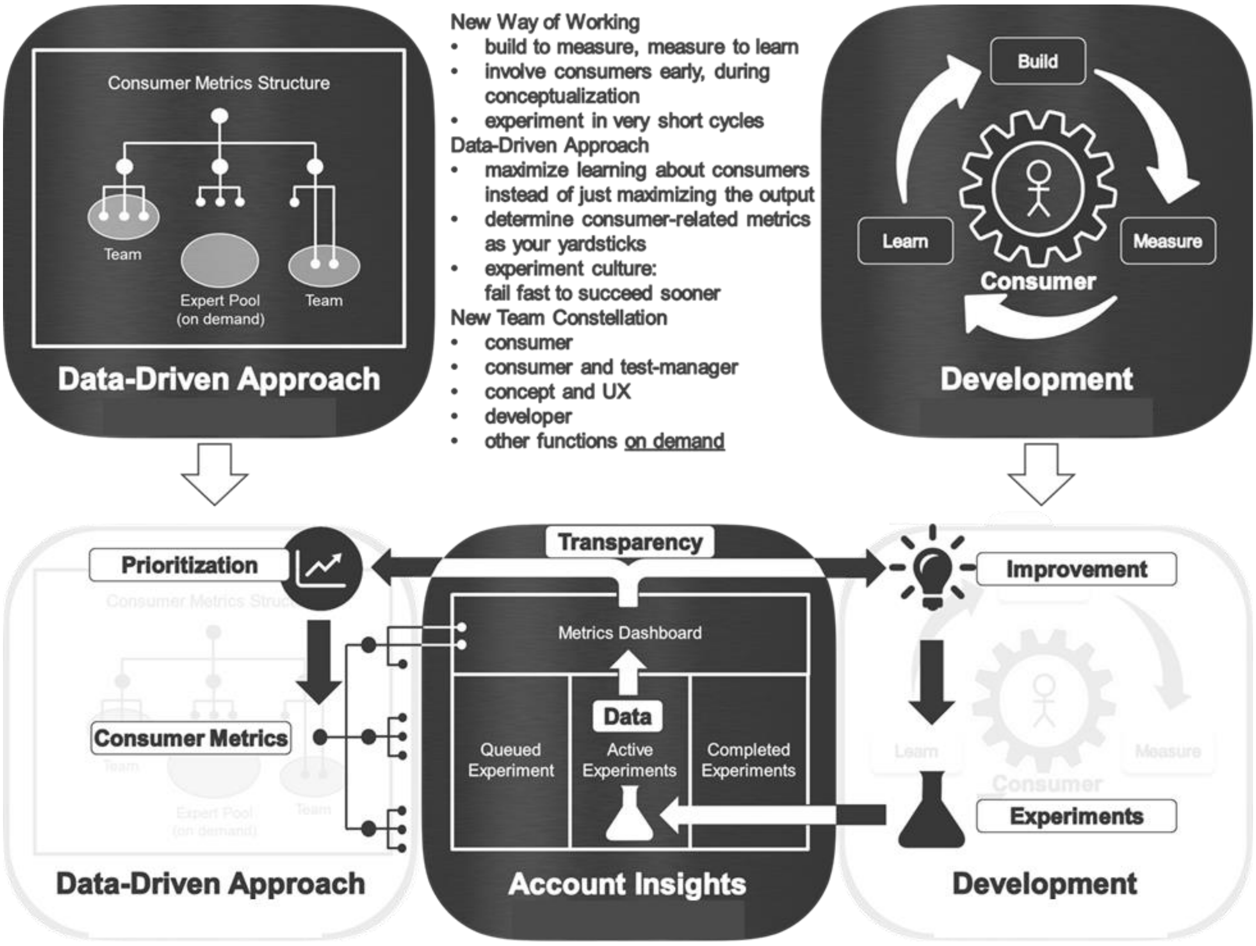

Figure 25. Excerpt from the slides for introducing the NWoW (own depiction).

This excerpt has been adapted for presentation in this thesis.

Intervention

We deep-dived the specifics of the method with the team to provide them with methodological knowledge (see also **Chapter 2.1.5.1**). Once they had been equipped with methodological knowledge, we kicked the development process off with an ideation workshop to identify approaches worth pursuing. The team presented a plethora of ideas. However, during the clustering and closing phase of our workshop, the current focus of the DIU (i.e., the ongoing migration to a new and central platform) surfaced, and the team leader carefully guided the process towards ideas that have already been discussed with stakeholders from the subsidiaries. We opted to focus on the *measure* and *learn* phases in our later iterations.

We continued and conducted four iterations. We employed UX labs and A/B tests to measure end-user interaction with the team's solution approaches and extracted insights by using the *download your learnings* and *insight statements* methods in the *learn* phase of an iteration (see **Table 16** for an overview). The to-be-built features that served us as testbeds included *personalization* in the form of personalized site elements, that is, engaging the end-user such as a personalized welcome page or user-specific article recommendations; the *advisory tool*, that is, navigation based on user-selected preferences; and the *personalized stage teaser*, that is, the user-specific customization of the central slideshow of the homepage.

For the first two experiments, six end users were invited to InCorp's UX lab. We booked the lab for two consecutive days with the aim of qualitatively measuring the end users' reactions to the current personalization concept and two click dummies of the advisory tool. In correspondence with the main focus group, we invited six 20–49-year-old women. Drawing on existing defined procedures, we adapted and developed the guidelines for conducting the UX lab sessions and introduced the moderators to the Dumas and Loring's (2008) 10 golden rules for moderating usability tests. We took screen and sound captures during the sessions. The captures were transferred to an adjacent room to allow team members to gather first-hand insights without interfering with the test setup.

#	Service to be Build	Methods used for Measure	Methods used for Learn
1	Personalization	UX lab	Download your learnings, insight statements
2	Advisory tool	UX lab	Download your learnings, insight statements
3	Personalization	A/B test	Experiment report
4	Personalized stage teaser	A/B Test	Experiment report

Table 16. Overview of the BML iterations in the organizational setting (own depiction).

Each experiment closed with the collection of insights using the *download your learnings* (Ideo 2016a) method. *Download your learnings* is a pen-and-paper-based team-centered method that is used for documenting the observations of individual team members and synthesizing them into a shared perspective. Thereafter, the downloaded learnings were reduced to the most important *insight statements* (Ideo 2016b). Creating *insight statements* involves selecting three to five of the most important insights concerning a development task. The *measure* and *learn* activities led to tweaks to the to-be-implemented feature.

We initiated two A/B tests in addition to the UX labs. We used the two tests to trial new versions of the personalization concept and the personalized stage teaser (see **above**). Together with the test manager, we used the software *Optimizely* to implement and define the A/B tests. A/B tests run for a predefined period of time. Usually, a small percentage of less than 20% of the traffic is rerouted to the B version of a test (see **Chapter 2.1.5.1**). This traffic allocation can be changed to speed up the process of achieving statistical significance, for example by using a 50/50 split. In collaboration with the test manager, we ensured that the test would report on actionable metrics and determined two weeks as the time horizons for the tests.

We initiated the tests and tracked the results using Google Analytics (GA). Thereafter, we wrote an experiment report (see Maurya 2012) for each test (see **Table 17** for an example). Experiment reports allow for the documentation of the core elements of an experiment on a single page and are suitable for communicating results and comparing the results of different tests over time. We discussed the results with the team. It appeared that the results had a motivating effect on the team, as the test showed that their efforts created measurable improvements. However, due to the current focus of the DIU, which was on migration and centralization, and the rigid schedule defined by the roadmap, the team was not able to leverage the insights gained for follow-on plans.

Our interventions allowed us to continually reflect on how our intervention (i.e., the execution of BML cycles) impacted its organizational environment. The concurrent and formative evaluation (see Sein et al. 2011) provided insights into specific organizational requirements in terms of effectively adopting an NWoW. In addition to our concurrent and formative evaluation, we closed our first series of interventions with a team workshop.

We used the team workshop to investigate the team's perceptions of ties and dependencies while implementing an NWoW. Together, we were able to identify potential areas for improvement. The experiments showed that applying lean startup methods can provide valuable end-user insights in an enterprise setting. While the experiments provided results to build on and enabled the team to improve the intended functionality and design of feature before implementing them, the team was not able to draw on the full potential of the method due to the surrounding organizational setting; learning and applying the method is challenging, but creating an environment that nurtures an NWoW is a separate challenge.

Background	Results
What are you trying to learn or achieve? We are attempting to determine whether personalized features and elements drive customer engagement. Personalized teasers are simple and could improve customer engagement.	**Enter your qualitative/quantitative data** A 27% increase in teaser clicks.
Falsifiable Hypothesis	**Validated Learning**
Declare your expected outcome Personalized stage teaser will lead to 15% increase in stage teaser clicks.	**Summarize your learning from the experiment [validated or invalidated]** Validated: The increase was higher than expected. The average order value (AOV) and conversion rate were not influenced (the AOV and conversion rate dropped slightly, but the results were not significant).
Details	**Follow-up Plans**
How will you set up this experiment? 1. Prepare existing stage teasers by adding a personal salutation. 2. Run 50/50 A/B test for logged-in users. 3. Use GA to measure the conversion rate of both teasers.	**What's the next experiment?** -

Table 17. Experiment report for the A/B test of the personalized stage teaser (own depiction).

Insights

We recapped our insights concerning driving lean startup interventions. Specifically, we developed a new artifact design, referring on our first artifact version (see **Figure 23**) to present and communicate our findings to the sponsorship of the DIU. We developed various propositions for practices intended to support the establishment and operation of an NWoW. In addition, we identified six additional disciplines for enabling and supporting an NWoW and designed a new artifact to present and communicate our propositions for every discipline (see **Figure 18** in **a2**).

Amongst others, the disciplines included in the artifact considered the management of teams; for example, outsourcing and, in particular, offshoring, are suitable methods for a rapid upscaling of a DIU (see Weingarth et al. 2019), but learnings gained by team members will perish with personnel turnover. Furthermore, having involved several parties within the same organizational setting can create distance between team members, which can in turn impair communication and transparency or may even lead to conflicts of interest. Having strong ties within a team is critical when adopting an end-user focus and iterating rapidly.

Iterating rapidly requires to provide teams with autonomy so they are enabled to make decisions that respond to the needs of the customer and user. Establishing autonomy involves multiple steps on different levels. For instance, the technological infrastructure used for conducting experiments must provide customization options in terms of analytics tools to enable a team to independently adapt such tools to its needs.

Leadership that draws on a roadmap as a central coordination tool also relies on holding teams accountable for pre-determined development targets. Holding teams accountable for such targets reduces the available design space for a team and impedes the leveraging of insights. In contrast, in the absence of a roadmap or similar instruments of coordination, leadership and teams require a new coordination tool, for instance, innovation accounting (see **Chapter 2.1.5.1**).

The common thread in the process of coordinating work to be done is data. Data provides insights into the customer and user. While teams adopt a narrower view on a specific end-user behavior and can be guided by the resulting insights, leadership can adopt a more abstract view, for example by using a funnel such as a customer factory (see **Chapter 2.1.5.1**).

Data can provide orientation, but a vision can indicate direction. The lean startup literature proposes developing a vision (see i.a. Ries 2011) and working towards scale (see i.a. Ries 2011, Blank 2013, Croll and Yoskowitz 2013). A vision provides a high-level coordination instrument, as it can align and unify the efforts of a DIU towards achieving a common target. Considering the requirements of scaling becomes increasingly important when attempting to realize such a vision. Scaling often goes hand in hand with orchestrating many teams. As teams share resources (e.g., technological infrastructure), dependencies among them may rise and can slow the experimentation of each team. The slowing effects of increasingly complex coordination can be overcome by reducing the need for coordination; for instance, a microservices architecture enables teams to develop their individual components of a digital product or service within their respective limited mandates.

3.3.3.3. s2: Internal Transfers

We transferred the artifact to two organizational contexts within the same corporation (see **s1**). Within the corporation, two executives were striving to adopt NWoW. We designed an interview guide for assessing the situations faced by these executives. The interview guide consisted of questions based on the seven disciplines of **s1** (see also **Figure 18** in **a2**), that is, *way of working*, *teams*, *infrastructure*, *leadership*, *data*, *vision*, and *scale*.

We used the interview guide to interview each executive in the context of their respective scenarios. The first scenario involved the integration and migration of an intranet platform based on Microsoft SharePoint. The second scenario focused on a digital innovation lab intended to provide end-users within the corporation with digital services that are as convenient to use as consumer-grade digital services. In the following, I describe both scenarios in greater detail and highlight the insights gained in terms of both of the two scenarios and the development of our artifact.

The Intranet Integration and Migration

We met with the head of the intranet integration and migration project and conducted and interview with him during the early planning stage of the overall project. For the initial inquiry, we conducted four semi-structured expert interviews based on our artifact-based interview guide. The interviews lasted two hours each, and we sought to obtain an informant feedback by our interviewee (see Guba and Lincoln 1985) to avoid misinterpretations. In the following, we present our findings concerning the structure of our questionnaire.

The company used two intranets: One is primarily used by IT, and the other serves as a general communication platform. In addition, the company used a collaboration platform. Together, these three platforms were used for publishing news, planning and communicating projects, and sharing files; they also serve as internal social media platform.

Insights

The vision of the intranet integration and migration project was to improve usability by facilitated information access and retrieval. This target was to be achieved by uniting three different intranet and collaboration platforms into a single social platform.

The focus group of the project was the whole company. A unified intranet platform meant a change to a more comfortable solution for end users. For IT, a unified platform meant that it had no longer to design and maintain its own intranet. News and content editors were required to adapt their practices to a new platform with the ultimate goal was to improve their workflows. Co-workers from the marketing department showed an increased interest in unifying the three platforms and explored different solution approaches within the boundaries of their department.

The leadership team behind the project consisted of a general project manager provided by IT, the head of IT communications, and two individuals from corporate communications. The leadership team held meetings on a regular basis. Further stakeholders were IT Governance, IT Risk Management, IT Operations, Digital, Marketing, Sales, and the works committee. In addition, the leadership team reported to a steering committee. The steering committee consisted of high-level executives and representatives from various organizational units.

Making scope changes required the leadership to follow a pre-defined procedure: First, projects had to submit requests for scope changes. Submitted scope changes had to include a description of the requested change and cost estimations, which were to be provided by all involved stakeholders. The demand board then decided regarding the change in scope in the light of the overall budget. Autonomous bottom-up decision-making was enabled within a very limited mandate.

The team behind the project consisted of internal employees and employees from two service providers. Both service providers contributed onshore personnel, some of whom worked on-site. One service provider was responsible for design and UX, while the other service provider was responsible for development. All internal team members were located in the same office building. In addition, there was also a project room available.

The traditional way of working was extended by DT workshops prior to the normal development process. The workshops enabled team members to identify design opportunities prior to the actual software implementation. Further experiments that would measure actual user behavior, such as A/B tests, were in conflict with regulations of the works committee.

The intention was to shift the infrastructure from on-premise to the cloud. Another reason for moving to the cloud was to reduce the number of software products used; prior to the move, the intranet platforms used by the company relied on the use of solutions provided by several third-party software providers.

Communication within the project relied on e-mail, Skype, and a collaboration platform. In selected cases, external employees received company PCs and accounts. The team’s choice of other digital tools was limited, as their introduction would have required additional projects to be undertaken.

A data-driven development was possible within a limited mandate. Qualitative data was successfully utilized by conducting DT workshops, but utilizing quantitative data proved more challenging. Conducting A/B tests within the corporation was not possible due to internal regulations and tool limitations (see **above**). However, we were able to determine the number of active users per country and department. We decided that the marketing department located at the head office could be considered a focus group. Given the fact that the marketing department had shown a high interest in developing solutions previously, this insight was deemed reasonable from a qualitative and quantitative perspective.

We closed our questionnaire with a question concerning the scale discipline but concluded that the scaling approach (as defined by our artifact) was not particularly relevant given the early stage of the project.

Overall, we recommended addressing two focal points to nurture the establishment of an NWoW: 1) enabling internal quantitative experiments by re-designing regulations given by the works council and 2) leveraging the motivation of early adopters and innovators, such as the marketing department, by intensifying their involvement in the development process.

The Digital Lab

We met with the head of the Digital Lab. For the inquiry, we conducted a semi-structured expert interview using an artifact-based questionnaire with a twist; instead of structuring the questionnaire along the seven disciplines from left to right as before (see **above**: The Intranet), we arranged the questions based on the seven disciplines, moving from inside to outside, that is, beginning with questions based on the central discipline of our model, we continued with questions towards the outer disciplines of the model. The interview lasted two hours, and we used a member check, also known as informant feedback (Guba and Lincoln 1985), to avoid misinterpretations. In the following, we present our findings. This presentation follows the structure of our questionnaire.

The digital lab was a small but growing organizational unit with the goal of leveraging leading-edge technology to address internal IT demand by providing consumer-grade services. The approach behind the digital lab was fundamentally different when compared with the traditional approach used within the corporation; the digital lab identifies leading-edge technology worth leveraging for the corporation and initiates related development activities without having an internal customer, who would normally determine the budget and define requirements. Therefore, the digital lab enjoys a higher degree of freedom.

The digital lab consisted of a young team of five employees of between 25 and 35 years of age. The high degree of freedom paired with the creative spirit of the market-oriented individuals behind the lab led to remarkable results in the past, such as an internal AppStore offering a consumer-grade experience for internal software distribution or a voice-based platform similar to Amazon's Alexa that can be used for booking internal business services such as booking an office.

Insights

The digital lab's way of working could be described as experimental and limited by boundaries. Conducting tests with users to obtain feedback can be described as an informal or limited approach due to the same reasons mentioned in the intranet case; conducting experiments with users outside the originating organizational unit, that is, the IT department, was not possible due to the regulations defined by works committee (see **above**).

The team consisted of five internal employees who were co-located and shared a common team space; the team members used Microsoft Teams for internal communication. Ties and dependencies that may have slowed the development process were addressed on a weekly basis within the team and communicated to the team leader. Additionally, one-on-ones were held between the team leader and each individual team member with the goal of discussing what worked and what did not in detail. In addition, a *team voice* process was employed that enabled team members to rate the team leader.

The infrastructure was chosen in light of the respective technology to be explored. The team worked in sandbox environments before integrating a solution within the live environment. The sandbox approach enabled the team to iterate quickly and with confidence.

The limited size of the digital lab when compared with full-grown DIUs led us to the conclusion that investigating questions based on further disciplines of our artifact would yield diminishing returns. The digital lab consisted of a single team. Further investigations into disciplines concerning leadership, data, vision, and scaling created limited insights.

The scale dimension, however, raised an interesting question, namely *how are the newly developed digital products and services of a digital lab operated after they have been deployed?* In this given specific case, answering this question revealed that digital products or services, once developed, were handed over to the traditional IT operations function. This is a remarkable finding: A digital product or service that has been developed using new ways of working is operated using old ways of working. Unfortunately, we were not able to further follow this path, as it was beyond the scope of our research. Nevertheless, we wished to share our insights concerning how hybrid models of new and traditional structures could serve as a way of improving the internal customer experience while maintaining cost efficiency.

We structured our findings from both an internal and external perspective. Internally, we argue that the existing way of working could be complemented by evaluation activities, as, at the time, digital products and services that have been launched and handed over to IT operations were not further followed up on and monitored by the Digital Lab. Thus, it is unclear whether the initial quality of a digital product or service can be maintained or even improved over time after this transfer of responsibility.

Externally, that is, outside the digital lab but within the corporation, the Digital Lab is similarly limited as the *intranet case* (see **above**); regulations defined by the works committee did not allow experiments and tests conducted involving direct contact with co-workers; thus, the Digital Lab could not draw on direct feedback. The team leader of the Digital Lab shared our perspective on these two external challenges, and we observed that he addressed this point in a pragmatic way by running for a seat on the works council.

In terms of our artifact development, we learned that a staged inquiry approach beginning with the central discipline and ending with the disciplines positioned at the sides of the model can facilitate the transfer and application of our model to different contexts. Hence, we concluded that the addition of a stage logic could support navigating through the individual concepts of the model.

Summary

The internal transfers provided interesting insights for both researchers and practitioners. Several organizational barriers towards adopting an NWoW were identified and addressed; for instance, the executive of the digital lab fielded himself as a candidate for the works committee to enable internal quantitative user tests.

We, as researchers, learned that our artifact would benefit from a constructive structure; that is, the arrangement of practices should start with fundamental practices at the beginning and end with the more complex practices at the conclusion of an assessment. We found that by arranging practices constructively, the intuitiveness of the artifact and the efficiency of the inquiry process could be increased. Based on these insights, we defined a new artifact that separates practices into stages.

We further learned about the functional and operational constraints of our solution space; DIUs explicitly focus on developing digital services and products for customers and users outside of the boundaries of a firm. Widely seen as a vehicle for driving innovation across both internal and external boundaries, the underlying conditions of DIUs differ from the conditions of other organizational settings that exclusively provide value within an organization. While our artifact may also provide value in these organizational settings in the sense that it can be used to identify internal barriers, we found that adopting an internal perspective would open up an entirely different perspective on the class of problems investigated.

3.3.3.4. s3: Re-Visiting InCorp's Digital Innovation Unit with an Advanced Artifact

Equipped with an artifact that had been further developed based on the input of various experts (see **Chapters 5.2.1** and **5.2.2**) and by insights provided by socio-technical theory (see **Chapter 2.2**), we revisited InCorp's DIU to compare the status quo against our current artifact version (see **a5** in **Chapter 3.3.2**).

Beginning our reflections on the status quo, we were able to observe a tremendous change (cf. **Chapter 3.3.3.2**): The number of external personnel has been cut in half, positions had been restaffed with internal employees, the leadership style had changed from delegating to a supportive approach, development had been moved from offshore to on site, and initiatives that targeted the modularization of the technological architecture had been initiated.

After we conducted seven expert interviews and attended nine meetings, we were able to jointly derive future perspectives on our artifact for the further development of InCorp's DIU. The conclusions drawn from these perspectives, however, should be considered with a grain of salt, as large parts of InCorp's DIU were busy with migrating the various platforms of the subsidiaries all around the world to the newest version (see also **above: s1**).

Migrations are characterized by a known problem and a known solution; therefore, the prevailing organization of teams in functionally oriented team structures was well-chosen in light of the migration undertaken in this case, which was intended to leverage economies of scale. Another benefit of having functionally oriented organizational structures in place is the improved ability to analyze a monolithic software architecture; an in-depth understanding of the current software architecture is necessary to prepare and inform future modularization efforts (see **Chapter 2.2.2**). We recommended switching from functional orientation to interdisciplinary orientation once the migration was completed in order to establish a foundation for a new way of working.

Switching to interdisciplinary team structures would provide InCorp's DIU with various benefits. Interdisciplinarity in teams enables quick bottom-up decision-making that can nurture innovation within boundaries. These boundaries are defined by software modules. InCorp's DIU strives to implement modular architecture. Defining interdisciplinary teams can be helpful in further understanding the requirements of modularity. Furthermore, the homomorphism of organizational and technological structures can lead to a structural homogenization of both systems; this effect can be leveraged to implement and maintain a modular technological design (see Conway 1968, MacCormack et al. 2012). In line with our proposition regarding switching from functional to interdisciplinary organizational structures in the future, we suggested that the seating plan in the work environment should match the new modular organizational and technological structures for supporting informal communication within teams (see Herbsleb and Grinter 1999, Kwan et al. 2011, Sushandoyo and Magnusson 2012).

In terms of technology management, the introduction of first architectural cuts was initiated. Specifically, we identified the initiation of a horizontal architectural cut that was based on the concept of *headless computing.* Headless computing refers to a separation of the presentation layer from the logic and data layers. Communication between these layers is then defined via APIs. Headless computing can be beneficial, as it adds flexibility when choosing future front-end technologies. However, we also felt that this separation of technological layers could be the natural consequence of communication barriers between functions, as most functions were staffed by different service providers, employment structures impact communication, and communication impacts architectural design (see Conway 1968, Colfer and Baldwin 2016).

From a vision and leadership perspective, the DIU had executed its migration plans successfully. The goal behind the migration was the centralization of development efforts. This shift to centralization stood in contrast with InCorp's closest-to-market strategy, which puts the power to determine scopes of development activities in the hands of local subsidiaries. The teams' ability to engage in autonomous decision-making was contrasted by this distribution of power, resulting in a lack of team autonomy.

Teams could have used autonomy for leveraging customer and user data as data reflects customer and user interests and behavior; as such, it could have been utilized as a guiding compass for directing development efforts of both individual teams and InCorp's DIU as a whole. We identified emphasizing the use of data as a valuable step for the future development of InCorp's DIU given that the migration had been completed.

From a scaling perspective, members of InCorp's DIU had started to develop a profound understanding of automating technological infrastructure by becoming familiar with Atlassian Bamboo. In the light of other opportunities for future structural development that we had discussed, we jointly concluded that the implementation of automation initiatives should be postponed to a later point in time. This point in time was defined as when the migration had been completed and the first steps had been made in terms of modularizing the technological infrastructure. Waiting until this point in time would ensure that the automation approach would support the new structures (see also Hammer et al. 1993).

Finally, we discussed the potential benefits of implementing a continuous process for checking organizational ties and technological dependencies. This process would have leveraged insights from interdisciplinary teams on a continuous basis, as the perspectives of individual teams can be a valuable source for understanding socio-technical relations (Imtiaz and Ikram 2013; see also James Coplien in Kwan et al. 2012).

In the specific case of InCorp's DIU, reflecting on modular organizational structures such as interdisciplinary teams in the context of a monolithic architecture would support developing a profound a profound understanding of modularization requirements. The homomorphism of organizational and technological structures leads to a structural convergence of both domains (see Conway 1968). This convergence could be made transparent by leveraging team insights, as teams work at the interface between organizational and technological systems. Since modularization is not a final state but an ongoing process, a continuous process for checking organizational ties and technological dependencies would be required in the long run (see also MacDuffie 2013 in Colfer and Baldwin 2016).

3.3.3.5. Summary of Intra-Organizational Shapings

We applied three different artifact versions (see **a1**, **a2**, **a5** in **Chapter 3.3.2**) in four intra-organizational inquiries (see **s1**–**s3**). The initial inquiry provided us with an in-depth understanding of an exemplary socio-political context that is relevant to the class of problems. In particular, the intra-organizational shaping supported the development of an initial problem and solution understanding. Thereafter, this understanding enabled us to reflect on whether a generalized solution approach would still address the needs of our initial organizational setting. The further applications of advanced artifact versions in intra- and inter-organizational settings enabled us to design with a focus on both depth and transferability, thus ensuring the resulting artifact is characterized by a high degree of applicability and generalization.

4. The N2DIU Model – A New Way to Design Digital Innovation Units

This chapter presents the core outcome of this thesis, namely the N2DIU model.

4.1. Purpose and Scope

In developing DIUs, high expectations meet the development of an organizational vehicle that is expected to drive a firm’s digital transformation. This organizational vehicle enables its drivers to conquer uncharted terrain internally within an organization but also externally in the context of an ecosystem.

We present a model that facilitates the development of such organizational vehicles. N2DIU stands for a ‘**N**ew way **T**o design **D**igital **I**nnovation **U**nits’ and presents a structured approach to developing DIUs.

DIUs draw on NWoW to develop innovative digital products and services. The implementation of such approaches often involves entering uncharted terrain within a company. The implications with regard to organizational and technological structures that arise as a result of implementing an NWoW might therefore be overlooked. The N2DIU model provides guidelines for embedding NWoW in organizational and technological structures that support and enable the intended modus operandi.

The N2DIU model represents the first explicit approach for guiding the design and development of DIUs. The N2DIU model provides a matched set of disciplines and practices that consider an NWoW as the pivotal discipline of a DIU. The proposed disciplines and practices can be used to assess and guide the transformation of existing organizational units into a customer- and user-driven DIU or for guiding the development of a new DIU from scratch.

A fast-paced and uncertain market requires continuous adaption. The N2DIU model defines continuous practices for adapting a digital product or service to the needs of its customer and user. The model's explicit structure enables its users to continuously plan, implement, and evaluate joint change initiatives for developing a DIU.

The N2DIU model defines socio-technically matched pairs of practices to ensure an aligned and balanced development and operation of joint digital innovation structures. The model’s modular architecture enables a stepped and robust approach to developing practices and the interfaces between practices.

As DIU research still remains a largely uncharted terrain, our model comes with limitations. A financial management perspective is not part of the model. However, the model's focus on the underlying structures of a DIU provide an explicit guideline that can be used to align high-level stakeholders towards common development targets. The N2DIU can be used to guide a joint communication and development between departments within a firm. The model's modular architecture enables its users to iterate through the development of a DIU by adopting well targeted digital transformation initiatives. Using the model as an assessment-blueprint enables its users to continuously plan, implement, and evaluate DIU practices on a collaborative basis.

The model is generally designed to be method-agnostic when it comes to selecting a software development approach that shall drive a DIU's digital product or service development. However, we recommend to rely on a software development approach that fulfills the following criteria: first, the selected development approach must be iterative (to enable making swift adaptions to a digital product or service), and, second, the selected approach must involve the customer and user early within the development process to enable receiving direct, rich, and instant product or service feedback with low effort. DT and LS are known for fulfilling these criteria. However, in general, the N2DIU model is agnostic; the model does not require its users to rely on a specific development approach as long as abovementioned requirements are met. For instance, a DIU development journey can be started with employing Scrum as an actual development approach if this approach is progressively adapted to meet the criteria.

4.2. Design Principles

The N2DIU model's development was guided by three design principles. These design principles are the result of reflecting on the model's design process and, specifically, the change moments in model development that influenced the current design (see Sein et al. 2011). In the following, we present the three design principles of the N2DIU model.

The model development started with implementing a software development aproach that describes a continuous adaption of an organizational entity to the requirements of its environment. Therefore, the first design principle that we identified is *continuity*.

With advancing model development progress, the model was complemented by defining disciplines that support the operation and establishment of such a development process. Reflecting on how we arranged the supporting disciplines around the continuous development process showed us that we had defined congruent pairs of organizational and technological disciplines that harmonize with each other. The second design principle we identified was *congruence*.

The model development continued with the definition of different stages of DIU development. The development of a DIU is a broad and tedious task. The model separates and rank-orders practices for enabling the implementation of stepped and robust digital change initiatives. Reflecting on how these requirements impacted the design of the model, we identified a third design principle, that of *modularity*.

Principle 1: Continuity

Companies strive to develop innovative digital products and services to stay competitive (see **Chapter 2.1.2**). The development of innovative digital products and services is an endeavor that involves continuous exploration of uncharted terrain and can thus occasionally be messy (see **Chapter 2.1.5.1**). Different companies explore and develop different digital products and services. As digital products and services replicate the internal structures of an organization, the variety of digital products and services is a direct consequence of the various internal structures that exist within such organizations (see **Chapter 2.2**). As the development of a digital product or service is an exploratory and sometimes messy endeavor, so is the development of a DIU. The explorative approach reduces uncertainty through a continuous adaption of an organization to its environment. The approach structures messiness to separate what works from what does not work.

Organizations continuously experiment and separate what works from what does not in the course of the development of digital products and services. Therefore, the structures of a DIU need to be continuously adapted to the needs of the specific digital product or service that a DIU produces. The continuous approach to digital product and digital service development ensures high degree of embeddedness of an organization within its ecosystem, while the adaptive organizational structures of a DIU ensure a structural fit with requirements of digital product or service development.

A model for guiding the development of a DIU must consider the continuous adaption to the various environmental circumstances under which DIUs are developed. Such a model must support a large variety of companies at various stages in their transformation journeys. Thus, such a model must support the development of a DIU from scratch but also from different starting points. Whether a company strives to create DIUs with completely new structures and resources or intends to transform existing structures and resources, the key to developing organizational and technological structures that provide innovative digital products or services lies in the continuous exploration and adaption involved in both developing the DIU and the digital product or service it produces. Therefore, a model for guiding the development of a DIU must draw on the concept of continuity.

Principle 2: Congruence

The positive effects of structural congruence have been found to be effective across different system levels, especially those between organizational and technological systems (see **Chapter 2.2**). This type of congruence is called socio-technical congruence.

Socio-technical congruence can yield various benefits, such as efficient coordination (Conway 1968, Sierra et al. 2017), an increased probability of build success (Kwan et al. 2011), a decreased number of software failures (Cataldo and Herbsleb 2013; see also Datta 2017), clearly defined responsibilities (Sierra et al. 2017), decreased resolution times for modification requests (ibid.), faster identification of coordination deficits (ibid.), increased team efficiency (ibid.), increased software quality (ibid.), cost reductions (ibid.), and an overall increase in development productivity (Cataldo and Herbsleb 2013) and organizational performance (Colfer and Baldwin 2016) in both novel and mature environments (Cataldo and Herbsleb 2013).

Organizations must be lean and flexible to continuously adapt to changing market conditions and to reduce uncertainty (see **principle 1**). A lean and flexible organization requires efficient coordination. Achieving socio-technical congruence is an approach that allows for efficient coordination.

The beneficial effect of a socio-technical congruence between organizational and technological systems must be considered when developing DIUs to enable not only lean and flexible digital product or service development but also the lean and flexible structural development of a DIU. Therefore, a model for guiding the development of a DIU must draw on the concept of socio-technical congruence by defining matched pairs of organizational and technological structures.

Principle 3: Modularity

The positive effects of modularity in systems development have been discussed in various publications. Modularity has been described as an efficient approach to coordination and technology management (see **Chapter 2.2**). Adopting the concept of modularity can be used to place responsibility in the hands of those who value it most (see Langlois 2002). Such a shift in the allocation of responsibility enables a transfer of decision rights. A targeted transfer of decision rights from the leadership to interdisciplinary teams leads to increased team autonomy (see **Chapter 2.1.5.2**). Autonomous acting interdisciplinary teams can initiate a continuous stream of exploration within their limited mandate, delineated by modular technological architecture. Continuous exploration can drive team engagement and performance; therefore, it can lead to the creation of a superior overall product. A continuous exploration further leads to a high degree of environmental embeddedness (see **Chapter 2.2**).

Companies that adopt modular structures renew their products more frequently, as modules can be adapted to a changing environment without the need to change the product as a whole, and the costs of propagating changes are thus decreased (see **Chapter 2.2**). It can be said that modularity can drive the rate at which an organization can adapt to changing circumstances. This is particularly important in contexts characterized by high uncertainty (see also **principle 1**).

Since no design is perfect and every design is unfinished by nature (see also Conway 1968), we chose to leverage the various benefits of modularity for the design of our model for guiding the design and development of a DIU. A modular model approach enables users of the model to adapt single modules to changing circumstances, propagate the discovery of new knowledge without changing the model as a whole, assign responsibility to selected modules of the model, and enable a stepped and robust change process. Furthermore, change initiatives planned on the basis of modules can be undertaken with confidence, as delays in establishing an individual module will have a limited blast radius. Therefore, a model for guiding the development of a DIU must draw on the concept of modularity.

4.3. The Constructs underlying the N2DIU

The N2DIU builds on three different types of constructs:

1) disciplines describing vertical structures as the core pillars of developing a DIU
2) tiers describing horizontal structures that indicate the increasing complexity with increasing DIU development progress, and
3) modular practices defining the intersections of horizontal and vertical structures.

This chapter introduces the three core constructs underlying the N2DIU. I provide detailed descriptions of the disciplines in **Chapter 4.3.1**. I present the modular practices in detail in **Chapter 4.3.2** by describing the development of a DIU as an exemplary journey through the four tiers of the model (see **Figure 26** for a first look at the N2DIU model).

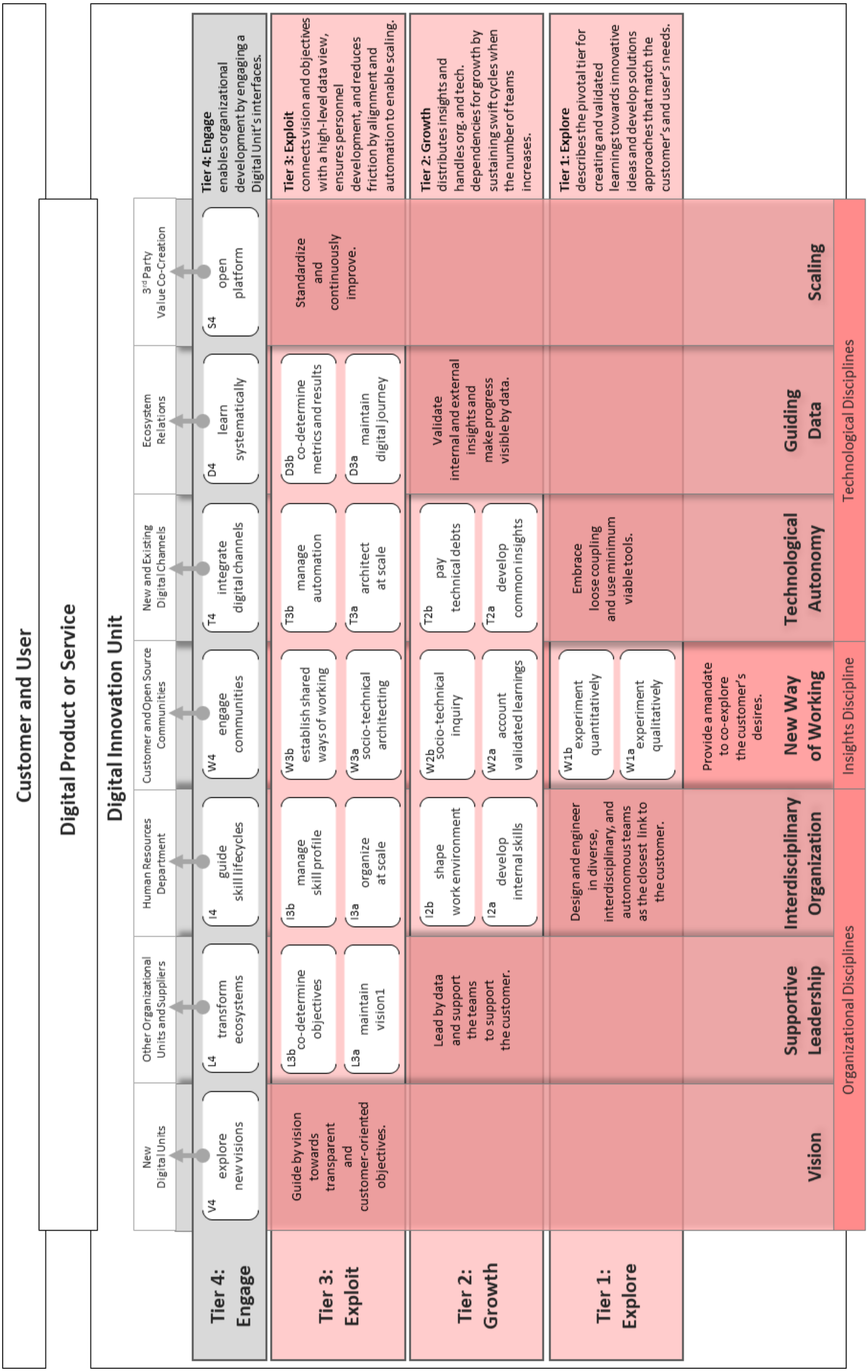

Figure 26. The N2DIU model (own depiction).

4.3.1. The Digital Transformation Heptathlon: The Seven Disciplines of Developing Digital Innovation Units

The N2DIU model is built on seven disciplines (see **Figure 27**). The identification of the seven disciplines was the result of the progressive artifact design (see **Chapter 3.3.2**) and a comparison of the disciplines with the state of the art with regard to DIUs (see **Chapter 2.1**).

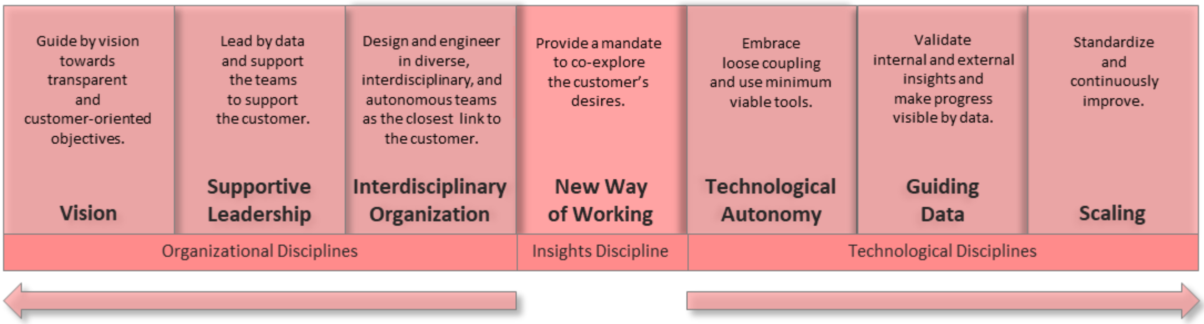

Figure 27. The seven disciplines of the *N2DIU* model (own depiction).

The pivotal discipline of the N2DIU model, *new way of working*, is supported and enabled by three organizational and three technological disciplines. The three organizational disciplines are

1) Interdisciplinary organization,
2) Supportive leadership, and
3) Vision.

The three technological disciplines are

1) Technological autonomy,
2) Guiding data, and
3) Scaling.

In this chapter, I focus on introducing the individual disciplines, beginning with the central discipline, the NWoW, and work my way from the inside of the model's disciplines to the model's outside by alternating between organizational and technological disciplines, beginning with the discipline *interdisciplinary organization*.

The N2DIU model places different emphasis on each discipline (see also **Figure 26**). Accordingly, the following descriptions of the disciplines differ in terms of their length; especially the first disciplines embody a larger extent.

New Way of Working

Innovative ideas are developed "[…] at the boundaries between mindsets, not within the provincial territory of one knowledge and skill base" (Leonard-Barton in Müller et al. 2014). NWoW enable innovation through exchanges at the boundaries of a company. An NWoW promotes conducting experiments in direct contact with the customer and user of a digital product or service. These experiments generate customer and user insights. The insights can be used to ensure that an organization can maintain a high degree of embeddedness within its ecosystem (**Chapter 2.2**). In the following, sub-headings are used to highlight the requirements of the NWoW discipline.

Establish an iterative development approach
that provides direct customer and user feedback

NWoW are method-agnostic; that is, whether the central development process is based on, for example, Scrum or lean startup is not decisive as long as the applied development approach fulfills two criteria:

1) it must be iterative to enable an exploration of innovative digital products and services in swift steps, and
2) it must validate ideas, concepts, prototypes, or solutions in direct contact with the customer and user to enable an iterative re-application of validated learnings for developing a digital product or service.

These criteria can be met either by relying on approaches that natively prescribe an iterative development approach based on validated learnings, such as DT and lean startup, or by the adaption of already existing development approaches that have proven effective within a company, for instance, by adding direct customer and user feedback to Scrum iterations.

Provide a Mandate to Experiment

In an NWoW, a mandate to experiment must be provided. This mandate enables quick iterations in order to facilitate direct knowledge exchange at the boundaries of an organization. Particularly in enterprises that wish to protect brand value, such a mandate for autonomous experimenting is not easily provided. The provision of a mandate to experiment can involve various stakeholders. However, without such mandate for direct customer and user interaction, the establishment of an NWoW is impossible, as teams will neither be able to experiment autonomously nor create validated learnings. Without validated learnings, the fuel for future iterations will be lacking.

Integrating a quality assurance function within a DIU, the implementation of non-disclosure agreements, or positioning a DIU as an autonomous unit that operates apart from its mother company can be suitable approaches to ease a company into the decision of providing a mandate to experiment. Without such a mandate to experiment, the speed of iterations can be tremendously decelerated.

Invoke a Cultural Shift

An NWoW requires a cultural shift. A culture characterized by faith, learning, risk-taking (see **Chapter 2.1.5**), and transparency (see **Chapter 2.2**) is required. Establishing a new culture requires fundamental changes; a cornerstone of a new culture is the direct feedback exchange with the customer and user; teams develop innovative approaches while directly interacting with the customer and user at the boundaries of the organization.

NWoW further require a change in the accountability paradigm to enable the establishment of a new culture. Traditional accountability paradigms use deliverables as in the development of features as accountable units. A new accountability paradigm must focus on knowledge exchange at the boundaries to foster innovation. Positioning validated learnings about the customer and user as the new accountable units enables data-driven business development and decision-making (see Cziesla 2014, Hansen and Kien 2015) and can improve both customer and employee engagement (see Urbach and Röglinger 2018). The new focus on validated learnings ensures that both teams and leadership maintain an outward perspective and a market orientation.

Communicate the Benefits of New Ways of Working

Overall, NWoW increase "[…] team satisfaction, thus, team performance, and lead to the creation of an overall better product" (Querbes and Frenken 2018). Furthermore, they are asserted to lead to cost reductions, increased revenue, faster times to market, and an overall improved digital experience (Power 2014, Bano et al. 2016, Kohavi and Thomke 2017; see also Weingarth et al. 2019).

Use NWoW selectively

It should also be noted that NWoW are not superior compared with traditional ways of working in every aspect (Weingarth et al. 2019). For instance, if a problem and the approach to solving it are well-known, following traditional ways of working can be beneficial.

Interdisciplinary Organization

Interdisciplinary teams are crucial for establishing an NWoW (see Drews et al. 2017, Corso et al. 2018). NWoW build on autonomous bottom-up exploration and development by interdisciplinary teams (see Ries 2011). High degrees of autonomy enable interdisciplinary teams to iterate quickly and with confidence. Enabling autonomy, however, requires fulfilling certain prerequisites in terms of the interdisciplinary nature of an organization. Being autonomous means being able to act in a highly independent manner. Dependencies can rise due to a scarcity of skills and knowledge or insufficient power in decision-making. Interdisciplinary teams are the central growth engine of a DIU.

"Addressing the topic of skills and teams early on
is what makes your digital innovation unit grow."

– DIU development expert

Transfer Responsibility to the Teams

A transfer of responsibility can increase the decision-making power of teams. Leadership has to transfer responsibility regarding defining the scope of a digital product or service to teams. Each team then becomes responsible for maintaining and producing its component of the overall digital product or service. Specifically, teams must be able to take responsibility for their parts from end to end and ideally also from cradle to grave (see Drews et al. 2017, Adersberger and Siedersleben 2018, Corso et al. 2018).

The improved decision rights and broader scope of responsibility enable teams to closely adapt and align their developments with the interests of the customer and user. Internal scope meetings are replaced with direct customer and user feedback loops, which enables teams to act and adapt quickly based on customer and user insights. However, maintaining autonomous and rapid iterations requires teams to have the roles necessary to maintain effective forms of communication and efficient decision-making.

Consider the Right Roles

Ensuring that a team is interdisciplinary in nature results in it having the core skills and knowledge required to autonomously explore and develop its part of a digital product or service. Pivotal roles in interdisciplinary teams are *developers*, *designers*, *concept/UX*, *test managers*, *operations*, *analysts*, and a *product owner* (see **Chapter 2.1.5.2**). Further roles that may be relevant in the context of operating an NWoW are *method coaches*, *architects*, *database experts*, *security experts*, *technology experts*, *marketing experts*, and *quality managers* (see **ibid.**). Interdisciplinary teams often consist of five to seven persons but can also be as large as nine persons (see Corso et al. 2018).

The Role of the Product Owner Changes

Pivotal changes in the team constellation and increased team autonomy entail pivotal changes with regard to the role of the product owner (PO). In traditional approaches, the PO was responsible for the conception, development, and operation of an entire digital product or service. However, the adoption of NWoW change the role of the PO in two ways.

First, the scope of the role changes: The PO no longer is responsible for an entire digital product or service but instead becomes part of an interdisciplinary team that is responsible for a particular aspect of that digital product or service. Accordingly, the number of POs per digital product or service changes; instead of having one PO in place, there is one PO for each part of a digital product or service (see also Kniberg and Ivarsson 2012).

Second, the nature of the PO's power changes. Traditionally, the PO was the pivotal decision-making when it came to the design, development, and operation of a digital product or service. In an NWoW, the role of the PO becomes less directive but more supportive in character, as a PO is responsible for keeping track of experiments and documenting validated learnings. The PO provides information for internal team decision-making but also for communicating the progress and results of a team with other teams and, specifically, with the POs of other teams. This inter-PO knowledge exchange facilitates a decentralized coordination and ensures alignment between teams (see ibid.).

Present the Full Picture

The structural change from functionally oriented teams to interdisciplinary teams provides various benefits: Having all of the necessary functions available within a team allows it to rapidly iterate, as it reduces a team's ties and the dependencies required for developing its piece of a digital product or service. Reducing ties and dependencies yields the benefit of autonomy, which in turn enables teams to iterate faster than their non-autonomous counterparts due to faster decision-making. Autonomous decision-making enables teams to develop a customer and user orientation, as opposed to an internal orientation (see **Chapter 2.1.5.2**). Employees who are allowed to experiment their way to success autonomously can develop intrinsic motivation (see **Chapter 2.2**), as they can identify with their results and strive to continuously improve their outcomes.

Technological Autonomy

Market requirements change continuously. Accordingly, a digital product or service has to continuously adapt to changing market circumstances. The communication structures of a company determine the design of the product or service that it produces (see **Chapter 2.2**). Technological structures determine the form of communication structures that exist within a company. Therefore, as a digital product or service has to continuously adapt to changing market circumstances, internal technological structures have to adapt as well.

Use Minimum Viable Technology

Digital product or service designs are prone to change, especially in the early exploratory development stages. A common concept in the digital product or service development in DIUs is that of the MVP. To match the nature of digital product or service development, DIUs should adopt the concept of a minimum viable technology (MVT) during the early development stages. Providing teams with autonomy in tool selection or providing them with a variety of tools that they can freely choose to use or dismiss ensures that teams will explore and use what suits their needs. This approach in technology selection enables them to adapt quickly.

"Teams should be able to use and configure tools
as they need to get their work done."

– DIU analyst and test manager

Balance Autonomy and Growth

It should be noted that the degrees of freedom change with the maturity of a DIU and its digital product or service. Decentralization enables exploration and growth, but centralization is necessary for driving efficiency. Over the course of the development of both a DIU and the digital product or service that it produces, the levels of decentralization and autonomy must be re-considered to enable inter-team knowledge exchanges. As systems tend to disintegrate with growth (see **Chapter 2.2**), shared tools become increasingly important, as, otherwise, the variety of tools and views on insights may create communication barriers among teams. The demand for autonomy in terms of technology selection reduces with the growth of a DIU.

Centralize from the Back-End towards the Front-End

The degree of autonomy in terms of the choice of technology may vary with the degree of the customer and user proximity to technological solutions. Solutions that are more remote to the perception of the customer and user may be chosen with an emphasis on centralization, for instance, back-end or data mining technology.

Embrace Modularity

Establishing a modular technological structure, for instance, by adopting microservices or self-contained-systems (see **Chapter 2.1.5.1**), can facilitate the definition of clear boundaries. These clearly defined boundaries enable teams to work autonomously on a shared architecture; teams can deploy, conduct integration tests, or conduct experiments autonomously in contact with the customer and user without the need to coordinate with other teams. Through this autonomy, teams are enabled from a technological perspective to take responsibility for their respective service or services from end to end and from cradle to grave (see **Chapter 2.1.5.1**). Being fully responsible and not technologically dependent on other teams also enables a team to release often and with confidence (see ibid.), which in turn motivates teams to renew and improve their part of the service more often (see **Chapter 2.2**). Embracing technological modularity becomes increasingly important with the growth of a DIU and the digital product or service it produces, as, otherwise, the dependencies among teams will grow exponentially and will significantly reduce both quality and the speed of development (see **ibid.**).

A modular technological structure that mirrors the modular team and process structures makes it possible to sustain an NWoW at scale. Modular structures are not only beneficial for teams and autonomy but also reduce the cost of failure such "[…] that a failure has a 'limited blast radius' and affects only a part of the user experience […]" (Mankins and Garton 2017). Such a limited blast radius supports teams in becoming more venturesome and can ultimately nurture innovation (see also Duerr et al. 2018, Weingarth et al. 2019); however, it may also be of interest to those responsible for leading a DIU.

Supportive Leadership

A Company's digital products or services must offer outstanding customer and user experience to be competitive. As competition and technological possibilities increase, designing, developing, and operating digital products or services become inherently more complex. This increased complexity requires the adoption of a leadership style that differs from traditional methods.

Traditional leadership features a central point of coordination. A pivotal task of such a traditional leadership is communicating with stakeholders to pre-define and plan development efforts and to transform them into coordination constructs such as roadmaps. Roadmaps can be used to assign pre-defined work to one or more teams.

There are two challenges related to using traditional coordination mechanisms in an NWoW: One is related to the assignment of pre-defined work, while the other is related to the coordination itself.

The Drawback of Using Roadmaps and Pre-Determining the Scope of Developments

A pre-definition of work can be disadvantageous in NWoW, as it narrows the available design space of teams (see **Chapter 2.2**); pre-defined deliverables incentivize teams to follow pre-determined solution approaches. These solution approaches do not necessarily reflect the interests of the customer and user; furthermore, holding teams accountable to deliver on pre-determined solution approaches can render adopting an NWoW obsolete, as the process of creating, learning from, and re-applying validated learnings within the development of a product or service is highly likely to lead to the identification of solution approaches that are in conflict with the initially assigned targets. Pre-defined solution approaches can suffocate the potential benefits of leveraging customer and user insights.

"Right now, it is very difficult to explain why experiments are important to our development."

– Interdisciplinary team PO

Traditional coordination mechanisms become increasingly unsuitable with an increasing number of teams, as the number of "[…] possible communication paths in an organization is approximately half the square of the number of people in the organization" (Conway 1968). Compared with relying on monolithic team structures, interdisciplinary team structures arguably result in a higher team count; a tribe consist of up to 150 persons (see **Chapter 2.1.5.3**), and a squad or interdisciplinary team is said to consist of five to nine persons (see **Chapter 2.1.5.2**), leading to up to 15–30 teams per tribe and tribe leader. Pre-defining and coordinating work with interdisciplinary teams can create a severe overhead when managed with traditional logic.

Decentralize Responsibility and Coordination

A DIU is an inversion of the organizational pyramid. Supportive or servant leadership is required in DIUs. High levels of autonomy and a reallocation of decision rights enable a DIU to leverage the motivation, engagement, and creativity of those employees who are the closest link to the customer and user, that is, interdisciplinary teams. Leadership has to create and maintain a support system in which teams can "[…] operate and innovate […] within their limited mandate[s]" (Ries 2011). Supportive or servant leadership is an autonomy-preserving approach that empowers teams, does not micro-manage (Steiber and Alänge 2013), and aligns the interests of a DIU (i.e., the interests of the teams within a DIU) with the interests of a company, while teams in turn align the DIU with the interests of the customer and user.

The benefits of a supportive or servant leadership style that involves the autonomy-preserving transfer of decision rights are reduced costs of coordination (see also the salt-in-the-restaurant example[11] in Langlois 2002), a wider design space, and higher levels of transparency at the interface to the customer and user and thus a high level of environmental embeddedness (see **Chapter 2.2**).

Guiding Data

"Data is the new oil" is a metaphor that has been increasingly adopted in communicating the importance of data today.[12] In an NWoW, data provides the fuel for developing a digital product or service. It guides the exploration of new and the improvement of existing digital products and services by providing a common language within teams, across teams, and across hierarchies. Guiding data is the cornerstone of communication and coordination in a DIU.

Use Data as an Internal and External Compass

Guiding data can support coordination within a DIU from two perspectives: First, data provided by the customer and user can be used to improve a digital product or service and further align it with the needs of the relevant market. Second, data provided by teams can be used to improve a DIU and further align it with the needs of those who produce a digital product or service. Considering both the internal and the external perspectives is necessary for the long-term success of a

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[11] "Restaurant owners do not assert their full property rights over the salt they offer customers, but instead place the salt 'in the public domain.' Even though this destroys the patron's incentive to husband salt, any inefficiencies are dwarfed by the transaction costs of monitoring and charging for the use of the salt" (Barzel 1989 in Langlois 2002).

[12] A Google trend analysis shows increased communication since the beginning of 2016, peaking recently in April 2019.

DIU, as the internal structures of an organization will be replicate in the digital product or service that it creates (see **Chapter 2.2**).

The requirements of both customers and users and teams change over time. Choosing the right guiding data is a continuous process. The continuous identification of data that reflects the requirements of customers, users, and interdisciplinary teams is mandatory to ensure a well-aligned development of both a digital product or service and the DIU that it is produced by.

Guiding data makes the progress of developing the structures of a DIU and the development of a digital product or service and related sub-services visible. As a consequence of this visibility, the impact of decisions becomes transparent, replicable, and transferable. Transparent decisions are beneficial for three reasons: First, making decisions intended to improve the internal and external performance of a DIU is incentivized; second, understanding the impact of decisions made informs subsequent decisions; and, third, a common view enables coordinating a DIU towards a shared vision.

Vision

A vision of what a product is intended to achieve (see Ries 2011) is as important as identifying the customer and user to be addressed (see Blank 2006). Innovative endeavors may succeed as a result of engaging the right customer and user with the right product (cf. Blank 2006). Both the product and the customer and user must thus be identified and explored.

Develop a Vision Iteratively

A vision emerges over time. A digital product or service is prone to change, especially in the early stages of the growth of a DIU. At this stage, insights concerning the customer and user are used to identify a broad direction rather than to fine-hone a mature idea. Conducting experiments in direct contact with the customer and user enables teams to design a digital product or service iteratively; in addition, direct contact with the customer and user enables teams to identify the appropriate customer and user base. Hence, a vision can be the result of a process of iterative development.

Co-Develop a Vision

A vision is co-developed by both the teams and leadership of a DIU. While the leadership can connect the vision of a DIU with the overall goals of a company, teams can identify market potentials, as they develop and act at the boundaries of a company.

Increase the Communication and Visibility of a Vision with Increasing Maturity

A vision is a tool for providing a high-level context for coordinating efforts. Scaled settings with high degrees of autonomy require a vision to ensure that all efforts can be focused towards a common goal without sacrificing the bottom-up problem-solving capabilities of teams. It is valuable to have a clear direction and a "[…] true north […]" (Ries 2011); however, the more explicitly coordination is exerted, the fewer degrees of freedom can be utilized for the development of innovative approaches. The degree to which a vision is explicated should increase as a DIU grows to avoid the risk that interdisciplinary teams in a DIU might take something for granted while exploring the potential of innovative digital products or services.

Scaling

Scaling is generally the final goal in developing a digital product or service (see Ries 2011, Blank 2013, and Croll and Yoskowitz 2013). The aim is to increase the generated revenue while ensuring that the efforts invested in providing a digital product or service are maintained at a reasonable level. Organizational, technological, and processual structures should be continuously improved for the successful scaling of a DIU.

Scale, But Do Not Scale Too Early

Scaling requires making a trade-off between exploration and exploitation. Teams iterate in direct contact with the customer and user to identify a problem-solution fit with a digital product or service. The inherently flexible design process and lean and agile organizational and technological structures enable swift re-orientations. Scaling, however, can add systemic rigidity.

Scaling is used to continuously improve a digital product or service and its production. Each organizational and technological structure that contributes to the production of the digital product or service can sooner or later be affected by the continuous improvement that drives scale. Structures will either be removed or supported. If they are supported, additional structures that improve the efficiency of the initial structure will be created; for instance, manual processes can be automated. Such added structures improve efficiency while adding rigidity, as changing the initial structure entails changing the additional efficiency-driving structures. Therefore, it is necessary to understand when scaling is beneficial and when it can become an impediment to further growth.

If a DIU focuses on scaling too early, the likelihood that the full innovative potential of the unit will not be exploited is high, as innovations will remain undiscovered. In contrast, if a DIU focuses on scaling too late, the chances are that the growth of a digital product or service will be limited by the exponentially increasing overheads (see also **Chapter 2.2.2**) caused by grown organizational and technological structures.

Scale Selectively

Scaling can be done selectively. Assuming that a digital product or service can consist of parts of different degrees of maturity, especially when such a product or service is based on a modular architecture, it is wise to focus scaling efforts on more mature parts while maintaining high degrees of freedom and low degrees of scaling in less mature parts.

Less mature parts may benefit from scaling efforts (e.g., improved support for developmental processes or automated deployments), but they should be provided with the required degrees of freedom to choose. Using this approach, a DIU can scale mature parts of a digital product or service but can also remain open to future explorative endeavors.

4.3.2. Tiers and Practices of the N2DIU Model

There are explorative and exploitative activities that are critical to the survivability and success of a firm; explorative activities refer to the identification and investigation of innovative business opportunities "[…] to avoid being rendered irrelevant by changes in the market and technology […]" (March 1991 in O'Reilly and Tushman 2013), while exploitative activities focus on "[…] efficiency, control, certainty, and variance reduction […]" (ibid.). Exploration is important to ensure the long-term survivability of a company (ibid.); however, it has been found that four out of five firms underemphasize exploration (Uotila et al. 2009). Scholars recommend "[…] that organizations need to explore and exploit simultaneously […]" (Tushman and O'Reilly 1996) to realize short-term wins and ensure long-term survivability.

The Four Tiers of the N2DIU Model

The tiers of the N2DIU model seize on the idea that an organization has to "[…] explore and exploit simultaneously […]" (Tushman and O'Reilly 1996). Four tiers for guiding the development of a DIU are defined: *explore*, *growth*, *exploit*, and *engage* (see **Figure 28**).

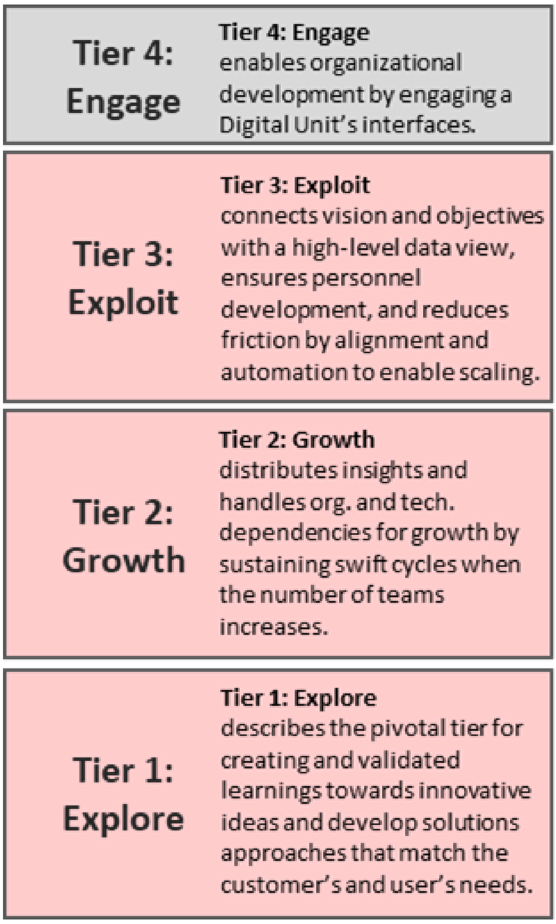

Figure 28. The four tiers of the *N2DIU* model (own depiction).

- *Explore* is the pivotal tier for creating customer insights and validated learnings to uncover innovative ideas and develop solution approaches that match customer and user's needs.
- *Growth* is the tier for distributing knowledge across teams and understanding dependencies that might slow the overall performance of a DIU.
- *Exploit* focuses on reducing the variance of the outcomes and increasing the efficiency on both previously explored and grown opportunities.
- *Engage* focuses on leveraging the accumulated knowledge of various areas accrued over the course of developing a DIU.

The first three tiers introduce new disciplines (see **Chapter 4.3.1**) and practices. The fourth tier is an exception; it does not add any further disciplines but focuses on leveraging the accumulated knowledge that has been developed within each discipline over time.

The concept of tiers enables the progressive development of existing DIUs. In existing DIUs, the levels enable focused development; for instance, if the existing business model of a DIU is to be exploited, that DIU should focus on becoming a tier 3 DIU. Alternatively, the tiers also can guide the development of a DIU from scratch.

Practices of the N2DIU Model

Practices describe specific activities that have to be continuously executed in the development and operation of a DIU. Each practice's presentation follows a pre-defined structure; a recurring theme is applied to facilitate navigation among the different categories of information that constitute the description of a practice.

The structure for presenting a practice resembles the components of an information systems design theory as proposed by Gregor and Jones (2007, see **Table 18**)[13]. Each practice is composed of six elements; that is, each practice's description begins with a table that provides an overview of the constructs that define a practice, followed by an introduction that motivates the purpose and scope behind establishing that practice.

Elements for describing a Practice	Content
Synoptical Table	Overview of the purpose and scope a practice.
Introduction	The motivation and purpose of a practice.
Activities	Description of the constructs that define the scope of a practice and its principles of form and function.
Indicators	Testable propositions for assessing whether a practice is practiced.
Synergies	Relationships with other practices in the model that propose options regarding the mutability of a practice.
Sources	Summary of the justificatory knowledge that motivates a practice.

Table 18. Structure of practices (own depiction).

Each practice is then further broken down into specific activities that can define either the form, function, or both of a practice and by information concerning the combinability of that practice with other practices; the information exchange at the interfaces of two practices can change how a practice is executed and therefore shows options for a practice's mutability.

[13] In their article "The Anatomy of a Design Theory," Gregor and Jones (2007) elaborate on six plus two (the latter two are optional) components of an IS design theory: 1) purpose and scope, 2) constructs, 3) principle of form and function, 4) artifact mutability, 5) testable propositions, 6) justificatory knowledge, 7) principles of implementation, and 8) expository instantiation.

Each practice is then further described by testable propositions in the form of indicators that emphasize what should be inspected and assessed to determine whether or not a specific practice has been executed.

Practices may yield both positive and synergistic effects when implemented concurrently. There are three different types of synergies between practices:

- a *processual synergy* describes the positive effects of information exchange at the interface between a practice of any discipline within the model and a practice of the discipline the *new way of working,*
- an *organizational synergy* describes the positive effect by an information exchange at the interface between a practice of any discipline and a practice of an organizational discipline, and
- a *technological synergy* describes the positive effect by an information exchange at the interface between a practice of any discipline and a practice of a technological discipline.

The relationships among practices are expressed by forward and backward references in the documentation. The use of forward references in scholarly publications is uncommon. However, the N2DIU model guides the design and development of DIUs; developing DIUs is a complex endeavor and sometimes requires taking a step back or forwards. This intentional design choice reflects the nature of a DIU development process. Note that a relationship between two practices is described in more detail when it is introduced the first time but is described briefly if it is mentioned a second time but from the opposing point of view; in this case, the documentation will provide a reference to the occurrence of the initial description.

Finally, the description of each practice closes with justificatory knowledge in the form of the sources that motivated the inclusion of a practice within the N2DIU model.

Structure of the Remainder of this Chapter

In the following sections, I introduce the tiers of the N2DIU model and describe how each tier relates to the disciplines of the model (see **Chapter 4.3.1**). Beginning with tier 1, I describe a journey that begins with the exploration of opportunities on tier 1, towards growing a DIU around these identified opportunities on tier 2, to exploiting the identified fit between the customer and user and a DIU's digital product or service on tier 3. Finally, I describe how knowledge transfers at the boundaries of a DIU can enable further ecosystem engagement on tier 4.

I introduce each tier by describing its purpose and focus and the disciplines introduced in that tier and providing an overview of the practices introduced with each tier. Each tier's practices can be further divided into by a- and b-practices. A- and b-practices describe sub-layers of practices within a tier. Each sub-layer of practice follows a certain purpose, which I describe with the introduction of each sub-layer. Thereafter, I present the practices of each tier in detail. I use quotes from my empirical material (see **Chapters 0** and **5**) where appropriate to enrich the descriptions of tiers and practices.

4.3.2.1. Tier 1: Explore

Tier 1: Explore focuses on creating validated learnings intended to support the development of digital products or services that match customer and user's needs. The highly explorative and autonomy-driven approach behind tier 1 is aimed to encourage innovation to in turn promote an entrepreneurial culture and plant the seed for innovation (see also **Chapters 2.1.2, 2.1.5.2**).

Disciplines

Tier 1: Explore introduces three disciplines (see also **Chapter 4.3.1**):

- Interdisciplinary organization,
- An NWoW, and
- Technological autonomy.

Each of the disciplines introduced with a tier defines certain foundational requirements. Tier 1 introduces three disciplines; thus, three requirements must be met. The first requirement is to have at least one diverse and interdisciplinary team that is provided with a certain degree of freedom regarding the scope of its development activities. A DIU expert from a large globally active corporation with experience of successfully developing a DIU emphasized why teams need to not only be interdisciplinary but also diverse:

"Team constellations need to be diverse.
Ten men between the ages of 20 to 25 cannot design the required customer experience for a target group of 70-year-old retired females."

– DIU development expert

The second requirement is the provision of a mandate to experiment that enables teams to experiment in direct contact with the potential customer and user. An analyst and test manager with more than five years of experience within a DIU explains why a mandate is required for an efficient process:

"Creating a test setup that works takes us two hours.
But communicating with everyone who wants to have a stake in it can take us up to two months."

– Analyst and test manager

The third requirement is the availability of a technological architecture that can be autonomously used by each team to experiment and develop their part of the digital product or service; the autonomous use of the technological architecture also includes degrees of freedom regarding the use of tools that teams might require in the course of their explorations.

Together, these three requirements ensure that teams can autonomously explore customer and user needs in swift cycles to continuously strengthen their engagement with a DIU's digital product or service.

Practices

Tier 1: Explore introduces two practices at the interfaces among the three disciplines (see **Figure 29**; see also **Figure 26** for a view of the whole model). The two practices are

- W1a: Experiment qualitatively
- W1b: Experiment quantitatively

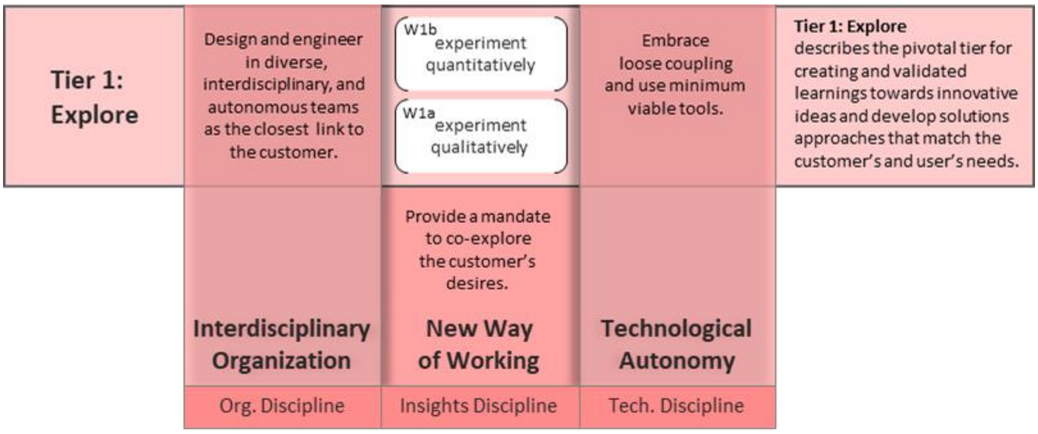

Figure 29. The *N2DIU* model: focus on *Tier 1: Explore* (own depiction).

Both kinds of experiments (*W1a* and *W1b*) provide different but mutually advantageous benefits: qualitative experiments are an efficient approach for exploring the problem space and taking the first steps towards a solution, while quantitative experiments are especially suitable for understanding the impact of solutions or potential solutions.

Both kinds of experiments are intended to be used within BML cycles (see also **Chapter 2.1.5.1**) to ensure that experiments are conducted in swift iterations with the goal of achieving a continuous alignment with customers and user's needs.

Practice W1a: Experiment Qualitatively

Identifier	Practice	Tier	Discipline
W1a	**Experiment qualitatively**	**1: Explore**	**New way of working**
Short Description			
W1a: Experiment qualitatively is a suitable means of efficiently creating validated learnings. Qualitative experiments are especially suitable for understanding the needs of the customer and user and exploring novel concepts and ideas. The outcomes of qualitative experiments are prototypes.			

Table 19. *W1a: Experiment qualitatively* (own depiction).

Introduction

Exploring new approaches in uncharted terrain is an inherently uncertain process. Explorative activities such as identifying new business opportunities or conducting a foundational overhaul of existing digital products or services require teams to create validated foundational learnings. Ideas and concepts that are worth pursuing must be identified. This process can involve several design iterations to refine a concept or even a pivot between different ideas (see Ries 2011, Maurya 2012). Qualitative experiments are an efficient approach for distinguishing between promising and non-promising concepts.

"Experiments are an efficient way to understand what doesn't work and what we should be doing instead."

– DIU analyst and test manager

Activities

W1a: Experiment qualitatively enables the efficient exploration of an as yet unknown problem and solution space. By refraining from an actual implementation of a fully working solution, validated learnings can be created in swift iterations. Different methods, for instance, DT (Brown 2009) and LS (Ries 2011), propose a wide variety of approaches for conducting qualitative experiments, such as conducting customer and user interviews, paper prototypes, mock-ups, click dummies, or MVPs, the latter of which can actually be a suitable vehicle for conducting both qualitative and quantitative experiments (see also *W1b: Experiment quantitatively*).

These and other approaches can be progressively applied to identify and refine an idea in direct contact with the customer and user, who can provide instant feedback. The strength of initiating the exploration (see **above; Tier 1: Explore**) of novel digital products and services with qualitative experiments lies in the reduction of uncertainty with a comparably low effort.

Indicators

Indicators for assessing whether a DIU conducts qualitative experiments are the early integration of the customer and user into the development process and whether the unit uses qualitatively validated learnings to fuel further experiments.

Synergies

Different synergies can be realized by combining qualitative experiments (*this practice*) and other practices included in the N2DIU model. A **processual synergy**[14] can be realized by combining *this practice* with *W1b: Quantitative experiments*. The results of qualitative experiments (*this practice*) are two-fold: First, qualitative experiments result in concepts and prototypes that are not necessarily meant to be made available to or tested with the general public, and, second, qualitative experiments result in the creation of validated learnings. Quantitative experiments (see *W1b*) go one step further by building on promising concepts and prototypes identified over the course of a series of qualitative experiments and initiating experiments for testing these concept's resonance with a wide range of potential customers and users. Quantitative experiments are the next logical step in the development of a digital product or service.

A further **processual synergy** can be realized when combining *W1a* with *W2a: Account validated learnings*. W2a processes and documents validated learnings in various formats for the distribution of knowledge across teams and time to bilaterally inform future experiments (*this practice*) in the long run.

Sources

W1a: Experiment qualitatively is predominantly inspired by DT (Brown 2009). Further sources that guided the choice of including qualitative experiments within the N2DIU model are Blank (2009), Ries (2011), and Maurya (2012), who describe an approach to experimentation that is

[14]The types of synergies are **bolded** to facilitate the reader's navigation. If not stated otherwise, the sequence of introduced synergies is as follows: **processual**, **organizational**, and **technological**. Processual synergies relate to practices that are based on the insights discipline, organizational synergies relate to practices that are based on organizational disciplines, and technological synergies relate to practices that are based on technological disciplines. Please consult **Chapter 4.3.1** for more details on the different disciplines of the N2DIU model.

characterized by obtaining customer and user insights with a high cadence and the least possible effort at the beginning and a shift to more elaborate experiments later to promote an increased level of maturity in terms of problem and solution knowledge.

A further source of inspiration is provided by Tashakkori and Teddlie (1998), who describe the benefits of combining qualitative and quantitative approaches within a mixed methodology. For more details on DT and LS, see **Chapter 2.1.5.1.**

Practice W1b: Experiment Quantitatively

Identifier	Practice	Tier	Discipline
W1b	**Experiment quantitatively**	**1: Explore**	**New way of working**
Short Description			
W1b: Experiment quantitatively is a suitable means for exploring the resonance of solution approaches in light of a broad audience and furthermore for testing minor modifications to existing solutions intended to improve a digital product or service. Quantitative experiments are particularly useful for initiating and tracking the growth of digital services or products.			

Table 20. *W1b: Experiment quantitatively* (own depiction).

Introduction

Quantitative experimenting refers to conducting experiments with the intention of obtaining validated learnings by reflecting on concepts and testing solutions in collaboration with a broad audience. Quantitative experiments are a suitable means for creating further validated learnings after a problem worth solving and first solution approaches have been identified.

"The experiments help us tremendously in identifying whether our developments have a real impact or whether a development increment was nonsense and not worth the effort."

– DIU analyst and test manager

Quantitative experiments are suitable for testing customer and user resonance with new solution approaches or for testing specific changes made to an existing solution approach. Quantitative experiments can be seen as a consequence of not only qualitative experiments (see Müller and Thoring 2012, Ximenes et al. 2015) but also prior quantitative experiments (see Ries 2011, Maurya 2012).

Activities

W1b: Experiment quantitatively refers to conducting quantitative experiments by applying different methods. For instance, fake-door tests can be used to test novel value propositions without the need to implement actual functionality, and MVPs are a suitable means of testing the resonance to the design and the functionality of a novel value proposition. Both approaches can be combined with A/B testing, which is also referred to as split-testing.

A/B testing refers to the comparison of two competing alternatives and splitting the digital traffic between them with the goal of determining which alternative yields a higher resonance. A/B testing can be used in combination with both the above-mentioned approaches and in combination with existing solutions. In this case, a new a novel solution is used to challenge the existing solution, and the traffic is split between both.

Quantitative experiments create validated learnings by quantification of the experiment outcomes and enable data-driven and swift decision-making (see also **Chapter 2.1.5.3**). However, identifying the appropriate metrics is not a trivial process.

"The team does not yet know which metrics matter."

– Interdisciplinary team PO

Note that the metrics used for quantifying the outcomes of quantitative experiments should be *actionable* (see **Chapter 2.1.5.1**).

Indicators

An indicator for assessing whether a DIU conducts quantitative experiments is the creation of validated learnings based on quantitative data, which should be gathered with with each change to a digital product or service that impacts the customer and user experience; this does not include the implementation of solutions to known problems (e.g., addressing software failures), however. A further indicator is whether the created validated learnings are used to fuel further experiments.

Synergies

Different synergies can be realized by combining quantitative experiments (*this practice*) with other practices included in the N2DIU model. A **processual synergy** can be realized by combination this practice with *W1a: Qualitative experiments*. Quantitative experiments (*this practice*) can be used to assess the general resonance between the customer and user and a solution approach. If a fundamentally different approach to a digital product or service is be explored, for instance, by conducting a pivot, new fundamental validated learnings must be obtained. In such a case, it is reasonable to go one step back to *qualitative experiments* (see *W1a*) to efficiently uncover these fundamental validated learnings. Furthermore, while quantitative experiments show correlations, they are limited in that they do not provide any insights into the causalities behind such correlations. To understand causalities in addition to correlations, a mixed qualitative (see *W1a*) and quantitative approach is appropriate.

A further **processual synergy** can be realized when combining *W2b* with *W2a: Account validated learnings*. The accounting of validated learning documents these in various formats to enable a distribution of knowledge across teams and time. This distribution of knowledge enables teams to bilaterally inform future quantitative experiments.

Sources

W1b: Experiment qualitatively is predominantly inspired by the LS approach (Ries 2011). Further sources that guided the choice of including quantitative experiments within the N2DIU model are Maurya (2012) and Croll and Yoskowitz (2013), with both sources providing additional insights into conducting quantitative experiments and selecting meaningful metrics. Detailed success stories concerning experimentation (and quantitative experimenting in particular) can be found in Ries (2011), Maurya (2012), and Kohavi and Thomke (2017). Similarly to qualitative experiments (see *W1a*), a Tashakkori and Teddlie (1998) and their propositions concerning combining qualitative and quantitative approaches served as a source of inspiration. Please also consult **Chapter 2.1.5.1** for more details on the LS approach.

4.3.2.2. Tier 2: Growth

Tier 2: Growth focuses on growing a DIU based on business opportunities worth pursuing (as identified in *Tier 1: Explore*). To achieve such growth, the second tier defines structures for distributing and preserving knowledge among teams (see also **Chapter 2.1.5.1**) as well as structures for understanding and managing the impact of organizational ties and technological dependencies on team and development performance (see also **Chapter 2.2**).

Tier 2: Growth introduces two additional disciplines, one of which can be classified as an organizational discipline and the other a technological discipline; the two disciplines are *supportive leadership* and *guiding data*. Each discipline defines requirements that, when fulfilled, serve as the foundation for related practices.

The requirements defined by the discipline *supportive leadership* are the provision and maintenance of a DIU as a platform for team-driven experiments; that is, the leadership supports the teams in supporting the customer and user. This view includes the abolishment of the practice of holding teams accountable for pre-determined development targets to preserve autonomy and provide teams with a wide solution space (see also **Chapter 4.3.1**). Such an abolition of holding teams accountable for pre-determined development targets requires a supportive leadership to draw on new coordination mechanisms. *Guiding data* enables the implementation of such coordination mechanisms.

The requirements defined by the discipline *guiding data* are expressed not only in the validation of decisions related to internal structural changes but also in the form of externally perceivable changes to the digital product or service a DIU offers; that is, decisions concerning structural changes to the unit or the product must be either informed or validated by data. This approach enables a continuous adaption of the internal structures of a DIU to the needs of the teams and a continuous adaption of the digital product or service to the needs of the customer and user (see also **ibid.**).

Together, both disciplines ensure transparent decisions and facilitate learning about both a DIU and the customer and user. Such transparency and knowledge facilitate aligning a DIU within an established enterprise by enabling knowledge exchange and preserving autonomy. Furthermore, transparency and knowledge exchanges facilitate the external alignment of a DIU with the needs of the customer and user in order to purposefully adapt digital products or services and to thus ensure that a DIU achieves a high degree of embeddedness within its ecosystem.

Tier 2: Growth introduces six practices. The six practices are positioned at the interfaces of the two disciplines introduced with this tier and the three existing disciplines introduced with tier one (see **Figure 30**; see also **Figure 26** for a depiction of the whole model). The six practices are as follows:

- W2a: Account validated learnings
- I2a: Develop internal skills
- T2a: Develop common insights
- W2b: Socio-technical inquiry
- I2b: Shape work environment
- T2b: Pay technical debts

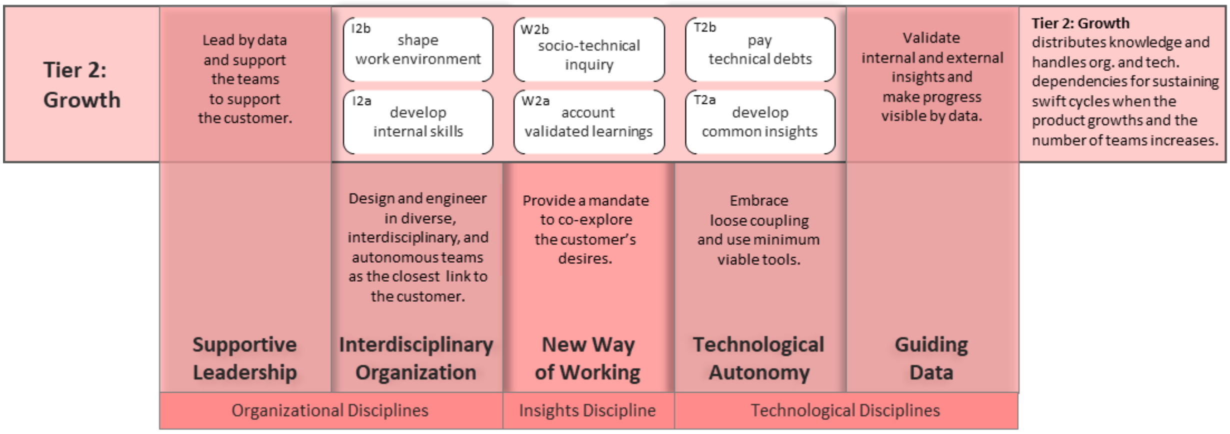

Figure 30. The *N2DIU* model: focus on *Tier 2: Growth* (own depiction).

The new practices introduced by *Tier 2: Growth* can be further differentiated into *x2a* and *x2b* practices.

The *x2a* practices aim to facilitate sustained development by describing activities through which teams can guide and plan their experiments and ensure that validated learnings are distributed among teams (*W2a*); in addition, these practices identify activities that focus on preserving accumulated knowledge concerning customers and users within a DIU, reducing friction due to structural mismatches on the organizational level (*I2a*), and reducing communication barriers that may hinder teams in exchanging results (*T2a*).

The *x2a* practices ensure that the knowledge held by individuals is distributed, reduce the potential negative effects of fluctuation, facilitate skill rotations between teams, and ensure that a common view on a digital product or service as a whole is achieved to avoid the disintegration of the digital product or service as a system grows.

The *x2b* practices are intended to facilitate an intentional organizational and technological decoupling. These practices describe structures for efficiently and continuously identifying socio-technical ties and dependencies that might have a negative impact on the teams' performance (*W2b*), for purposefully channeling communication and manage the implicit impact of communication on technological structures (*I2b*), and for solving related root causes underlying a slowing tie or dependency and paying related technological debts (*T2b*). The *x2b* practices provide supportive leaders with an in-depth understanding of how to manage a growing number of ties and dependencies and furthermore how to accumulate the knowledge required to inform future foundational organizational and technological restructuration if necessary.

Practice W2a: Account Validated Learnings

Identifier	Practice	Tier	Discipline
W2a	**Account validated learnings**	**2: Growth**	**New way of working**
Short Description			
W2a: Account validated learnings leverages and distributes validated learnings provided by the bottom-up-driven approach to experimentation of a DIU's NWoW. W2a emphasizes using validated learning as the central accounting unit in a DIU. The process of accounting validated learning supersedes traditional accountability paradigms and induces a cultural change. In addition, such an accounting serves as the pivotal mechanism for knowledge exchange and coordination in teams, among teams, and among teams and the leadership of a DIU.			

Table 21. *W2a: Account validated learnings* (own depiction).

Introduction

A cultural change requires a change in a company's accountability paradigm (Ries 2017). Such a change in an accountability paradigm can affect those who are accountable and what they are accounted for. As opposed to traditional leadership approaches, a supportive leadership approach (see **above**) does not prescribe the development of specified deliverables but rather identifies an aspect of a digital or service a team should focus on and discusses the general direction in which that component should be taken.

Traditionally, deliverables-based coordination relies on various coordination instruments that embed deliverables as a focal communication instrument; meetings are held to define deliverables, efforts are estimated, as-is progress and to-be progress are compared and discussed, and roadmaps are designed and transparently positioned to align various stakeholders around a common purpose. Relying on deliverables-based coordination, however, renders experiments in direct contact with the customer and user obsolete, as the insights obtained are not intended to be iteratively incorporated.

"Right now, it is very difficult to explain
why experiments are important to our development."

– Interdisciplinary team PO

The change in the way in which work is coordinated enables teams to iterate swiftly, as they do not have to coordinate with stakeholders other than customers and users when defining the scope of changes to concerning their part of the digital product or service.

"If you don't change pivotal processes, like, how decisions are made and based on what these decisions are made, then nothing will change."

– DIU leader

The increased flexibility that results from a decrease in the importance of long-term oriented planning and of a coordination that is based on deliverables (see Drews et al. 2017). In an NWoW, teams autonomously build deliverables not as an end in itself but rather to identify and match the customer and user's needs; teams iterate on the basis of experiments to create validated learnings (see **Chapter 4.3.2.1**). As validated learnings are the new unit of output, they must be the new accounting unit.

Activities

W2a: Account validated learnings refers to a process that is based on regular team-spanning meetings for exchanging validated learnings that can be documented in different formats. *Experiment reports* are a pivotal instrument for planning and reviewing the creation of validated learnings (Maurya 2012). Experiment reports are an efficient way of determining ex ante the background and hypothesis of an experiment and documenting ex post the results, details, validated learnings, and follow-on plans for the next iteration.

Other instruments such as the *value proposition canvas* (Osterwalder et al. 2014) or the *business model canvas* (Osterwalder and Pigneur 2010) can support teams in planning and creating validated learnings by highlighting different areas of development that can be considered when conducting experiments in a larger context. In addition, these instruments can be used on the individual team level or on a team-spanning level by considering different levels of aggregation.

The cadence of team-spanning meetings can vary. Explorative experiments are highly likely to yield more fundamental validated learnings over a short period of time that can change the development direction a digital product or service can take, whereas exploitative experiments focused on refining a digital product or service may be less prone to breaking new ground and are therefore less likely to result in fundamental changes to the design design of a digital product or service. In accordance with a DIU's focus on either exploration or exploitation, it appears reasonable to choose to vary the cadence used for the distribution and discussion of validated learnings (e.g., between one to six weeks).

The benefits of accounting validated learnings are the opportunity to manifest and drive a cultural change towards an entrepreneurial culture that focuses on the customer and user's needs; the distribution of customer- and user-related knowledge; a focus that shifts from the input to the outcomes of development activities; teams being enabled to plan, communicate, and track their progress with a focus on the customer and user; an efficient bottom-up-driven coordination of autonomous teams; and a first initial approach to counteracting the disintegration of a growing and highly autonomous system (cf. Conway 1968).

Indicators

An indicator for assessing whether a DIU takes validated learnings into account is the existence of regular and instrument-based (see **above**) communication that focuses on autonomously created validated learnings; a negative example in the sense of accounting for validated learnings is the use of traditional artifacts for coordinating development efforts that preserve a top-down approach to scope definition (e.g., the definition of roadmaps and related processes).

Synergies

Different synergies can be realized by combining the accounting of validated learnings (*this practice*) with other practices of the N2DIU model. **Processual synergies** can be realized when this practice is combined with the tier 1 practices *W1a: Experiment qualitatively* and *W1b: Experiment quantitatively* (see **Chapter 4.3.2.1** for a description of the synergies).

A further **processual synergy** can be realized when combining *this practice* with the practice *W2b: Socio-technical inquiry*. *W2b* involves the identification of organizational ties and technological dependencies might slow development. The ties and dependencies are identified through an end-to-end process view derived from the teams' perspectives. Linking the process of identifying slowing organizational ties and technological dependencies (see *W2b*) to the process of communicating validated learnings (*this practice*) enables an efficient structural review that can provide many examples based on the individual processes for creating validated learnings. Leveraging the combination of both practices can indicate the impact of restructuring organizational ties or technological dependencies. However, it should be noted that the cadence of *W2a* and *W2b* should differ, as the rate at which experiments are conducted might be faster than conducting structural changes.

An **organizational synergy** can be realized in combination with *I2a: Develop internal skills*. *I2a* describes how internal knowledge fluctuation and communication barriers can be reduced by considering certain aspects when sourcing of skills or by reducing the degree of outsourcing. The knowledge documentation and distribution function of the process of accounting of validated learnings (*this practice*) can be helpful in terms of mitigating the potential negative effects of knowledge fluctuation and communication barriers (cf. *I2a*).

A **technological synergy** can be realized in combination with *T2a: Develop common insights*. *T2a* describes how a shared technological view on customer and user insights enables teams to communicate, plan, jointly coordinate, and track experiments. Therefore, a shared view on customer insights (*T2a*) can reduce communication barriers and facilitate the communication of validated learnings (*this practice*).

Sources

W2a: Account validated learnings is inspired by *innovation accounting*, as described in Ries (2011), Maurya (2012), and Ries (2017). Further sources that informed the choice to include the accounting of validated learnings in the N2DIU model are Blank (2006, 2009) and Ries (2011), both of whom emphasize the importance of customer discovery and validated learnings; Osterwalder and Pigneur (2010) and Osterwalder et al. (2014), who define suitable constructs for guiding growth around a pivotal value proposition; Westerman et al. (2014), Cianni and Steckler (2017), Haffke (2017), and Weingarth et al. (2019), who emphasize the importance of driving a cultural change with an NWoW in light of the digital transformation of a firm; and, finally, Ries (2017), who highlights the importance of changing the prevailing accountability paradigm in terms of achieving a cultural change.

Practice I2a: Develop Internal Skills

Identifier	Competency	Tier	Discipline
I2a	**Develop internal skills**	**2: Growth**	**Interdisciplinary organization**
Short Description			
I2a: Develop internal skills is crucial in allowing a DIU to avoid the emergence of communication barriers between functions. The development of internal skills can further reduce fluctuation of knowledge concerning the customer and user and the use of tools and methods. Both communication barriers and knowledge fluctuation are known to have a negative impact on development performance and the design of a digital product or service. The development of internal skills is decisive in ensuring the long-term success of a DIU.			

Table 22. *I2a: Develop internal skills* (own depiction).

Introduction

The efficient and effective growth of both a DIU and the digital product or service it produces requires progressive knowledge development. It also requires experience in terms of applying the right tools and techniques to successfully leverage validated learnings. Validated learnings can be documented and distributed across teams and team members (see also practice *W2a*), but there is also a tacit component associated with individuals. Overall, a DIU should strive to develop and maintain internal skills to both avoid knowledge fluctuation and preserve tacit and explicit knowledge concerning both the digital product or service and the customer and user.

Activities

I2a: Develop internal skills addresses challenges related to knowledge fluctuation and structurally induced communication barriers through various recommendations. The goal of this practice is to allow members of a DIU to build and maintain internal skills. Outsourcing is known as a viable option for scaling a DIU (see Weingarth et al. 2019), but, ideally, outsourcing should be kept to a minimum and focus on sourcing specialized knowledge. *I2a* recommends focusing on the development of internal skills but highlights certain aspects that should be considered in the case of outsourcing.

Approaches to increasing strengthening internal skills are talent acquisition, the acquisition of service providers or startups with similar backgrounds (see Hess et al. 2016, Cianni and Steckler 2017, Swaminathan and Meffert 2017), the creation of a startup incubator (see Hess et al. 2016), and the use of the signaling effect that the adoption of an NWoW in an innovative DIU can have on potential future employees.

Interdisciplinary teams usually consist of five to seven members but can also be larger (see Corso et al. 2018). Members of interdisciplinary teams can be provided by the internal business and IT functions of a company to create a new form of business-IT collaboration (see also Urbach and Ahlemann in Legner et al. 2017) and to overcome any potential silo mentality.

An NWoW introduces a methodical approach to work that can fundamentally differ from those of traditional. The adoption of this new approach can be supported by providing explicit and tacit knowledge. Regular training on methods on several levels and the provision of lean and agile coaches can provide a basis for nurturing the development of skills (see Andler 2012, Virgenschow 2015; see also Böhmann et al. 2015, Kirsner 2016b, Weingarth et al. 2019).

"I think that providing teams with support in selecting and applying the right methods is necessary for testing hypotheses."

– DIU leader

The provision of knowledge can be intended to support the selection of a method and the application thereof or to moderate and resolve discussions (Vetterli et al. 2013, Virgenschow 2015). Innovative organizational units such as DIUs provide teams with a pooled capacity by staffing lean or agile coaches and experts to make this knowledge available. The knowledge is provided in individual sessions on demand or regular training. Improved method knowledge can also improve interdisciplinary collaboration, as it facilitates speaking a common language.

If a DIU has to rely on sourcing to initiate growth, certain aspects should be considered. DIUs rely on interdisciplinary structures. For instance, a functionally oriented sourcing strategy that is based on sourcing functions from different service providers can nurture the emergence of communication barriers between functions.

The reasons behind the emergence of communication barriers are various: Service providers may compete for the same budget, may have signed contracts that are based on different conditions, or may follow different hidden agendas. Hence, they may not necessarily share the same views on a digital product or service (see Müller et al. 2014, Colfer and Baldwin 2016).

In the event that outsourcing is required to enable the rapid growth of a DIU, leadership should consider sourcing from a full-stack provider to avoid communication barriers arising among the roles within an interdisciplinary team. Leadership should also put a strong emphasis on intradisciplinary communication.

Leadership can further consider sourcing from several full-stack providers to leverage the potential benefits of having a healthy degree of competition between different interdisciplinary teams or utilize different levels of experience; for instance, service provider A might be suitable for exploring new innovative approaches, while service provider B might be suitable for exploiting an established business.

Leadership should consider the option of designing sourcing contracts that incentivize interdisciplinary communication and collaborative behavior. These contracts should further determine the degree of fluctuation, meaning that the degree to which a service provider can exchange personnel should be defined. In addition, shared agreements that span several providers could be an option for reducing the potential negative effects of knowledge fluctuation and communication barriers.

Indicators

Indicators for assessing whether a DIU builds internal skills are the degree of outsourcing, the number of involved service providers, the contract design (especially if several service providers are active within a DIU), the structures of outsourcing (i.e., whether a functionally oriented or interdisciplinary oriented respectively a full-stack sourcing is effective), the provision of regular method training, the provision of coaches, and whether or not a company draws on the signaling effect of a DIU to attract or recruit new talent.

Synergies

Different synergies can be realized by combining the building of internal skills (*this practice*) with other practices of the N2DIU model. A **processual synergy** can be realized when combining this practice with the practice *W2a: Account validated learnings*; the documentation and distribution of validated learnings can have a mitigating effect on knowledge fluctuation (see also *W2a: Account validated learnings* for a more detailed description).

An **organizational synergy** can be realized when combining this practice with the practice *I2b: Shape work environment*. I2b describes how the intentional shaping of a work environment impacts the flow of communication within a DIU; a work environment that is designed in an intentional manner can support reducing communication barriers (*this practice*) and assist a DIU to reap the benefits of structural congruence. Furthermore, such an intentional design can strengthen the signaling effect of a DIU in terms of attracting new talent (see ibid.).

A **technological synergy** can be realized when combining *this practice* with the practice *T2a: Achieve common insights*. T2a states how a shared view on customer insights can benefit teams when planning and communicating experiments and their outcomes. Such a shared view on customer insights can further support reducing communication barriers and strengthen the ties in interdisciplinary teams (*this practice*) from a technological perspective, as technological structures are known to be replicated within communication flows and can thus have a preserving effect on the desired organizational structures (see **Chapter 2.2**).

Sources

I2a: Building internal skills was predominantly inspired by Maurya's (2012, 2016) observations concerning the effects that outsourcing can have on the implementation of an NWoW and by the findings on the impact of firm membership on structural congruence presented in the works of Müller et al. (2014) and Colfer and Baldwin (2016). Further sources that influenced the choice to include this practice in the N2DIU model are Andler (2012) and Kirsner (2016), both of whom emphasize the importance of conducting training on a regular basis; Virgenschow (2015), who emphasizes the importance of providing a method coach; Böhmann et al. (2015) and Weingarth et al. (2019), who observed that firms institutionalize training facilities similar to DIUs for developing digital skills and disciplines; and Hess et al. (2016), Wade (2015) in Bekkhus (2017), Cianni and Steckler (2017), and Swaminathan and Meffert (2017), who highlight the importance of attracting digital talents by, for example, employing talents, acquiring startups, engaging in corporate transactions, or creating a startup incubator.

Practice T2a: Develop Common Insights

Identifier	Competency	Tier	Discipline
T2a	**Develop common insights**	**2: Growth**	**Technological autonomy**
Short Description			
Achieving common insights enables teams to identify and develop growth vectors. A common view on insights can be used to facilitate intra-team communication and inter-team knowledge exchange. Furthermore, an autonomy-oriented bottom-up selection of tools ensures that teams can draw on tools that are suitable for their needs and are therefore helpful in understanding and addressing the needs of the customer and user.			

Table 23. *T2a: Achieve common insights* (own depiction).

Introduction

Teams are required to share a common perspective on insights that they can quickly adjust and adapt to their needs. In the growth phase of developing a digital product or service, creating quantitatively based validated learnings and promoting the exchange of related insights between teams become increasingly important for identifying and nurturing the growth vectors of a digital product or service while maintaining a common view on the whole.

"Everyone needs to be able to understand the experiment results of other teams so we can learn, gain insights, and accumulate knowledge as a whole."

– DIU analyst and test manager

Autonomy in the development of innovative digital products or services is crucial, as it motivates teams to continuously improve and adapt their part of a digital product or service to customers and users' needs (see **Chapter 2.1.5.2**).

Activities

T2a: Achieve common insights aims to create a common data-oriented understanding of customer and user insights that enables teams to assess whether they are on the right development path. This understanding supports knowledge exchange both within and across teams (see also Gottesheim 2015). An established and shared perspective on customer and user insights can further strengthen the positioning of validated learnings as the core driver of development efforts; thus, it can also support the process establishing a new culture and an NWoW.

The choice of a tool for establishing a common view on data should be left to the teams in the early development stages of a DIU, as choosing a suitable tool and view on data can depend on the underlying technology of a digital product or service and the availability of tools on the market. As consolidating the requirements of various teams in the form of a common view on insights can be challenging, reconciling these requirements with the requirements of the overall enterprise can impede the development of a DIU.

Indicators

Indicators for assessing whether a DIU has achieved a common view on insights are whether teams are provided with the freedom to choose their own tool or tools for for tracking and processing customer and user insights, whether such tools are used as pivotal instruments for the intra- and inter-team communication of insights, and whether the tools used can be customized by teams to reflect the needs of the customer and user.

Synergies

Different synergies can be realized by combining the achieving of common insights (*this practice*) with other practices of the N2DIU model. A **processual synergy** can be realized by combining *this practice* with the practice *W2a: Account validated learnings* (see *W2a* for a more detailed description); a common view on insights further facilitates knowledge exchange across team boundaries and can strengthen the establishment of a way of working that is based on validated learnings from a technological perspective.

An **organizational synergy** can be realized by combining *this practice* with the practice *I2a: Develop internal skills* (see *I2a* for a more detailed description); a common view on insights (*this practice*) can further mitigate the effects of communication barriers, which is one of the goals of *I2a*.

Technological synergy can be realized by combining *this practice* with the practice *T2b: Pay technological debts*. *T2b* focuses on how the identification and resolution of the underlying root causes of technological performance issues and failures are necessary to avoid the long-term slowing effect of technological debts. A shared perspective on insights (*this practice*) can highlight bottlenecks in the customer's digital journey. Such bottlenecks can occur either in the design of a digital product or service or as a result of technological issues. In either case, such a bottleneck can be identified when a shared perspective on insights exists, and, in the latter case, adding performance-relevant metrics to a common view on insights can support the process of identifying the issue and its root cause (see *T2b*).

Sources

T2a: Achieve common insights was inspired by Croll and Yoskowitz (2013), who dedicated their book *Lean Analytics* to the topic of how a data-based view can be used as a navigation tool for towards growth. In addition, *T2a* was inspired by reflecting on a combination of the works of Conway (1968), Chandy and Tellis (2000), and Ries (2011), which led to the insight that, while established enterprises tend to implement on-size-fits-all solutions, they should instead allow for a bottom-up selection of technology in innovative settings given the uncertainty associated with developing digital products and services in NWoW (see **Chapter 4.3.1**).

Practice W2b: Socio-Technical Inquiry

Identifier	Competency	Tier	Discipline
W2b	**Socio-technical inquiry**	**2: Growth**	**New way of working**
Description			
W2b: Socio-technical inquiry refers to a continuous process for leveraging an end-to-end process view obtained through the lens of interdisciplinary teams. This view is intended to allow a company to maintain high levels of productivity and organizational flexibility; in addition, it can be used to inform and prepare for fundamental architectural changes by providing a profound understanding of the system in question.			

Table 24. *W2b: Achieve common insights* (own depiction).

Introduction

Developing a profound understanding of organizational and technological ties and dependencies is crucial when attempting to grow a DIU and prepare it for upscaling. Such a profound understanding must consider the different natures of ties and dependencies. Ties and dependencies can be latent in the sense that they draw on knowledge that is not explicitly defined; they can be transient, as the state of a system can change continuously; and they can be made explicit in the form of architectural definitions and documentation (see **Chapter 2.2**).

Understanding and managing the different kinds of ties and dependencies is essential for maintaining a high level of productivity and organizational flexibility. Undesirable dependencies often occur at the boundaries of a DIU and can limit the degree of autonomy and thus reduce the overall development speed.

"Currently, the main effort in setting up experiments is due to reconciliation and alignment with external functions."

– DIU analyst and test manager

"The speed of our iterations is tremendously limited as soon as we have to interact with the established core processes of the enterprise."

– DIU leader

Productivity is critically reliant on team autonomy in DIUs (see **Chapter 2.1.5.2**). The scope of a team's autonomy should include making decisions concerning a defined domain within the overall context of a digital product or service. The decision rights range end-to-end over different development stages, such as ideation, conceptualization, prototyping, improving, and operating a cutout of a digital product or service. This end-to-end view is seen as a valuable source for understanding ties and dependencies (Imtiaz and Ikram 2013); furthermore, it can be leveraged to identify and understand the different natures of ties and dependencies. As the network of ties and dependencies grows with the growth of a DIU, understanding and identifying ties and dependencies and their natures is an essential step in maintaining high levels of autonomy and organizational flexibility in scaled DIUs.

Organizational flexibility is crucial for the sustained growth of a DIU. As a system grows, its structures tend to become rigid (see Conway 1968). The internal structures of organization imprint themselves within the products or services that those organizations produce (see ibid.); thus, the product or service created by a rigid system will sooner or later fail to match the requirements of an ecosystem that is characterized by a high degree of uncertainty (see also **Chapter 4.2**). Therefore, it is crucial that a company identifies a means of constantly driving change and adapting the structures of a system to the requirements of customers and users with regard to a digital product or service. Informed and inter-subjectively understandable decisions support the process of driving change.

Leveraging an end-to-end process view based on the observations of teams can inform decisions and reason future structural changes. As opposed to architectural reviews, which adopt a view that is detached from the daily operations of teams and capture neither latent (see Colfer and Baldwin 2016) nor transient (see ibid.) ties or dependencies, an end-to-end process view can uncover ties and dependencies of different natures that are relevant to the actions of teams (see **Chapter 2.2**).

A team's development process integrates both organizational and technological resources to develop a digital product or service. Thus, both organizational and technological ties and dependencies that have a negative impact on a team's productivity can surface during the development process. A shared understanding of the development process based on a team's perspective can allow such ties and dependencies to be easily identified; in addition, such an understanding can provide information concerning the perceived relevance of solving the underlying issues without the need to conduct lengthy and resource-intensive architectural reviews.

Organizations are complex systems; thus, the actual processes of teams do not necessarily follow predefined lines. Therefore, leveraging an end-to-end process view can further be used to obtain information on ties and dependencies that are undefined within documentation or tools and that reflects the current and actual state of an overall system. Information on the actual and current state of a DIU and on latent and transient ties and dependencies and an efficient assessment of the perceived impact thereof on productivity can contribute to the process of documenting ties and dependencies that might negatively impact the growth of a DIU and the reasons behind them. Such documentation can prove useful when communicating issues to stakeholders who are relevant to resolve such issues. Therefore, leveraging an end-to-end process view on a regular basis not only makes it possible to uncover potential opportunities for maintaining and increasing productivity but also contributes to maintaining organizational flexibility by exposing what has to change and why.

Fundamental architectural changes can be necessary to ensure that the internal structures of a DIU match the requirements of the digital product or service that it produces. Conducting fundamental architectural changes can affect DIUs that have been developed on a greenfield but also holds true when established structures shall be transformed. DIUs build on modular structures in the organizational, processual, and technological domains to maintain flexibility and upgradeability with regard to both the digital products or services that they produce as well as the internal structures of the producing DIU (see also **Chapter 4.2**). Furthermore, modular structures can facilitate achieving structural congruence among these domains (see also **Chapter 4.2**).

Achieving structural congruence is known to provide various benefits, such as overall increased development productivity and faster times to market. Maintaining flexibility and upgradeability with regard to both a digital product or service and the internal structures of a DIU is important in continuously adapting to the needs of the market, especially when a unit grows (see **above** and also **Chapter 4.2**).

It can be said that congruent modular structures are mission-critical for success at scale. The challenge related to defining and implementing modular structures is two-fold: 1) As system requirements and a system itself change over time, modularization is by definition not a final state but a continuous process (MacDuffie 2013 in Colfer and Baldwin 2016), and 2) premature modularization efforts are prone to fail, as they can lead to undesirable system designs (see ibid.). Avoiding the risk of premature modularization and modularizing successfully and with confidence require a profound understanding of a system's ties and dependencies.

A profound understanding of a system's ties and dependencies can be developed by drawing on an end-to-end process view which can be provided by interdisciplinary teams. The benefits of structural congruence, among others, relate to the process of developing a digital product or service. By inversion of this argument, structural incongruence will arise in the development process of teams in the absence of these benefits and will become visible in impediments. Such impediments can affect either the organizational system or the technological system. Since interdisciplinary teams feature modular organizational structures, understanding technologically related impediments as identified through the view of interdisciplinary teams means understanding the requirements of modularization on the technological level. The replication of organizational structures in technological structures (see Conway 1968) features equalizing forces between the organizational system and the technological system (see **Chapter 2.2**). Analyzing the force that is exerted by the organizational system on the technological system can lead to the creation of a profound understanding of the modularization requirements of the technological system given that the unit of analysis in the organizational system that emits the force is itself modular. Therefore, the technologically related impediments identified by interdisciplinary teams, should be documented and analyzed to create a profound understanding that can allow a DIU to drive fundamental architectural changes towards an intentional modular design.

Activities

W2b: Socio-technical inquiry refers to a regular process that leverages an end-to-end process view based on the perspectives of interdisciplinary teams. The target behind is maintaining high levels of productivity, autonomy, organizational flexibility, and informing and preparing for fundamental architectural changes by the identification of slowing ties and dependencies of different natures and the development of a profound system understanding.

Socio-technical inquiries are coordinated in a top-down fashion but are bottom-up-driven; that is, the leadership inquires on a regular basis, and the interdisciplinary teams assess and describe slowing ties and dependencies that have a negative impact on their productivity.

Areas for identifying ties and dependencies can include process dependencies (see Herbsleb and Grinter 1999, Droge et al. 2012, Cataldo and Herbsleb 2013, Kwan et al. 2012), for instance, if experiments require clearance by quality assurance; dependencies due to distance and geographic dispersion (see Herbsleb and Grinter 1999, Bano et al. 2016, Colfer and Baldwin 2016, Datta 2017), which can include dependencies on co-workers in other buildings as well as on co-workers on other continents; and technological dependencies (Herbsleb and Grinter 1999, MacCormack et al. 2012), for instance, if deployments cannot be made at a desirable speed due to technical reasons, or, for instance, if teams are dependent on each other in the process of deploying. Furthermore, leadership should monitor the impact of different employment structures (see Müller et al. 2014, Colfer and Baldwin 2016), as, in scenarios characterized by a high degree of outsourcing, complex employment structures can create communication barriers.

Asking teams to bare specific organizational ties and technological dependencies that might impact their productivity can have a negative impact on the culture of a DIU. From a negative perspective, endeavors intended to improve teams' productivity could be interpreted as accusatory in nature, as they may involve identifying and addressing specific ties or dependencies that might have a slowing impact. Therefore, it can be reasonable to add a layer of abstraction to this kind of inquiry, for instance, by utilizing the Spotify Health Check (Kniberg 2014) or the Atlassian Team Health Monitor (Atlassian 2018), as these approaches do not directly focus on identifying specific ties and dependencies but instead check certain attributes of a team's health. Kniberg (2014) recommends a quarterly cadence for conducting such inquiries.

Indicators

Indicators for assessing whether a DIU checks ties and dependencies manifest in the form of regular inquiries into teams' productivity through the teams' perspectives; the way in which teams perceive and accept such inquiries, as this might impact the quality of the inquired information; whether the structural insights gained are documented, analyzed, and summarized for driving directed structural change initiatives; and, finally, whether structural changes are planned, communicated, and conducted in collaboration with the responsible stakeholders.

Synergies

Different synergies can be realized by combining a socio-technical inquiry (*this practice*) with other practices included in the N2DIU model. A **processual synergy** can be realized by combining *this practice* with the practice *W2a: Account validated learnings* (see *W2a* for more details); combining the continuous process of *W2a* with this practice, which is continuous in nature, can strengthen the process of checking for ties and dependencies by providing examples based on specific experiments. It should be noted that the processes behind *W2a* and *this practice* should follow a different cadence (see the respective *practice*).

Another **processual synergy** can be realized in combination with practice *W3a: Align experiments*. *W3a* describes how interdisciplinary teams maintain alignment and avoid systemic disintegration in the development of a digital product or service using a continuous process to ensure the development of a homogenous digital product or service, and enable and coordinate the implementation of cross-cutting features. The profound understanding of the organizational and technological system provided by *this practice* can inform the socio-technical alignment process of *W3a*.

An **organizational synergy** can be realized by combining this practice with the practice *I2b: Shape work environment*. *I2b* describes how an intentional design of a work environment and its seating plan impacts communication flows and therefore the design of technological structures. *This practice* supports identifying unintentional technological designs. Changing these unintentional designs and avoiding future implementations of such designs can be managed by relying on the intentional design of communication flows enabled by *I2b*.

A **technological synergy** can be realized by combining *this practice* with the practice *T2b: Pay technological debts*. *T2b* describes the increasing monitoring and reduction of technological debts as the maturity of a digital product or service grows. The information on technological issues provided by *this practice* can support the process of identifying debts.

Sources

W2b: Socio-technical inquiry was inspired by MacDuffie (2013 in Colfer and Baldwin 2016), who highlights the risks of premature modularization and notes that modularization is a continuous process; the various sources that describe the benefits of structural congruence (see **Chapter 4.2**); the various sources that provide evidence on ties and dependencies and the different aspects thereof that are relevant when attempting to achieve congruence (see Herbsleb and Grinter 1999, Droge et al. 2012, Kwan et al. 2012, MacCormack et al. 2012, Cataldo and Herbsleb 2013, Bano et al. 2016, Colfer and Baldwin 2016, Datta 2017); the various sources that describe the bi-directional replicating nature of structures (see i.a. Conway 1968, Benders et al. 2005, Colfer and Baldwin 2016; see also **Chapter 2.2** for more details); and the Spotify Health Check (Kniberg 2014) or the Atlassian Team Health Monitor (Atlassian 2018), which provides more details concerning how a process for checking ties and dependencies can be implemented within an organizational setting.

Practice I2b: Shape Work Environment

Identifier	Competency	Tier	Discipline
I2b	**Shape work environment**	**2: Growth**	**Interdisciplinary organization**
Short Description			
I2b: Shape work environment focuses on shaping and supporting communication flows. Communication flows impact the structural design of a digital product or service. A purposefully shaped work environment can result in both inspired employees and the creation and maintenance of an intended technological design.			

Table 25. *I2b: Shape work environment* (own depiction).

Introduction

The spatial constellations in which co-workers and teams collaborate have a direct impact on their productivity. Co-location and the enabling of informal communication have been identified to support communication in general (Luz et al. 2018, Sierra et al. 2017), drive cross-boundary knowledge exchange (Herbsleb and Grinter 1999, see also Colfer and Baldwin 2016: *partial mirroring*), support information exchange in general (Rytsavera et al. 2012), create an increased awareness of the availability of skills and access to skills (de Kare-Silver 2011), build trust (cf. Herbsleb and Grinter 1999), lead to the formation of positive team relations (cf. Bano et al. 2016), facilitate collaboration (de Kare-Silver 2011) and issue resolution (Herbsleb and Grinter 1999), and support an efficient way of working in general (see Herbsleb and Grinter 1999).

"We require all team members to be on site to make good decisions and to iterate swiftly."

– Interdisciplinary team PO

Overall, co-location facilitates the creation of trustful and efficient coordination and communication. Since communication structures are known to be replicated within the product or service that an organization produces (see Conway 1968), it is reasonable to assume that trustful and efficient communication can have a positive effect on the development of products or services.

However, it should be noted that co-location and informal communication can also have undesirable effects in terms of technological design, as they can lead to an unintended white-boxing of the internals of technological modules. This might prove beneficial when attempting to solve an issue in a quick and efficient manner, but, should information flow too well between two employees who work on two different modules, a higher degree of coupling may occur the technological system (see MacCormack et al. 2012). Therefore, when shaping a work environment, the responsible person(s) must bear in mind that an unrestricted flow of communication can have unintended impacts on technological structures.

In contrast, the drawbacks of geospatial dispersion are clearly described in the literature. Geographic distance can inhibit informal communication (Herbsleb and Grinter 1999), lead to lack of trust (Herbsleb and Grinter 1999), negatively impact the formation of team relations (Bano et al. 2016), prolongs issue resolution (Herbsleb and Grinter 1999), reduces confidence in making changes to a system (ibid.), negatively impact code quality (ibid.), and increases software defects, especially in settings that are distributed across time zones (Kwan et al. 2011).

"Remote working hinders us in forming truly interdisciplinary teams."

– DIU leader

Collaborative technologies for bridging the gaps of time and space have been found to work only in simple contexts. Furthermore, such technologies have been found to amplify language gaps (Herbsleb and Grinter 1999).

Geographical dispersion is described as having a negative effect in settings that are distributed across time zones (see ibid., Kwan et al. 2011), but this effect has also been observed with teams distributed across two offices less than 100 m apart (see Schimera 2017). The adequacy in terms of dynamic and competitive environments of geographically distributed development settings has also been called into question (Bano et al. 2016).

DIUs develop digital products or services in dynamic and competitive environments. Therefore, a DIU must leverage the benefits of co-location and informal communication. The communication structures of an organization are replicated with the digital product or service that it produces (see Conway 1968); therefore, the roles responsible for the shaping of a work environment and the seating of co-workers and teams must take the underlying modular organizational and technological structures into account. Completely unrestricted communication flows can lead to an undesirably tight coupling between the structures of a digital product or service; therefore, degrees of spatial separation within co-located settings must be considered.

Activities

I2b: Shape work environment refers to a process by which to ensure a continuous adaption of communication flows by the intentional shaping of a work environment. This process can include measures that focus on increasing wellbeing and creativity to create a generally positive perception of the work environment (see Klaffke 2019) and strengthening the signaling effect of a DIU; however, such measures should first and foremost focus on the design of communication flows, as they impact the development and the structures of a digital product or service.

In a DIU, co-workers should be co-located to enable informal communication. It is necessary to continuously assess which skills are required to develop a specific part or parts of a digital product or service; the individuals with these skills should be arranged in accordance with design efforts (see Conway 1968). Skills that need to be available to an entire team (e.g., quality assurance or method coaches) should be co-located as well (see also Colfer and Baldwin 2016).

The seating of co-workers should reflect the technological structures of the digital product or service produced by a DIU; for example, members of interdisciplinary teams should be seated in close proximity to each other to facilitate informal communication within a team. Teams that share technological interfaces should be seated next to each other. Individuals with skills that are relevant to all teams should be seated at a central position to ensure easy access for all teams. In between teams, dividing elements that minimally restrict the flow of communication should be used; for instance, installing room dividers or glass walls appear to be reasonable measures.

As requirements related to design efforts change over time, the shaping of a work environment is an ongoing process of adapting a DIU's environment and seating plan to match the needs of its design efforts.

Indicators

Indicators for assessing whether a DIU is intentionally shaping its work environment are whether required skills are co-located, whether required skills are arranged around design efforts, whether there are pooled co-located skills that can be regularly accessed by all teams, whether there are minimal spatial separation between teams where reasonable, and whether the shaping of the work environment is continuously adapted in response to design requirements.

Synergies

Different synergies can be realized through combinations of the way in which the work environment is shaped (*this practice*) and other practices included in the N2DIU model. A **processual synergy** can be realized by combining *this practice* with the practice *W2b: Socio-technical inquiry*, as a regular inquiry can inform the purposeful shaping of the work environment (see *W2b* for a more detailed description).

An **organizational synergy** can be realized in combination with the practice *I2a: Develop Internal Skills*, as the signaling effect of a modern work environment supports the attraction of talents (see *I2a* for more detail).

A further **organizational synergy** can be realized in combination with *I3a: Organize skills at scale*. I3a describes the scaled organization of skills and the definition of cross-boundary communication structures to avoid systemic disintegration and enable economies of scale. The defined cross-boundary communication structures can be strengthened by shaping the work environment (*this practice*) to reflect these structures by ensuring the spatial proximity of relevant skills.

A **technological synergy** can be realized in combination with *T2b: Pay technological debts*. T2b describes monitoring activities and the reduction of technological debts with the increasing maturity of a digital product or service. The implementation of undesirable dependencies can be the result of undesirable white-boxing due to informal communication between individual skills. Undesirable dependencies fall under the category of architectural technical debts. The likelihood of such debts arising can be reduced by rearranging the relevant skills to channel informal communication differently.

Sources

I2b: Shape work environment was predominantly inspired by Conway (1968), MacCormack et al. (2012), and Colfer and Baldwin (2016), who highlight the impact of communication structures on technological design; Herbsleb and Grinter (1999), Kwan et al. (2011), and Bano et al. (2016), who identify the various benefits of co-location and informal communication in competitive and dynamic environments (see also Schimera 2017); and Klaffke (2019), who describes the requirements of modern work environments.

Practice T2b: Pay Technological Debts

Identifier	Competency	Tier	Discipline
T2b	**Pay technical debts**	**2: Growth**	**Technological autonomy**
Short Description			
T2b: Pay technical debts describes the monitoring and reduction of technical debts with the increasing maturity of a digital product or service.			

Table 26. *T2b: Shape work environment* (own depiction).

Introduction

Lean and agile development approaches can benefit from a clean point of departure. Over the course of iterating in such innovative approaches, technical debt can rapidly develop due to the prototypical nature of the created results (see Kruchten et al. 2012; see also **Chapter 2.1.5.1**).

In a fast-paced environment, creating technical debts might be "[…] a good investment […]" (Kruchten et al. 2012), but, over time, growing interests of these debts can bring all productivity to a halt. Lean and agile approaches are prone to grow vastly technical debts over time if they are not actively managed (see Holvitie et al. 2014).

Unaddressed technical debts cause friction and can negatively impact the pace of development and productivity (see ibid., Bavani 2012, Guckenheimer 2014). If not actively managed, debts can grow and claim severe technical interest, leading to a state that is highly unpredictable in nature and can be characterized as involving fire-fighting efforts rather than focusing on the customer and user-driven development (see Bavani 2012).

Being bound by technical debts can make it challenging to retain a high level of autonomy and can thus negatively impact teams' motivation and performance (see **Chapter 2.1.5.2**). The uncontrolled growth of a technological system can be the consequence of or the reason for socio-technical incongruence; hence, it can promote inefficient coordination, software failures, and an overall decreased productivity (see **Chapter 4.2**). Therefore, actively managing and repaying technical debts are crucial for sustaining lean and agile development (see also Kruchten et al. 2012).

Activities

T2b: Pay technical debts refers to the process of regularly identifying, raising awareness of, and paying technical debts. Paying technical debts requires management support and resources in the form of time and budget (Bavani 2012). The goal is to achieve a balance between achieving short-term wins and maintaining long-term productivity (Kruchten et al. 2012).

Leadership must clearly communicate the importance of monitoring and reducing technical debts and dedicate resources to these processes. The importance of paying technical debts increases with the maturity of a digital product or service as mature designs are less prone to fundamentally changes. While software defects refer to directly visible issues in a digital product or service that are worth fixing, technical debts refer to a more latent and internally relevant category of technologically related issues that have a negative impact on productivity.

Technical debts relate to the architecture or code (see McConnel 2007: type 1 and type 2 debts) of a digital product or service; debts related to architecture can have a negative impact on adaptability and business responsiveness, while code-related debts can have a negative impact on the quality and maintainability of a digital product or service (see Kruchten et al. 2012; see also Bavani 2012).

Code refactoring and coding standards have been identified as effective approaches to reducing code-related debts (see Holvitie et al. 2014). Managing architectural debts, in contrast, is a more complex task. A common approach for identifying debts is the use of tools that employ a static architectural view. However, such a view can create an incorrect focus, as it may fail to identify all relevant aspects of debts (Kruchten et al. 2012).

A regular process for identifying and paying debts is required (Gruver 2015). Different types of debts must be identified and documented to plan and execute focused repayments (Kruchten et al. 2012). As paying technical debts is a highly technical undertaking, certain competencies within interdisciplinary teams can be dedicated to paying technical debts, while other competencies may not be required to the same degree. Developers in an interdisciplinary team may focus on reducing defects, addressing other forms of technological debt (see above), or implementing fundamental architectural and structural changes. The unused resources in an interdisciplinary team can conduct qualitative experiments, prepare quantitative experiments, or plan UX changes. Using this approach, a DIU can adopt a strong but temporary functional orientation.

Indicators

Indicators for assessing whether a DIU is paying technical debts are whether the concept of technical debts is part of regular communication, whether there is an assigned responsibility for managing (i.e., identifying, documenting, and ranking) technical debts, and whether the leadership plans for and provides the resources required for reducing technical debts on a regular basis.

Synergies

Different synergies can be realized through combinations of paying technical debts (*this practice*) and other practices in the N2DIU model. A **processual synergy** can be realized by combining *this practice* with practice *W2b: Socio-technical inquiry*. *W2b* leverages an end-to-end process view based on the perspectives of teams to identify slowing organizational and technological ties and dependencies. The identification of such ties and dependencies can highlight the existence of technological debt (*this practice*, see *W2b* for more details).

An **organizational synergy** can be realized in combination with practice *I2b: Shape work environment*. *I2b* describes how an intentional design of a work environment can channel communication flows. Unintentional communication flows can result in undesirable technical designs and dependencies (see also Colfer and Baldwin 2016). Specific technical debts (*this practice*) can lead to the identification of unintended communication flows and can thus indicate the need for a reshaping of the work environment (*I2b*) to avoid the reoccurrence of specific technical debts.

A **technological synergy** can be realized in combination with practice *T2a: Achieve common insights*. *T2a* describes a shared view on customer and user insights to enable teams to communicate, plan, coordinate, and track experiments and their impact on the performance of a digital product or service. A common view (*T2a*) includes both customer- and user-oriented and performance-related metrics, both of which can indicate bottlenecks in the digital journey of a customer or user. These bottlenecks can highlight the existence of technical debt (*this practice*), and can thus inform the management of technical debts.

Another **technological synergy** can be realized in combination with practice *T3a: Architect at scale*. *T3a* describes the design and maintenance of an intentional modular technological architecture to ensure the autonomy of teams from a technological perspective and to sustain the flexibility and upgradeability of a company's overall system. Modularization requires a profound understanding of the technological architecture. *This practice* contributes to creating such a profound architectural understanding through its focus on constantly reviewing and maintaining the technological base. Furthermore, *this practice* keeps the technological basis clean, trains the DIU in conducting fundamental technological changes, and thus facilitates future fundamental architectural changes such as modularization initiatives (see *T3a*).

Sources

T2b: Pay technical debts was inspired by Bavani (2012) and Guckenheimer (2014), both of whom describe the negative effect of technical debts; Holvitie et al. (2014), who emphasize the role of technical debt in agile development settings; Gruver (2015), who highlights that managing technical debts requires a dedicated and regular process; and McConnel (2007) and Kruchten et al. (2012), both of whom distinguish among various types of technical debts.

4.3.2.3. Tier 3: Exploit

Tier 3: Exploit focuses on scaling a DIU based on business opportunities nurtured in *Tier 2: Growth*. The third tier defines structures for providing teams and leadership with a high-level context to align a DIU towards common goals, a high-level data view to guide scaling efforts towards such common goals, the perseverance of autonomy, and the reduction of friction in settings with a high number of teams.

Tier 3: Exploit introduces two additional disciplines that can be further differentiated into one organizational and one technological discipline; the two disciplines are *vision* and *scaling*. Each discipline defines requirements. Fulfilling these requirements provides the foundation for practices that are defined on the basis of each discipline.

The requirements defined by the discipline *vision* are the definition, communication, and maintenance of a clear and simple overall target that is customer- and user-oriented, digital product- or service-oriented, and describes a target market position. Such a vision is initiated by leadership and teams to provide a high-level context for aligning all efforts within a DIU around a common purpose (see also **Chapter 4.3.1**).

The requirements defined by the discipline *scale* focus on the availability of the resources for and the definition of achieving a highly efficient, friction-less, and well-structured DIU by increased degrees of standardization, automation, and architectural investments (see also **Chapter 4.3.1**).

Tier 3: Exploit introduces 10 practices. These 10 practices are positioned at the interfaces among the two disciplines introduced in this tier and the five existing disciplines introduced with tiers one and two (see **Figure 31**; see also **Figure 26** for a view of the whole model). The 10 practices are

- *W3a: Socio-technical architecting*
- *I3a: Organize at scale*
- *T3a: Architect at scale*
- *L3a: Maintain vision*
- *D3a: Maintain digital journey*
- *W3b: Establish shared ways of working*
- *I3b: Manage skills profile*
- *T3b: Manage automation*
- *L3b: Co-determine objectives*
- *D3b: Co-determine metrics and results*

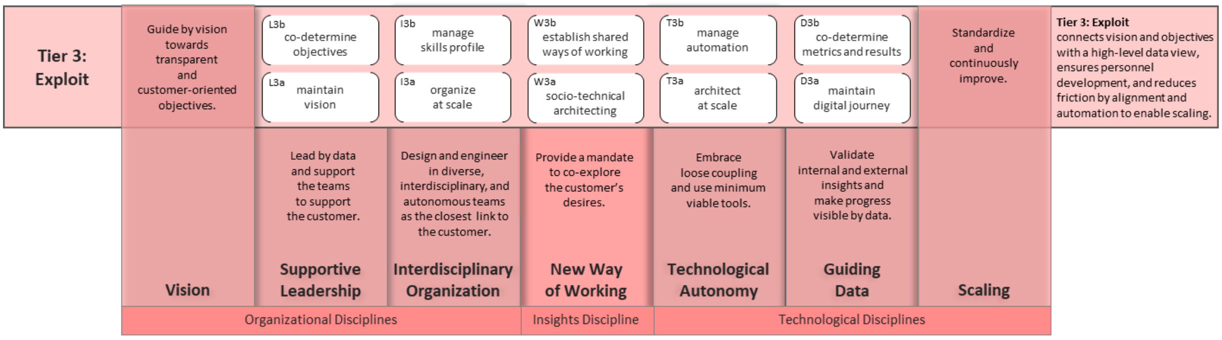

Figure 31. The *N2DIU* model: focus on *Tier 3: Exploit* (own depiction).

The new practices introduced with *Tier 3: Exploit* can be further differentiated into *x3a* and *x3b* practices. The *x3a* practices focus on the alignment of structures within a scaled system to avoid systemic disintegration and to maintain a unified digital product or service (*W3a*); the organization of teams at scale to enable and support skill and knowledge exchange between teams at scale (*I3a*); the intentional modular design of the technological architecture for preserving autonomy and swift development cycles at scale (*T3a*); the definition, communication, and maintenance of a vision to provide a high-level context and a common target (*L3a*); and the definition and maintenance of a high-level data view to ensure that the development of a digital product or service is aligned with the vision (*D3a*).

The *x3b* practices focus on establishing a streamlined bottom-up-determined set of development methods as shared ways of working (*W3b*), an experience-based approach to skills management to ensure the distribution of experience and the on-going identification of skill demands (*I3b*), automation to reduce manual efforts and quality deviations (*T3b*), the mixed bottom-up and top-down definition of objectives (*L3b*), and the continuous identification and refinement of metrics and results to enable data-driven development (*D3b*).

Practice W3a: Socio-Technical Architecting

Identifier	Competency	Tier	Discipline
W3a	**Socio-technical architecting**	**3: Exploit**	**New ways of working**
Short Description			
W3a: Socio-technical architecting compares information provided by different organizational and technological contexts within a DIU to evaluate whether the internal structures of a DIU are aligned and thus whether a seamless customer and user experience can be provided and whether this seamless customer and user experience matches the needs of the market.			

Table 27. *W3a: Socio-technical architecting* (own depiction).

Introduction

Systems tend to disintegrate with increasing size (Conway 1968). Systems disintegrate as a consequence of having excessively large teams focused on the same design effort, traditional management approaches and their negative impact on inter-team communication, and the socio-technical replication of such disintegrating communication structures within product or services (ibid.).

The need for coordination rises with the number of components in a system (see Querbes and Frenken 2018). Modularization can be used as a coordinating mechanism for assigning responsibilities (Parnas 1972 in Herbsleb and Grinter 1999). However, a "[…] modular strategy is vulnerable to unanticipated 'cross-cutting' product features, as they require coordinated changes to multiple modules […]" (Cataldo and Herbsleb 2013). With a high degree of modularization, a harmonization of organizational and technological dependencies is required (Cataldo and Herbsleb 2013). With the growth of a DIU, the focus shifts from nurturing individual teams to nurturing the interplay of teams (see Schimera 2017). To preserve teams' autonomy, "[…] alignment without excessive control […]" (Mankins and Garton 2017) must be achieved.

The preservation of autonomy and the avoidance of excessive control can be achieved by a shift away from holding teams accountable for achieving pre-determined targets. Instead, a platform must be provided that guides development efforts through intentionally designed structures within the internal systems of a DIU (see **Chapter 4.3.1**; see also **Chapter 2.1.5.2**).

A unifying communication structure that takes into consideration both organizational and technological structures and the internal and external perspectives of a DIU is required to avoid systemic disintegration. Such a unifying communication structure will be replicated within the product or service that an organization produces and hence can ensure the provision of a seamless customer and user experience that matches the requirements of the market (see also Conway 1968).

Activities

W3a: Socio-technical architecting focuses on leveraging knowledge on the replicating nature of a DIU's structures and on the benefits of socio-technical congruence to maintain an aligned DIU.

The replicating nature of communication structures can lead to a transient state of socio-technical incongruence; for instance, the disintegration of communication structures can occur in an organizational environment before they are replicated within the technological structures. Given that a system is more likely to disintegrate as a result of growth (Conway 1968, Cataldo and Herbsleb 2013, cf. also Querbes and Frenken 2018) and given that a system's design is intentional and purposeful, it can be assumed that the early identification of socio-technical incongruence indicates that a system is moving towards disintegration. However, it cannot always be assumed that an overall design of a system was intentional and purposeful from the beginning.

An internal disintegration of communication structures will be replicated in a DIU's technological structures in the form of a fragmented digital product or service and will thus produce a fragmented customer and user experience. Socio-technical congruence is dynamic, as "[…] there may be changes in the coordination needs, dependencies or social structures" (Sierra et al. 2017; see also Conway 1968). Therefore, it must be continuously checked whether an unintentional internal incongruence indicates an approaching disintegration; alternatively, if a system is socio-technically congruent at a given time, it must be checked whether its internal structures are based on design efforts that reflect the pivotal value propositions in order to evaluate whether socio-technical congruence is the result of purposeful system design or the result of an advanced disintegration.

Conway (1968) delineates a system management activity intended to prevent a system's disintegration. This activity can benefit from "[…] more efficient communication among designers […]" (ibid.). A state of socio-technical congruence is known to enable efficient communication among the participants in a socio-technical system (see Kwan et al. 2011, MacCormack et al. 2012, Sierra et al. 2017; see also **Chapter 4.2**). Therefore, the first step in a systems management activity intended to counteract system disintegration and nurture system alignment is the maintenance of socio-technical congruence.

The second step is to connect internal socio-technical structures with an external perspective that considers the customer and user. Socio-technical congruence can provide various benefits (see **Chapter 4.2**); however, should a DIU's internal socio-technically congruent structures not be aligned with the needs of the market, the chances are that a DIU will efficiently produce what should not be produced at all (see **Chapter 2.2.2.4**; see also *Mirroring Trap* in Colfer and Baldwin 2016). Reflecting on an internal socio-technically congruent state from a customer- and user-oriented perspective can ensure that a system is not only socio-technically congruent but also that the achieved socio-technical congruence is intentional and purposeful.

W3a: Socio-technical architecting is a practice that focuses on integrating and aligning the information provided by different contexts. Therefore, in contrast to other practices within the N2DIU model, *W3a* is highly dependent on other practices that inform alignment activities. In accordance with the two proposed steps above, *W3a* is dependent on the input of *I3a: Organize at scale* and *T3a: Architect at scale* to achieve an internal alignment of socio-technical structures and is dependent on *L3a: Maintain vision* and *D3a: Maintain digital journey* to ensure that the internal alignment of socio-technical structures is intentional and purposeful.

The internal alignment of socio-technical structures draws on the knowledge provided by the **organizational practice** *I3a* and the **technological practice** *T3a*. *I3a* describes the organization of interdisciplinary teams at scale and the definition of inter-team communication structures. *T3a* describes the establishment of an intentional modular technological design to ensure a low degree of technological dependency among teams and clear responsibility boundaries. Analyzing the internal alignment of socio-technical structures focuses on mapping the organizational structures of *I3a* and the technological structures of *T3a* to identify a state of either congruence or incongruence. For this purpose, *W3a* compares communication structures, for instance, the organizational matrix provided by *I3a*, with technological structures, for instance, the architectural view on the technology landscape provided by *T3a*.

The mapping of communication structures such as interdisciplinary teams to technological modules can serve as a first indicator of socio-technical congruence or incongruence; ideally, this comparison will result in a one-to-one mapping of teams and modules. A team can also be assigned to one or, if necessary, more technological modules (Conway 1968). It should be noted that the assignment of a team to more than one module might lead to unintended dependencies among the affected modules due to the team's knowledge of the internals (see also **Chapter 4.3.2.2**). The assignment of two teams to one technological module should be avoided, as it limits both teams' autonomy. As a side note, merging two teams into one team should also be avoided to prevent increasing the risk of systemic disintegration due to assigning too many skills to a design effort (see above: introduction to *this practice*).

Further socio-technical structures that should be compared are functionally oriented communication structures (see *I3a*: chapters) and technological architecture layers (see *T3a*, e.g., front-end); interest-oriented communication structures (see *I3a*: guilds) and technologies (see *T3a*, e.g., web or mobile) or technological change initiatives (e.g., see *T3a*, architectural restructuring efforts). Ideally, organizational and technological structures should match one-to-one; that is, each technological dependency should be mappable to an organizational communication structure and vice versa.

In cases involving internal socio-technical incongruence, system management must evaluate whether this transient state is intended or the consequence of an approaching systemic disintegration and communicate the potential issue with the responsible stakeholders of *I3a* and *T3a* to plan a change initiative in either the organizational or the technological system. In the case of a state that is socio-technically congruent, it must be evaluated whether the congruence of the internal structures works towards a common purpose or whether it is not in line with the overall target of the DIU in question.

Reflecting on and connecting internal socio-technical structures with an external perspective that considers customers and users can draw on the knowledge provided by the **organizational practice** *L3a* and the **technological practice** *D3a*. *L3a* describes the definition, communication, and maintenance of a customer- and user-oriented vision to provide interdisciplinary teams with a high-level context for aligning internal efforts around a common purpose. *D3a* describes the definition, communication, and maintenance of a high-level data view that describes the customer and user's journey and flow through the usage of a digital product or service.

Together, *L3a* and *D3a* describe a high-level target and serve as an internal instrument for evaluating whether a DIU is working towards this target. Reflecting on the internal socio-technical structures of a DIU in light of a target and based on an instrument that reflects the degree of target achievement can support system management in determining whether the internal socio-technical structures of a DIU are externally aligned with the needs of the market.

The synergetic relations among practices *I3a*, *T3a*, *L3a*, and *D3a* can be viewed from various perspectives (see **Figure 32**). Ways of viewing them include considering how the structure of *I3a* (i.e., teams and communication structures) shape the structures of *T3a* (i.e., technological modules and dependencies), how the structures of *T3a* (i.e., technological modules and related value propositions) determine the outcome of *D3a* (i.e., the customer and user's rate of adoption), and, finally, how the results presented by *D3a* do or do not drive the overall target of a DIU as identified by *L3a*.

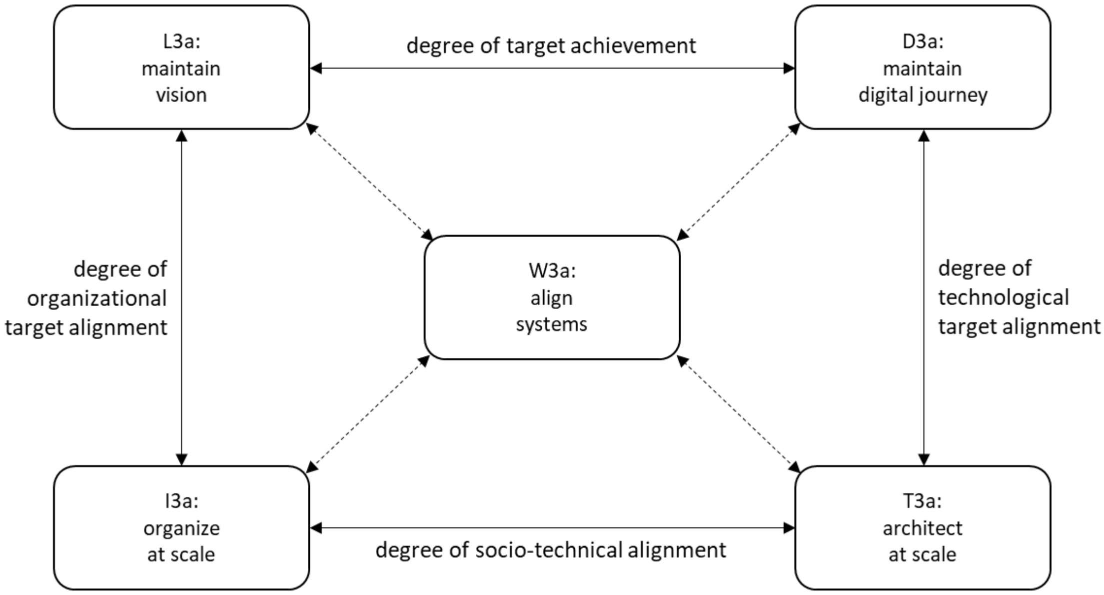

Figure 32. Relations among X3a practices (own depiction).

W3a: Socio-technical architecting describes the continuous evaluation and, if necessary, re-alignment of structures. Ideally, organizational structures should match technological structures and dependencies on a one-to-one basis. In addition, a company's technological structures and modules should ideally match the value propositions that can arise in a digital customer or user's journey on a one-to-one basis. The value propositions regarding the digital customer and user journey should all play a part in driving a DIU's vision. The tasks of a DIU's system management include evaluating the alignment of these structures, communicating deviations, and planning and implementing change initiatives with the respective stakeholders.

Indicators

Indicators for assessing whether a DIU is actively engaging in activities intended to ensure systems alignment are whether there is an assigned responsibility that continuously evaluates the internal and external alignment of a DIU. That role identifies internal incongruences, identifies misalignments between the internal structures and the external needs, communicates these misalignments and incongruences to the relevant stakeholders within a DIU, and plans and drives change initiatives with the goal of achieve external alignment and internal congruence.

Synergies

Two synergies can be realized by combining socio-technical architecting (*this practice*) with other practices included in the N2DIU model. A **processual synergy** can be realized by combining *this practice* with practice *W2b: Socio-technical inquiry*; the profound understanding of the organizational and technological system provided by *W2b* can inform the internal alignment perspective of *this practice* by indicating incongruences and providing knowledge concerning latent and transient ties and dependencies (see also *W2b*).

Another **processual synergy** can be realized in combination with practice *W3b: Establish shared ways of working*. *W3b* describes the bottom-up definition of a streamlined set of methods and tools based on the experience of interdisciplinary teams in a DIU. Socio-technical architecting (*this practice*) can contribute to the establishment of shared ways of working (*W3b*) by providing a congruent and aligned foundation with clear responsibilities and efficient communication and can therefore facilitate the definition of shared ways of working. *W3b*, in contrast, can contribute to socio-technical architecting (*this practice*) by providing a congruent process (see also Kwan et al. 2012).

Sources

W3a: Socio-technical architecting was inspired by the observations of socio-technological theorists such as Conway 1968, Cataldo and Herbsleb 2013, and Querbes and Frenken 2018 who describe the advancing disintegration of a system with its growth; Mankins and Garton (2017), who note that alignment in highly autonomous functioning systems must be achieved without imposing control; Conway (1968), who describes the need to employ a systems management function to avoid the risk of a system's disintegration and further identifies initial requirements for such a function; Colfer and Baldwin (2016), who highlight that the risk of a system's disintegration must be viewed from both an internal and external perspective; and, finally, socio-technical theorists such as Kwan et al. 2011, MacCormack et al. 2012, and Sierra et al. 2017 who provide valuable insights into the factors that can indicate an approaching disintegration.

Practice I3a: Organize at Scale

Identifier	Competency	Tier	Discipline
I3a	**Organize at scale**	**3: Exploit**	**Interdisciplinary organization**
Short Description			
I3a: Organize at scale describes the explicit definition and visualization of a DIU's organizational chart based on the four organizational structures with the goals of counteracting the disintegration of a system and maintaining the ability to implement cross-cutting features.			

Table 28. *I3a: Organize at scale* (own depiction).

Introduction

DIUs rely on interdisciplinary teams (see Drews et al. 2017, Haffke 2017, Adersberger and Siedersleben 2018, Corso et al. 2018, Duerr et al. 2018). An emphasis on interdisciplinary communication structures can nurture a well-functioning interplay among several functions. The drawback of relying on communication structures based exclusively on the definition of interdisciplinary teams is impeded knowledge exchange among functions and reduced economies of scale within functions. Therefore, additional communication structures are required to counteract systemic disintegration.

As a system grows, it tends to disintegrate (Conway 1968; see also Querbes and Frenken 2018). This disintegration is described as first appearing in an organizations communication structures before replicating itself within that organization' technological structures (see Conway 1968). Interdisciplinary teams are responsible for designing, developing, and operating individual modules of an overall digital product or service (see **Chapter 2.1.5.2**). Interdisciplinary teams nurture a smooth flow of communication within teams but can lead to impeded communication between teams. The disintegration of communication structures between interdisciplinary teams can complicate the implementation of changes that affect more than one module of a digital product or service (see Cataldo and Herbsleb 2013).

A scaled DIU requires more than the definition of interdisciplinary teams. Additional communication structures are required to maintain knowledge exchange within functions and competency in the implementation of cross-cutting features. The clear definition of such structures can further support the maintenance of socio-technical congruence, as explicating structures make visible and communicable what needs to be aligned (see also **Chapter 4.2**).

Activities

I3a: Organize at scale focuses on implementing and explicating communication structures for nurturing interdisciplinary team communication, functionally oriented communication, cross-team and cross-functional communication, and communication in work-related areas.

The adoption of a matrix structure in DIUs has been identified as a suitable means of establishing and leveraging interdisciplinary and intra-functional communication structures (see Weingarth et al. 2019). The Spotify matrix (Kniberg and Ivarsson 2012), which is increasingly being adopted among practitioners in innovative organizational settings (see Schimera 2017, Corso et al. 2018), is an example of such a matrix structure.

The Spotify matrix defines four organizational structures for channeling communication within teams, within functions, and across teams and functions and for bundling communication within work-related areas. Hence, adopting the Spotify matrix is a suitable approach for strengthening interdisciplinary collaboration, facilitating knowledge exchange within functions, and maintaining competency in the implementation of cross-cutting change initiatives. Together, the four kinds of organizational structures defined by the Spotify matrix can be used to maintain purposeful communication and thus avoid a systemic disintegration; furthermore, they provide a common language for explicating organizational structures to facilitate achieving and managing a socio-technical congruent state, as the explicit structures enable comparing organizational structures with technological structures. The following information concerning the structures of the Spotify matrix is based on Kniberg and Ivarsson (2012).

The four organizational structures defined by the Spotify matrix are

1) tribes,
2) squads,
3) chapters, and
4) guilds.

Tribes refer to a work-related area focused on a pivotal value proposition, for instance, a digital product or service, or an internally visible value proposition, for instance, infrastructure services. A tribe is defined as a co-located community consisting of less than 100 persons. Tribes designate a tribe lead and contain squads and chapters.

Squads describe interdisciplinary teams (see also **Chapter 2.1.5.2**). Squads collaborate within their boundaries on a daily basis. A squad's work is prioritized by a dedicated product owner, who is also responsible for communicating the current status of a squad. Chapters describe functionally oriented communication structures that span across squads. Members of a chapter are also members of a squad. Chapters meet on a regular basis to share knowledge and discuss current challenges. Each chapter has a designated chapter lead, who is tasked with "[…] all the traditional responsibilities such as developing people, setting salaries, etc." (Kniberg and Ivarsson 2012). The roles of the product owner and chapter lead are comparable with the roles of the "[…] 'professor and entrepreneur model' recommended by Mary and Tom Poppendieck […]" (Kniberg and Ivarsson 2012), with the product owner representing the entrepreneur and the chapter lead representing the professor. Together, they create a "[…] 'healthy' tension […]" (ibid.), as the entrepreneur "[…] tends to want to speed up and cut corners […]" (ibid.) and the professor "[…] tends to want to […] build things properly" (ibid.).

Guilds define "[…] communities of interest […]" (Kniberg and Ivarsson 2012). A guild is defined as a structure for sharing knowledge on a certain topic. Examples are "[…] the web technology guild, the tester guild, the agile coach guild, etc." (ibid.). The boundaries of a guild can cross squads, chapters, and even tribes. As a guild can cross the boundaries of tribes and the purpose of a guild is usually defined as the sharing of knowledge concerning a specific subject matter area, a guild "[…] often includes all the chapters working in that area and their members "[…], but anybody who is interested can join a guild" (ibid.) Each guild is coordinated by a guild coordinator.

Indicators

Indicators for assessing whether a DIU is organizing teams at scale are whether there is a defined organizational matrix structure, whether this organizational matrix structure defines the four kinds of communication structures described above, whether these structures are generally visible to everyone in a DIU, whether the structures are updated on a regular basis, whether the structures inform the other practices of a DIU, and whether updates on the organizational structure are informed by the other practices of a DIU.

Synergies

Different synergies can be realized by combining the organization of skills at scale (*this practice*) and with other practices included in the N2DIU model. A **processual synergy** can be realized through combining *this practice* with practice *W3a: Socio-technical architecting*. *W3a* refers to the alignment of internal socio-technical structures and other internal structures with a market-oriented view to avoid an internal system disintegration and ensure that an organization's internal structures are externally aligned with the needs of the market. The organization of skills at scale (*this practice*) provides an explicit overview of defined organizational structures that can inform the internal socio-technical alignment of *W3a*.

An **organizational synergy** can be realized by combining *this practice* with practice *I2b: Shape work environment*. *I2b* focuses on the design of spatial structures and the arrangement of interdisciplinary teams and skills within these structures. These spatial structures the flow of communication. *This practice* can provide valuable information concerning the purposeful seating of teams and skills to achieve a purposeful channeling of communication; for instance, interdisciplinary teams whose technological modules' interplay provides added value for customers and users should be seated in proximity to each other (see also *I2b*).

Another **organizational synergy** can be realized through combining *this practice* with practice *I3b: Manage skills profile*. *I3b* ensures the distribution of knowledge through a skills management function based on employee's individual experience levels. Mapping individual skill levels to the explicated structures provided by *this practice* provides a valuable overview that can be used to evenly distributing different skill levels.

A **technological synergy** can be realized by combining *this practice* with practice *T3a: Architect at scale*. *T3a* describes the dedicated management of intentionally designed modular technological structures to ensure the updatability of the digital product or service produced by a DIU and to maintain the autonomy of interdisciplinary teams by keeping technological dependencies among them to a minimum. The defined structures of *this practice* can inform the technological design of *T3a*, as organizational structures should be reflected by technological structures and vice versa.

Sources

I3a: Organize skills at scale was inspired by socio-technical theorists such as MacCormack et al. 2012, Colfer and Baldwin 2016, Querbes and Frenken 2018 who highlight the importance of modular structures for product development; Drews et al. (2017), Haffke (2017), Adersberger and Siedersleben (2018), Corso et al. (2018), and Duerr et al. (2018), who describe modular organizational structures, specifically interdisciplinary teams, as a core organizational structure of a DIU; Kniberg and Ivarsson (2012), who describe the Spotify matrix as an organizational matrix structure that is fundamentally based on organizing interdisciplinary teams; and Schimera (2017), Corso et al.

(2018), and Weingarth et al. (2019), who provide examples of the adoption of matrix structures, specifically the Spotify matrix, in DIUs.

Practice T3a: Architect at Scale

Identifier	Competency	Tier	Discipline
T3a	**Architect at scale**	**3: Exploit**	**Technological autonomy**
Short Description			
T3a: Architect at scale describes the design and maintenance of an intentional modular technological architecture for preserving the autonomy of interdisciplinary teams and for maintaining a flexible and updateable architecture.			

Table 29. *T3a: Architect at scale* (own depiction).

Introduction

A technological system with a modular design can limit the blast radius of changes (Mankins and Garton 2017). A modular design of a technological system can facilitate the "[…] coordination of […] development work […]" (Herbsleb and Grinter 1999) by enabling the assignment of clear responsibilities (Parnas 1972 in Herbsleb and Grinter 1999) and by providing clearly defined interfaces (Querbes and Frenken 2018). Both clearly defined responsibilities and interfaces can ensure that interdisciplinary teams maintain a high degree of autonomy. A modular design enables the adaption of modules "[…] to changing circumstances (e.g., prices, consumer tastes), without the need to re-design the whole product […]" (ibid.); hence, organizations that design on the basis of modular structures renew their products over shorter cycles (ibid., MacCormack et al. 2012). Furthermore, modules identify clearly defined scopes. Clearly defined scopes enable skills to rapidly become effective in what they are doing, as they do not need to learn how a large and highly interdependent system works (see MacCormack et al. 2012).

By contrast, a monolithic software architecture in combination with a large number of interdisciplinary teams can lead to excessively demanding coordination efforts (see Schimera 2017). Even if teams are provided with high degrees of autonomy through autonomy-enabling organizational and processual structures, the use of a monolithic technological architecture as a shared medium creates dependencies among teams; in such contexts, coordinating deployments can require tremendous coordination efforts, and making changes to a software product can result in unforeseen consequences, as the "blast radius" of changes is not limited by any boundaries (cf. Mankins and Garton 2017). Therefore, relying on a monolithic architecture can prevent teams in a DIU from releasing often and with confidence (cf. Lwakatare et al. 2016).

Activities

T3a: Architect at scale focuses on creating and maintaining an intentional modular system design. With an increasing number of teams, there is an increasing need for clearly defined and modular technological structures. While a DIU can benefit from embracing the concept of loose coupling from the beginning, a modular system design and the continuous management and adaption of such a design become mandatory when operating a DIU at scale.

As the internal communication structures of an organization are replicated within the digital product or service that it produces (see Conway 1968), an organization's internal communication structures should focus on externally perceivable services such as those provided to the customer and user. These value propositions can be used as a basis for identifying the right modules to design.

It is commonly recommended that companies rely on a microservices architecture to implement a modular service concept (Balalaie et al. 2016, Ebert et al. 2016, Drews 2017, Schimera 2017, Weingarth et al. 2019). As a lightweight alternative to virtualization, containerization can be utilized for the implementation of a microservices architecture. At the time of writing, a popular technology for enabling the implementation of a container-based architecture is *Docker* (Callanan and Spillane 2016, Agarwal et al. 2018). In contrast to typical virtualization solutions, solutions such as Docker remove the hypervisor layer and do not require guest operating systems that run on top of a hypervisor. Therefore, containerization effectively eliminates administrative tasks such as configuring or updating operating systems.

An often-overlooked aspect of modularization is that modularization is by definition not a final state but an ongoing process (ibid.), as system requirements are prone to change (Conway 1968). Therefore, the maintenance of an intentional modular design must rely on a continuous process.

Designing a modular technological system involves challenges. Creating and maintaining a modular system design requires a profound understanding of the specific requirements of such a system. Most modularization efforts fail due to a premature modularization (MacDuffie 2013 in Colfer and Baldwin 2016); in this case, modularization initiatives have been carried out but without achieving an intentional design. Establishing and maintaining an intentional modular design can be informed by other practices that contribute to the process of continuously establishing and maintaining a profound system understanding.

Indicators

Indicators for assessing whether a DIU is organizing its technological architecture at scale are whether there is a designated system owner role (which can be occupied by one or more persons; see also Kniberg and Ivarsson 2012); whether a container-based infrastructure technology has been implemented and is used and maintained on a regular basis; and whether the owner(s) of the system regularly update the architectural style thereof in accordance to the needs of the DIU. Architectural requirements are subject to constant change, as the requirements of the customer and user, as well as those of the digital product or service produced by a DIU, are subject to constant change. The process of identifying and detailing these requirements can be informed by other practices included in the N2DIU model.

Synergies

Different synergies can be realized by combining the organizing of a DIU's technological architecture at scale (*this practice*) with other practices included in the N2DIU model. A **processual synergy** can be realized through combining *this practice* with practice *W3a: Socio-technical architecting. W3a* refers to a pivotal practice in a DIU that involves aligning internal socio-technical structures as well as aligning internal structures with the demands of the market. *This practice* can inform this alignment process by providing information on the current architectural design, and *this practice* can be informed by the input of *W3a*, as *W3a* can provide architectural requirements that can contribute to an intentional modular design (see also *W3a*).

An **organizational synergy** can be realized by combining *this practice* with practice *I3a: Organize skills at scale*. *I3a* refers to the definition and maintenance of various organizational structures with a focus on interdisciplinary teams. The modular structures defined and implemented by *this practice* can support the coordination of skills at scale by the identification of clear technological boundaries and areas of responsibility (see also *I3a*).

A **technological synergy** can be realized through combining *this practice* with practice *T2b: Pay technical debts*. *T2b* can support the process of developing a profound understanding of the technological structures within a DIU and can therefore provide valuable knowledge concerning the modular design of technological structures as defined in *this practice* (see also *T2b*).

Another **technological synergy** can be realized in combination with practice *T3b: Manage automation*. *T3b* describes the automation of technologically supported processes, for instance, deployments or the provision of infrastructure, to further improve the efficiency of a DIU. Automation efforts are not limited to the management of a modular technological infrastructure (*this practice*), but the provision and management of a modular technological infrastructure can benefit from automation on a large scale.

Sources

T3a: Architect at scale was inspired by Schimera (2017), Mankins and Garton (2017), Lwakatare et al. (2016), and Herbsleb and Grinter (1999), all of these authors highlight the importance of modular technological structures in maintaining efficient coordination at scale; MacCormack et al. (2012) and Querbes and Frenken (2018), who highlight the importance of modular technological structures in maintaining technological flexibility and adaptability; MacDuffie (2013) in Colfer and Baldwin (2016), who emphasize the risks of premature modularization, the need for a profound system understanding before initiating modularization efforts, and the need for continuous modularization efforts; Balalaie et al. (2016), Ebert et al. (2016), Drews (2017), Schimera (2017), and Weingarth et al. (2019), who recommend adopting the concept of microservices for a modular technological architecture; and, finally, Callanan and Spillane (2016), Agarwar et al. (2018), who recommend Docker as a suitable contemporary solution for implementing a microservices architecture.

Practice L3a: Maintain Vision

Identifier	Competency	Tier	Discipline
L3a	**Maintain vision**	**3: Exploit**	**Supportive leadership**
Short Description			
L3a: Maintain vision describes the definition, communication, and maintenance of a clear and unifying purpose to provide teams with a high-level context and align all efforts within a DIU towards a common goal.			

Table 30. *L3a: Maintain vision* (own depiction).

Introduction

Innovative work environments that rely on high degrees of autonomy require coordination and alignment mechanisms but should not be subject to excessive control (Mankins and Garton 2017). Providing teams with a high-level context that guides their decisions when they are working autonomously requires "[…] clarity of purpose […]" (ibid.). In a startup, this clarity of purpose is achieved through that startup's vision (Ries 2011, Niculescu et al. 2014). Every experiment performed should drive towards this goal (ibid.).

"All activities done should drive a common goal."

– DIU leader

In the early stages of the development of a digital product or service, there should be a basic idea driving the experimentation efforts of teams. This idea can change over the course of various experiments as teams uncover new validated learnings about the beliefs concerning the customer and user and the digital product or service produced by a DIU.

With the execution of various experiments, a digital product or service and the foundational idea behind it can become increasingly mature. Simultaneously, a DIU might also grow alongside its its digital product or service. As a system grows, it tends to disintegrate (see Conway 1968). Therefore, a coordination mechanism that aligns all efforts within a DIU towards achieving a common target without sacrificing the autonomy of teams is required. Mankins and Garton (2017) note that "Coordination comes through context and through a deep understanding […]".

The provision of context in the form of a common vision can be a valuable instrument when attempting to achieve such coordination. While a vision might not be clear right from the beginning, it can be formulated with time and experience. With the increasing growth of a DIU, a vision becomes necessary for achieving alignment. The definition and communication of a vision enable teams to autonomously think about and connect with the overall target of a DIU and can nurture a sense of community (see Jackson 2017).

Activities

L3a: Maintain vision focuses on for the definition and continuous communication of a customer- and user-oriented vision to provide teams with a high-level context for driving their experiments towards achieving a common target.

The term *vision* can be interpreted in various ways. Some understand a vision as a communication construct for aligning the interests of internal stakeholders around a common goal. Such a vision can include various interests under a common umbrella but might also lead to the communication of a cluttered picture of what should be achieved in light of the overall ecosystem, as it may attempt to merge conflicting interests. Such a vision is neither clear (cf. Hansen et al. 2011) nor unifying (cf. Westerman et al. 2014).

A vision consists of different elements. It can address a specific market segment, describe an offer, and describe what a company or an organizational unit wants to achieve with its offer within the specific market segment. What follows are two examples two examples of vision statements from well-known organizations:

Starbucks: "[…] to establish Starbucks as the premier purveyor of the finest coffee in the world while maintaining our uncompromising principles while we grow." (Panmore 2019)

Tesla: "[…] to create the most compelling car company of the 21st century by driving the world's transition to electric vehicles." (Panmore 2018)

Unifying and aligning teams around a common purpose (see Westerman et al. 2014) requires a vision that is clear and transparent (Hansen et al. 2011). A unifying vision describes a clear goal related to a market position (as opposed to internal opportunities). The clear focus and comprehensibility of such a vision are accompanied by a shared spirit towards striving for the identified goal, which can increase the effectiveness of teams' experiments (see Humble et al. 2015).

A common goal provides teams with a unifying high-level context that can be intersubjectively shared. As systems tend to disintegrate with growth (see **Chapter 2.2**), the provision of a high-level context becomes increasingly important with an increasing number of autonomous teams. It is in the interests of the leadership as vision keepers (see Furr and Dyer 2014) to identify, define, and communicate a vision and adapt it if required.

Indicators

Indicators for assessing whether a DIU is maintaining its vision are whether there is a designated vision-keeper, whether this role involves maintaining and updating a clear and unifying vision in collaboration with the teams of a DIU, whether this role highlights and communicates the common vision, whether this role presents this vision in the light of the outcomes of a DIU (e.g. by reviewing progress as it is made visible through the application of other practices, such as *D3a: Maintain data journey*), and, finally, whether this role uses the vision as basis for co-determining objectives (see *L3b*).

Synergies

Different synergies can be realized by combining *maintaining vision* (*this practice*) with other practices included in the N2DIU model. A **processual synergy** can be realized when combining this practice with practice *W3a: Socio-technical architecting*. *W3a* describes the alignment of different systems to reduce the risk of a systemic disintegration. One view that *W3a* considers is the external perspective on the market and the customer and user. Due to its external orientation, *this practice* can contribute to this alignment of different systems by providing a true north for achieving an external alignment.

An **organizational synergy** can be realized by combining with practice *L3b: Co-determine objectives*. *L3b* describes coordination based on a bottom-up and top-down definition of objectives. These objectives should drive a vision. Therefore, *this practice* can inspire the definition of objectives as defined through the application of *L3b*.

A **technological synergy** can be realized in combination with practice *D3a: Maintain digital journey*. *D3a* describes the definition of the digital journey of the customer and user through the digital product or service. The underlying construct of the digital journey can be described as a data-based funnel that reflects the usage of a digital product or service as a whole. *D3a* can therefore indicate whether or not the experiments of a DIU contribute towards achieving the overall goal, that is, the vision (*this practice*).

Sources

L3a: Maintain vision was inspired by Mankins and Garton (2017), who emphasize the importance of alignment without excessive control in autonomously functioning systems; Ries (2011) and Niculescu et al. (2014), who describe a vision as an aligning mechanism in entrepreneurial endeavors; Hansen et al. (2011) and Westerman et al. (2014), who emphasize that a vision should be clear and unifying; and Furr and Dyer (2014), who describe leadership as the vision keepers.

Practice D3a: Maintain Digital Journey

Identifier	Competency	Tier	Discipline
D3a	**Maintain digital journey**	**3: Exploit**	**Guiding data**
Short Description			
D3a: Maintain digital journey describes the definition and continuous maintenance of a high-level data view within a so-called customer factory. A customer factory is characterized by a sub-structure that reflects the modular technological architecture of the DIU and the teams' data view on their respective modules, which should be ideally technically integrated to allow for automated real-time updates of the customer factory. The purpose of creating a customer factory is to identify bottlenecks in the digital journey of customers and users, identify future potentials for development, and provide a DIU with a compass towards target achievement.			

Table 31. *D3a: Maintain data overview* (own depiction).

Introduction

"Ways must be found to reward […] managers for keeping their organizations lean and flexible. There is a need for a philosophy […], which is not based on the assumption that adding man-power simply adds to productivity. The development of such a philosophy […] will need to be answered before our system-building technology can proceed with confidence" (Conway 1968). As interdisciplinary teams are made accountable for creating validated learnings (see *W2a*), as opposed to creating deliverables, and the structures of different system levels replicate and resonate with each other (Conway 1968), it stands to reason that the accountability paradigm that is used to hold leadership accountable against has to change as well. A digital journey provides a high-level overview of the performance of a DIU; thus, it is a suitable instrument for realizing a new accountability paradigm for the leadership in a DIU. Instead of focusing communication on specific developments within a unit, the rate at which a DIU moves towards achieving its overall target comes to the fore.

Activities

D3a: Maintain digital journey aims to establish a data-based overview of the overall performance of a digital product or service while linking overall performance with the outcomes of the experiments conducted by individual teams.

Data-based instruments that describe the digital journey of the customer and user, for instance, a customer factory (Maurya 2012), provide high-level overviews of the performance of a DIU and, given that this high-level data view is linked to the modules of interdisciplinary teams (see Schimera 2017 and *W3a: Socio-technical architecting*), can be used to visualize whether teams' experiments contribute to achieving the vision of a DIU. The definition of a digital journey used in this practice, goes beyond the definition and elaboration of a customer factory, as it links a high-level data view with the outcomes of the experiments conducted by interdisciplinary teams.

A customer factory describes a funnel that starts with unaware customers and users and ends with satisfied customers and users who have used a digital product or service. The concept of customer factory is based on McClure's pirate metrics for growth (see McClure 2007, Maurya 2012), which define five high-level metrics. The acronym used for the five metrics, *AARRR*, is the reason for the name *pirate metrics*; it stands for *acquisition, activation, retention, referral,* and *revenue.* A customer factory connects these five concepts to a digital customer and user journey. Similarly to the definition of metrics in quantitative experiments, the defined metrics in a customer factory must be actionable (see **Chapter 2.1.5.1**: Lean Startup: Experimentation towards Growth; see also *W1b*). Specifically, there is a strong relationship between the metrics defined by interdisciplinary teams to measure their experiment outcomes and the metrics used in a customer factory; these metrics can be congruent or can be used to define a contextual relationship at different levels of abstraction.

I recommend technologically integrating the individual data views of interdisciplinary teams into the digital journey, but doing so is not necessarily required right from the beginning of the process of establishing a digital journey; regular manual integration of data can also contribute to the navigation of a DIU. The following information elaborates on pirate metrics (McClure 2007) and how to integrate the provision of data within a customer factory (Maurya 2012).

Acquisition covers the question of what drives customers and users to use a digital product or service. The acquisition stage can include various activities and channels, such as paid or organic traffic, newsletters, and app stores. For connecting the outcomes of the experiments of interdisciplinary teams with a digital journey, the teams responsible for the design, development, and operation of acquisition channels must be identified, and their data views must be included within the acquisition segment of a digital journey. In the context of the flow in a customer factory, the acquisition channels are linked to the digital touchpoints of *activation*.

Activation covers digital touchpoints that lead customers and users to a first interaction with the value experience offered by a digital product or service. These interactions can involve different entry points, for instance, the home screen of an app or the homepage of a website, but, in general, every entry point that leads customers and users to utilize a value proposition is relevant in this segment. For connecting the outcomes of the experiments of interdisciplinary teams with a digital journey, the teams responsible for the design, development, and operation of value propositions of a digital product or service, must be identified, and their data views must be included within the activation segment of a digital journey. In the context of the flow of a customer factory, the digital touchpoints of *activation* are linked with the digital touchpoints of *retention, referral,* and *revenue*.

Retention covers digital touchpoints that lead the customer and user to repeated usage of a digital product or service. These touchpoints relate to *activation*, as it is the core value proposition of a digital product or service that drives customer and users to engage in repeated usage. Measuring retention requires two constructs: 1) churn rate and 2) cohorts. In contrast to the general concept of customer and user retention, the churn rate describes the rate at which customers and users abandon the use of a digital product or service. The churn rate is a viable instrument for determining the growth of a digital product or service: If the churn rate is lower than the acquisition rate, a digital product or service will grow. The costs of a high churn rate can be tremendous, as acquiring new customers, and users has been found by different studies to be "[…] five to 25 times more expensive than retaining […]" (Gallo 2014) existing customers and users. Calculating and maintaining an overview of the ratio between the acquisition and churn rates is part of the *retention* segment. Forming cohorts to keep track of measurements is generally recommendable when attempting to understand the customer and user's flow through the digital journey, but it becomes necessary when attempting to understand retention; without cohorts, it remains unclear which type of customer and user is generally loyal to a product or service and when a certain customer and user type stop using a product or service (see also **Chapter 2.1.5.1**: Design Thinking, "Personas," as a basis for designing cohorts). A lack of this information hampers answering the question after the *why* customers and users stop using the digital product or service, as information regarding which kinds of customers and user is abandoning the product or service is lacking; therefore, purposeful and efficient investigations cannot be conducted. A further target behind cohort analyses is the identification of certain actions and thresholds that stimulate customer and user retention. For instance, Twitter found that customers and users who followed 30 people were likely to return (Balke 2017), and Dropbox determined "[…] that users who uploaded at least one file were much more likely to use Dropbox again […]" (ibid.). To connect the outcomes of the experiments conducted by interdisciplinary teams with a digital journey, teams responsible for the design and development of retention mechanisms must be identified, and their data views must be included within the retention segment of a digital journey. In a first step, this mapping can result in linking the respective teams of a respective value proposition (see *activation*), as *retention* is based on the repeated usage of value propositions. The outcome of this mapping can inspire the identification of potential avenues for future experiments should no dedicated retention mechanisms be identified.

Referral aggregates the digital and non-digital activities of customers and users related to recommending a digital product or service. Such activities can take the form of word-of-mouth, which can be assessed in a qualitative or mixed qualitative-quantitative manner (e.g., with questionnaires), or by measuring the digital touchpoints that interface with other digital products or services within the overall ecosystem (e.g., social media channels). For connecting the outcomes of the experiments of interdisciplinary teams with a digital journey, teams responsible for the design and development of referral mechanisms must be identified, and their data views must be included within the acquisition segment of a digital journey. Creating these connections might also lead to the identification of potential avenues for future experiments should no referral mechanisms be identified.

Revenue describes the digital interactions between customers and users and a digital product or service that yield the desired outcome. This outcome can be monetary, but, particularly within contexts characterized by larger ecosystems and multi-sided business models, such an outcome can take different forms (e.g., validated learnings and insights concerning customers and users). The relevant digital touchpoints can take various forms, such as the customer and user adding items to a shopping cart, check-out activities, or the indirect provision of information by using a digital product or service (meta-data). Accordingly, identifying the relevant digital touchpoints can result in the identification of existing digital touchpoints (as determined in *activation*) or in the identification of dedicated digital touchpoints that lead to creating the desired results. To connect the outcomes of the experiments of interdisciplinary teams with a digital journey, teams responsible for the design and development of outcome generating mechanisms must be identified, and their data views must be included within the acquisition segment of a digital journey. Depending on the business model behind a digital product or service, this mapping can result in the teams responsible for value propositions that can produce insights (see *activation*) being linked to dedicated teams responsible for the design, development, and operation of payment and fulfillment services.

Overall, a digital journey that maps customers and users' experiences to the experiments and outcome perspectives of interdisciplinary teams and to the internal modular structures that constitute a digital product or service represents a multi-purpose coordination instrument. Similar to accounting validated learnings on level of teams, this instrument can be used to establish a new accountability paradigm for the leadership, as it visualizes a DIU's growth based on outcomes and not on added "[…] man-power […]" (Conway 1968). Furthermore, it provides the leadership of a DIU with an internal coordination instrument by enabling the identification of bottlenecks and potential avenues for future experiments. This internal coordination instrument is not based on holding teams accountable for pre-determined development targets; therefore, it does not narrow down the solution space of teams. In addition, it preserves autonomy, keeps an organization lean and flexible, and enables a DIU to continuously align with the needs of its surrounding ecosystem.

Indicators

Indicators for assessing whether a DIU is maintaining a digital journey are whether there is a designated role for creating and updating a customer factory, whether there is a defined customer factory that is highly visible to all within the DIU, whether the metrics used in the customer factory are linked to technological modules and the interdisciplinary teams responsible for the respective modules, and, ideally, whether the customer factory is technologically integrated with the metrics of the teams for the sake of efficient real-time updates.

Synergies

Different synergies can be realized through combinations between the maintaining of a digital journey (*this practice*) and other practices included in the N2DIU model. A **processual synergy** can be realized in combination with practice *W3a: Socio-technical architecting*. *W3a* describes the alignment of internal socio-technical structures and the alignment of internal structures with a market-oriented view (see *W3a* for more details). *This practice* provides a market-oriented view by providing information on the adoption and growth of a digital product or service. Therefore, *this practice* can contribute to the alignment of systems as defined in *W3a*.

An **organizational synergy** can be realized in combination with practice *L3a: Maintain vision*. *L3a* describes the definition, communication, and maintenance of a customer-, user-, and market-oriented vision for aligning the internal efforts of a DIU around a common purpose. *This practice* provides information regarding whether a DIU is making progress to achieving its target (see also Jackson 2017).

A **technological synergy** can be realized in combination with practice *D3b: Co-determine metrics and results*. *D3b* describes the continuous identification and refinement of metrics and results to enable a mixed top-down and bottom-up coordination of development efforts. *This practice* can provide a foundation for identifying results worth pursuing (*D3b*). Furthermore, a competitive environment that is characterized by uncertainty is prone to constant change. As the overall ecosystem constantly changes, a digital journey (*this* practice) needs to be constantly adapted. While the overall digital journey should be defined in light of the overall vision of a DIU, the specifics within a digital journey (i.e., the metrics) should be refined in short cycles to adapt a digital product or service constantly on a more detailed level. The maintenance of *this practice* can benefit from reflecting on the current state of the digital journey against the need to identify results and metrics on an ongoing basis (*D3b*), as such a reflection can uncover what needs to be updated within the digital journey.

Sources

D3a: Maintain digital journey was inspired by Conway (1968), who emphasizes the need to change the accountability paradigms of system managers; Jackson (2017), who argues that a monitoring instrument is required for checking whether teams' activities are contributing towards the realization of a common vision; McClure (2007) and Maurya (2012), who propose a concept suitable for realizing such a monitoring instrument; and, finally, Schimera (2017), who notes that a high-level data view should be linked with the outcomes of interdisciplinary teams.

Practice W3b: Establish Shared Ways of Working

Identifier	Competency	Tier	Discipline
W3b	**Establish shared ways of working**	**3: Exploit**	**New way of working**
Short Description			
W3b: Establish shared Ways of working describes the bottom-up identification and streamlining of core development approaches and methods. To achieve such a streamlining, methods are identified as de facto standards based on their wide adoption among interdisciplinary teams.			

Table 32. *W3b: Establish shared ways of working* (own depiction).

Introduction

Achieving "[…] efficiency, control, certainty, and variance reduction […]" (O'Reilly and Tushman 2013) is crucial for exploiting business opportunities that have been proven to have an impact on the market and realizing sustained short-term wins. A balance between consistency and innovation must be achieved within an organizational system (Mankins and Garton 2017); while new business opportunities can be explored with approaches that enable a high degree of autonomy, the process of scaling business opportunities that have been proven to have an impact on the market can be further supported by structures that reduce the variance in and improve the efficiency of the process.

In early development stages, autonomy and isolation can support rapid development (Herbsleb and Grinter 1999). However, the resulting divergence on different approaches can impede organizational and technological interoperability. Diverging ways of working can foster innovation but can aggravate knowledge and experience exchange between teams (Herbsleb and Grinter 1999). Experience in turn impacts a team's productivity and can reduce the number of defects in a digital product or service (Datta 2018).

Shared ways of working are required for achieving alignment and efficiency (Schimera 2017) and support the exchange of experience. Establishing shared ways of working can be a challenging task as, due to high degrees of autonomy, teams can develop vastly different approaches or even sub-cultures (ibid.). Establishing shared ways of working is, however, a beneficial task; besides improving organizational and technological interoperability. Shared ways of working further contribute to achieving socio-technical congruence (see Sierra et al. 2017) and reaping the related benefits (see **Chapter 4.2**).

Activities

W3b: Establish shared ways of working refers to the reduction of variance by identifying the methods most commonly adopted by teams for driving the development of a digital product or service. These "[…] best-practice methods are discovered over time and determined by popular adoption from the bottom up. A practice or tool becomes a standard only when enough squads have adopted it to make it a de-facto standard" (Mankins and Garton 2017). The identified methods and approaches are then explicitly defined to facilitate a transfer of methodological knowledge and to facilitate further supporting the underlying processes from an organizational and technological perspective. An evaluation of experiments reports (see *W2a*) can support in co-determining the approaches to support together with interdisciplinary teams. The definition of such a way of working can limit teams' degree of autonomy. Autonomy requires rules to preserve autonomy (Jackson 2017). Rules can help to maintain a high level of efficiency while they ensure that the lived autonomy of one individual does not negatively impact the autonomy of other individuals, thus, would create slowing ties or dependencies.

As a DIU is being scaled, the organizational and technological environment becomes increasingly complex. The continuous maintenance and intentional change initiatives required to ensure an overall efficient state may overload teams with duties that are not directly related to increasing the value of a digital product or service. The additional effort required to operate and maintain a system at scale must be considered in managing work, as it "[…] has been observed that the number of defects owned by a team is influenced by the amount of work the team is engaged in" (Cataldo et al. 2006; Cataldo et al. 2008; Wagstrom et al. 2010 in Datta 2018). Therefore, the number of active tasks that a team is engaged in should be limited to *two* (Schimera 2017) or *three* (Ries 2011).

Indicators

Indicators for assessing whether a DIU is establishing shared ways of working are whether there is a common inter-team understanding of the tools and methods used for experimenting, whether there are defined de facto standard methods for conducting experiments, whether these definitions are communicated and maintained, and whether the leadership monitors teams' workloads with regard to the number of concurrent activities and initiatives and, if necessary, intervenes in collaboration with the teams or relevant stakeholders from outside a DIU to reduce the number of concurrent activities that a team engages in to two or less.

Synergies

Different synergies can be realized by combining the *establishment of shared ways of working* (*this practice*) and other practices included in the N2DIU model. A **processual synergy** can be realized by combining *this practice* with practice *W3a: Socio-technical architecting*. *W3a* describes the internal alignment of systems to avoid systemic disintegration and the alignment of such systems with external requirements. *W3a* can provide a socio-technically congruent foundation that enables the assignment of clear responsibilities and efficient communication and coordination and can thus reduce outcome variance through the implementation of clearly defined structures and facilitate the definition and establishment of streamlined methods and processes based on such a congruent foundation (see also *W3a* for more details).

Another **processual synergy** can be realized by combining *this practice* with *W4: Engage communities*; the clear definition of shared ways of working (*this practice*) enables a DIU to engage with communities outside of the boundaries of the unit (e.g., open-source communities), as a clearly defined processes can facilitate communication concerning a common approach, thus, facilitates collaboration among the involved parties.

An **organizational synergy** can be realized through combining *this practice* with practice *L3b: Co-determine objectives*; the clearly defined processes and approaches as identified in *this practice* lead to transparency in the process of producing results and therefore transparency in terms of achieving objectives (see *L3b*). Transparency in both the outcomes and the process that leads to the creation of outcomes enables both teams and leadership to understand what leads to success and can therefore enable the identification of potential areas for improvement.

A **technological synergy** can further support the process of identifying the abovementioned areas for improvement. The objectives defined by *L3b*, are further broken down into a data perspective in *D3b: Co-determine metrics and results*; *D3b* can provide more detailed insights concerning the progress of achieving objectives. Therefore, *D3b* can further shed light on the potentials for improvement to the process. Understanding the relationship among shared ways of working on the one hand (*this practice*) and objectives (*L3b*), results, and metrics (*D3b*) on the other hand, might require the documentation of correlating factors over time.

Another **organizational synergy** can be realized in combination with practice *I3b: Manage skills profile*. Well-defined shared ways of working (*this practice*) enable the redistribution of skills among teams and therefore support achieving a balance of skill levels and the distribution of knowledge among teams. Furthermore, communicating shared ways of working (*this* practice) can increase task familiarity across teams by reducing the variety in terms of the processes utilized and can therefore reduce the number of defects in the digital product or service.

A further **technological synergy** can be realized in combination with practice *T3b: Manage automation*. The clearly defined processes provided by the establishment of shared ways of working (*this practice*) can reduce the scope of required automation efforts, as process variation will be reduced.

Sources

W3b: Establish shared ways of working was inspired by O'Reilly and Tushman (2013), who describe the need to combine both exploration and exploitation within an organization; Herbsleb and Grinter (1999) and Schimera (2017), who highlight the importance of shared ways of working; Mankins and Garton (2017), who describe how to define shared ways of working in organizational settings characterized by high degrees of autonomy; and, finally, Ries (2011), Schimera (2017), and Datta (2018), who emphasize that the number of parallel initiatives undertaken by a team should be limited to *two* or *three*.

Practice I3b: Manage Skills Profile

Identifier	Competency	Tier	Discipline
I3b	**Manage skills profile**	**3: Exploit**	**Interdisciplinary organization**
Short Description			
I3b: Manage skills profile describes the categorization of a DIU's skills according to their experience levels and the skill-based distribution of skills for distributing knowledge, reducing the quality variances of the digital product or service, emphasizing exploration and innovation, or for driving automation initiatives.			

Table 33. *I3b: Manage skill profile* (own depiction).

Introduction

DIUs can support the development of digital skills and disciplines (Westerman et al. 2014, Bekkhus 2017, Haffke 2017, Tumbas et al. 2018) and can furthermore be used as a means to attract and pool talents (Galbraith 2014; see also Hess et al. 2016). Both the training and the acquisition of skills require an understanding of the gap to be filled; the specific skills that require training and the missing skills that must be acquired must be identified.

"In a digital unit, skill requirements are high and also prone to change.
We introduced a skill model to understand what we have, what we require now,
and what we might need in the future.
It also enables us to allocate and rotate skill levels as needed."

– DIU development expert

Activities

I3b: Manage skills profile aims to enable a targeted knowledge distribution. A targeted distribution of knowledge enables a DIU to adopt certain modes that provide certain effects. Achieving a balanced knowledge distribution, for instance, can facilitate teams to increase their degree of task familiarity, thus to decrease the variance of quality concerning the digital product or service (Datta 2017).

Skills and skill levels can be categorized using models for assessing career levels, such as job ladders. The Dreyfus model of skill acquisition (Dreyfus and Dreyfus 1980) has been successfully applied and is still in use in the course of ING's transformation (see van Kemenade 2018). The model is used to map the existing competencies within a certain organizational setting to skill levels. The Dreyfus model defines five levels of skill acquisition:

1) novice,
2) advanced beginner,
3) competent,
4) proficient, and
5) expert.

The five levels are then further defined by their relation to four mental functions; specifically, these functions are *recollection*, *recognition*, *decision*, and *awareness.* Each mental function is characterized in a binary manner; the *novice* exhibits the poorest characteristics, while the *expert* exhibits the strongest characteristics. Each level improves in one of the characteristics compared with a previous level; consult Dreyfus and Dreyfus (1980) for more details.

The ING assumes a diamond shaped distribution of their skills across the five levels, that is, a low count of *novices* and *experts* but a plethora of competent. The diamond shaped distribution is used to reflect the actual skill distribution (see van Kemenade 2018). The deviations of the diamond shape uncover skill demands.

The Meshach (2019) generally shares the approach of adopting a diamond shaped distribution across the five levels but recommends shifting the distribution towards the lower or higher end, depending on the development focus to be adopted. For instance, the Meshach recommends shifting the focus towards the lower levels, with emphasis on the *advanced beginner* level, when *ideation and prototyping* is the focus (ibid.). In contrast, if the goal is to *build at scale*, he recommends a stronger focus on levels above *competent* (ibid.).

Indicators

Indicators for assessing whether a DIU manages skill profiles are whether the lead of a DIU discusses and co-assesses the skill levels of individuals with the chapter leads of each team (if available, see *I3a*) or alternatively with the product owner of a team or a similar central role and whether this information is used to distribute the skill levels with focus on either specific product or service developments tasks (e.g., *ideation and prototyping*) or balancing the skill level distribution in general to avoid quality variances between the individual components of a digital product or service. Such assessments and related skill rotations should be done on a regular basis. The definition of a suitable cadence can be inspired by practice *W2b: Checking ties and dependencies*, that is, adopting a quarterly cadence.

Synergies

Different synergies can be realized in combinations between the managing of skill profiles (*this practice*) and other practices included in the N2DIU model. A **processual synergy** can be realized in combination with practice *W3b: Establish shared ways of working*. *W3b* describes the bottom-up definition of standard development methods. The adoption of shared ways of working among teams supports the rotation of skills, as re-organized skills (*this practice*) are able to familiarize quickly with the processes in a new team (see also: *W3b*).

An **organizational synergy** can be realized in combination with practice *I3a: Organize at scale*. *I3a* describes the definition of different organizational structures to shape the flow of intentional communication within and across teams. The explication of these organizational structures shows dependencies within and across teams and, as far as the theory of the N2DIU model goes, provides the first explicit description of organizational structures. Therefore, *I3a* can provide a foundation for identifying and explicating the skill levels (*this practice*) of individuals within interdisciplinary teams but also at the interfaces among various organizational structures. Visualizing the varying skill levels to be found in common organizational structures supports developing an understanding of why certain organizational structures or interfaces perform as they do (see also: *I3a*).

A further **organizational synergy** can be realized in combination with practice *M4: Guide skill lifecycle*. *M4* describes the engagement of an organization with communities of interest outside of its own boundaries to acquire skills. *This practice* creates an overview of the different skills available in a DIU; therefore, it can provide a basis for planning and communicating skill acquisition activities.

A **technological synergy** can be realized by combining *this practice* with practice *T3b: Manage automation*. *T3b* describes the gradual increase in the number of automated (technologically supported) processes that otherwise must be done manually. Therefore, *T3b* can impose high requirements with regard to specific technology-related knowledge on the one hand and requires a high experience related to the prevalent structures and processes on the other (see also Meshach 2019: *Build at Scale*). *This practice* can support the identification of the high levels of experience required for enabling focused automation initiatives.

Sources

I3b: Manage skill profiles was inspired by organizations that adopt job ladders or skill levels for understanding the distribution of skills and experience among their employees and the related skill and experience requirements (see van Kemenade 2018, Meshach 2019), by models that define structures for conducting skill level categorizations (see Dreyfus and Dreyfus 1980), and by recommendations for distributing skill levels according to the different exploration and exploitation needs of an organization (see van Kemenade 2018, Meshach 2019).

Practice T3b: Manage Automation

Identifier	Competency	Tier	Discipline
T3b	**Manage automation**	**3: Exploit**	**Technological autonomy**
Short Description			
T3b: Manage automation describes the identification of suitable opportunities for increasing automation as a means of reducing quality variance and accelerating development cycles.			

Table 34. *T3b: Manage automation* (own depiction).

Introduction

Automation can reduce the time required for development cycles (Weingarth et al. 2019). Build, deploy, and release cycles do not add any value in terms of development productivity (Gruver 2015), and, if taken to an extreme perspective, it could be stated that "If you have to do it twice, there is a case for automation" (van Kemenade 2018). However, it is best to monitor what should be automated and to also consider why and when such automation should be undertaken.

Automation is a suitable approach for increasing the efficiency of experiments in a DIU. Experiments can focus on exploring a new digital product or service or by the alteration of an existing digital product or service. An experiment can provide directly visible added value to customers and users' experience or contribute to a system's performance or stability. These changes to a digital product or service must be tested with regard to their intended purpose; that is, it must be determined whether or not a desirable effect can be achieved without negatively affecting other aspects of a digital product or service. Such tests entail deployment and analysis efforts that could potentially be automated. Based on the degree of novelty of a change, it might be worthwhile to identify and investigate different automation options.

Activities

T3b: *Manage automation* describes the automation of technologically related activities that stand out due to their repetitive character and, unless automated, must be manually managed. Deployments, testing, and configuring are recurring activities in experimenting; the automation of such activities can improve development productivity by increasing teams' efficiency. Automation can support teams in releasing often and with confidence, as manual efforts and variances in the process are reduced (see Lwakatare et al. 2016).

In organizational contexts that are characterized by both a high degree of innovativeness and the reliable execution and incremental development of existing digital products or services, it must be decided which structures should be automated and which should not. These decisions can be guided by an organization's perspectives on resource availability and structural rigidity.

Grounding decisions on the need to manage limited resources is intuitively comprehensible in the light of traditional management approaches; basically, it can be said that, insofar as resources for doing so are available, structures that promise the highest return on investment should be automated. In such cases, the return on investment can be interpreted as the difference between the costs of automation and the costs of manual labor and the estimated costs of maintaining a certain degree of quality when relying on manual labor and when relying on automated labor.

Considering that structural rigidity is relevant in maintaining an agile and flexible development process, automation can be seen as a structure that is to be added to an existing structure. Each additional structure that is added to an existing structure adds rigidity. If the enhanced structure in question is geared towards exploring innovative approaches outside of already established boundaries, it must be determined whether automation can be added with reasonable effort and without compromising explorative endeavors. Even though in this example structural rigidity results from a relationship between two technological structures (i.e., a technological structure is technologically supported), the effect is comparable with the socio-technical phenomenon described by the mirroring trap (Colfer and Baldwin 2016). The mirroring trap refers (see also **Chapter 2.2.2.4**) to an excessively tight alignment between the structures of two systems such as the organizational and technological system leading to a system failing to align with innovations outside of its own boundaries. The force of a strong internal alignment can create a strong internal focus; furthermore, structures supported by other structures create a dependency or dependencies amongs these structures, which can impede creating the dependencies required for alignment with other structures. Similarly, existing technological structures can become increasingly rigid if further supported by or aligned with other layers of technology or technological subsystems. For instance, the automation of structures must be watched carefully in the light of exploration as changes in the digital product or service may entail the emergence of new structural requirements.

When identifying suitable structures for driving automation, the automation of back-office and front-office activities can be differentiated. Back-office activities, such as deployments and configurations for testing different scenarios related to a single technology or for testing the same scenario across various technologies, are more likely to be suitable targets for automation.

Automating back-office activities will not have a direct effect on a digital product or service from the customer or user's perspective but can reduce quality variance and ensure the delivery of a digital product or service.

Front-office related activities, for instance experiments that focus on measuring customers and users' perception of directly visible changes to a digital product or service, must be further differentiated. These experiments can be divided into qualitative and quantitative experiments (see also **Chapter 4.3.2.1**: *W1a* and *W1b*). While quantitative tests can potentially be automated by a tool support to certain degrees, qualitative tests should be done manually, as they are intended to test innovative ideas with low effort. As qualitative experiments do not necessarily follow a predefined structure, the design, execution, and analysis of results of a qualitative experiment are hardly automatable. Furthermore, qualitative experiments should not be automated to avoid adding structural rigidity to something that should not be rigid at all, as they would otherwise fail at achieving their intended purpose (see also McPeak 2017 for a list of specific experiment types that are worth automating).

Automation is a cornerstone of DevOps (Perera et al. 2017). Within the context of DevOps, the terms *deployment pipeline* (Soni 2015), *DevOps toolchain* (Callanan and Spillane 2016), and *DevOps pipeline* (Miglierina and Tamburri 2017) all describe the same concept; it describes the path from committing code to the provision of a digital product or service to its customer and user. This path can be automated using various tools (see **Chapter 2.1.5.1**). Code repository and version control management software can support the automated handling of code management. Examples of tools are Git, Subversion, and Mercurial (de França et al. 2016). The automation of the build process can be supported by utilizing continuous integration software such as Bamboo, Jenkins, or TeamCity (Ebert et al. 2016). The preparation of deployments can be supported by automating the provision of package using Maven, Ant, or Gradle (Airaj 2016). Configuring test environments can be automated with the help of orchestration tools, which feature an integration with containerization tools (see *T3a*) such as Kubernetes (Barna et al. 2017).

Indicators

Indicators for assessing whether a DIU is managing automation are whether there is a designated individual that is responsible for driving automation efforts within a unit. This role coordinates and plans in collaboration with experienced employees (see *I3b*) what should be automated. The automation degree of the deployment pipeline, that is, whether code management, builds, deployments, and configurations are automated or not, is another suitable indicator.

Synergies

Different synergies can be realized in combinations of the management of automation (*this practice*) and other practices in the N2DIU model. A **processual synergy** can be realized in combination with practice *W3b: Establish a common way of working*. *W3b* describes the bottom-up identification and definition of de facto standards for development approaches. The definition of de facto standards facilitates automation, as it highlights which processes can benefit from automation (see also *W3b*).

An **organizational synergy** can be realized in combination with practice *I3b: Manage skill profile*. *I3b* describes the identification of skill levels within a DIU and the derivation of future requirements in terms of both development and acquisition. The identification of experienced co-workers facilitates the determination of what should be automated and how automation should be driven based on the co-workers' experience (see *I3b*).

A **technological synergy** can be realized in combination with practice *T3a: Architect at scale*. *T3a* describes the intentional modular design of technological architecture. Identifying and implementing an intentional modular design before automating technological structures can prevent the unintentional automation of structures and thus reduce the risk of making investments that are characterized by low returns (see also *T3a*).

Another **technological synergy** can be realized in combination with practice *T4: Integrate Digital Channels*. *T4* describes the integration of a digital product or service with other digital products or services within an ecosystem. Both integrating and becoming integrated require a certain degree of maturity on the part of the technical interfaces. Automation can lower the degree of quality variance within the boundaries of a company. Therefore, the likelihood that a company will successfully provide a suitable basis for third parties to integrate their own digital products or services.

Sources

T3b: Manage automation was inspired by various sources that highlight the importance of automation in the digitization journey (see Gruver 2015, Drews et al. 2017, van Kemenade 2018, Weingarth et al. 2019); socio-technically related sources (see i.a. Conway 1968, Colfer and Baldwin 2016) that provide knowledge regarding the structures to be automated; and various sources that provide specific examples of tools that can enable automation (see Soni 2015, Airaj 2016, Ebert et al. 2016, de França et al. 2016, Barna et al. 2017, Callanan and Spillane 2016, Miglierina and Tamburri 2017).

Practice L3b: Co-Determine Objectives

Identifier	Competency	Tier	Discipline
L3b	**Co-determine objectives**	**3: Exploit**	**Supportive leadership**
Short Description			
L3b: Co-determine objectives describes the joint top-down and bottom-up determination of transparent objectives for guiding the development of a DIU and its digital product or service offers.			

Table 35. *L3b: Assign objectives* (own depiction).

Introduction

In NWoW, a few monolithic teams give way to plethora of interdisciplinary teams (see Drews et al. 2017, Corso et al. 2018). As the number of teams increases, the effort involved in coordinating teams using traditional approaches increases exponentially (see also Brooks 1975, 1995). An approach to coordinating work that maintains team autonomy and enables coordination with reasonable effort must be established.

Mixed top-down and bottom-up coordination approaches can maintain autonomy of teams while reducing the costs of coordination. Google OKR and Spotify Rhythm both provide approaches that are characterized by mixed top-down and bottom-up coordination. Both approaches aim for the co-definition of objectives that are then broken down into results and measurable data (see also **Chapter 2.1.5.3**).

Activities

L3b: Co-determine objectives describes the adoption of a mixed top-down and bottom-up coordination approach that focuses on coordination via high-level *objectives* (see Google OKR in Klau 2013) or *beliefs* and *bets* (see Spotify Rhythm in Kniberg 2016). Both approaches (Google OKR and Spotify Rhythm) have been adopted by various companies (see Steiber 2014, Kniberg 2016). They have been described as dynamic systems for coordinating continuous innovation (see Steiber and Alänge 2013).

Both Google OKR and Spotify Rhythm are characterized by an abstract and more specific level of coordination. The N2DIU model separates and mirrors these two perspectives, as the more abstract view is driven by organizational targets such as the vision (see also *L3a*), and the realization of these targets becomes visible in specific, measurable results and data (see also *D3a*). Both the abstract and the specific perspectives individually provide benefits in terms of the coordination of work: The abstract perspective facilitates inter-team communication concerning shared goals, while the more specific perspective facilitates coordination within teams and other groups (see *chapters* and *guilds* in *I3a*). Together, both views enable alignment and the identification of overarching targets and their realization as well as the data-driven realization of specific targets. Inspired by the ideas of teams, the bottom-up approaches enable the identification of overarching targets that define what a DIU should be striving for (see Doerr 2018). *L3b: Co-determine objectives* focuses on the definition of high-level *objectives* (see Google OKR) or *beliefs* and *bets* (see Spotify Rhythm), while the data-driven perspective for realizing these objectives is described in a technologically oriented counterpart to *L3b*, that is, *D3b: Co-determine metrics and results*.

Objectives describe high-level stretch goals (Rework 2016) that are intentionally designed to be "[…] beyond the threshold of what seems possible […]" (ibid.). *Objectives* or *beliefs* and *bets* describe specific future states that can be determined as having been or not having been achieved, as opposed to continuous activities. As objectives are designed to be stretch goals, they are considered to have been achieved when 60–70% of the previously defined target is hit (Doerr in Klau 2013). Constantly achieving above 70% is interpreted as indicating that an objective is ill-designed. *Objectives* or *beliefs* and *bets* are both determined on several hierarchical levels; in addition, both follow different cadences. The annual definition of objectives is used to define broad directions. These directions are prone to change as new knowledge emerges over the course of achieving an annual objective. Quarterly defined objectives describe more specific goals that are less prone to change and pursued in support of the annual objectives. In Spotify Rhythm, beliefs and bets are defined more specifically in terms of the hierarchical levels to be considered and related cadences (see **Chapter 2.1.5.3**) but follow the same logic in general. Objectives, beliefs, and bets are openly discussed and co-determined between different hierarchical levels. It is recommended not to exceed five objectives per organizational node at a time (Doerr in Klau 2013). It should be added that teams should not work on more than two to three initiatives simultaneously (see *W3b*).

Indicators

Indicators for assessing whether a DIU is co-determining objectives are whether its leadership is co-determining objectives for its future development and also for individual team development; whether these objectives are based on different sources of information, for example, whether they are derived from the common vision of a DIU (see *L3a*) or on the basis of the metrics and results of individual teams (see *D3b*); and whether these objectives are openly communicated, reviewed, and further co-determined on a regular basis across teams.

Synergies

Different synergies can be realized by combining the co-determination of objectives (*this practice*) with other practices included in the N2DIU model. A **processual synergy** can be realized in combination with practice *W3b: Establish a common way of working*. *W3b* describes the bottom-up identification and definition of de facto standards regarding development approaches; therefore, the practice creates transparency and reduces variance on the process level. *This practice* creates transparency with regard to achieving targets. Considering both the insights provided by practices from a long-term perspective can enable teams and leadership to understand the relations among different processual approaches and results and therefore makes it possible to understand what leads to success and under which circumstances (see also *W3b*).

An **organizational synergy** can be realized in combination with practice *L3a: Maintain vision*. *L3a* describes the definition, communication, and maintenance of a customer-, user-oriented, and market-oriented vision for aligning the internal efforts of a DIU around a common purpose. Objectives should drive the vision; the vision can inspire the definition of objectives as in *this practice* (see also *L3a*).

Another **organizational synergy** can be realized in combination with practice *L4: Transform ecosystems*. *L4* describes how the leadership of a DIU draws on mature knowledge to transform the interfacing structures of a DIU; can include the processes or structures in general of other organizational units but also structures of suppliers. The definition of objectives, or beliefs and bets (see *this practice*), can be conducted on different levels of abstraction and can also be used to align initiatives across organizational boundaries. Therefore, objectives defined in a DIU can aim for and support the transformation of interfacing structures, thus driving the digital transformation of a firm concentrically from a DIU towards the outer boundaries of a company's ecosystem.

A **technological synergy** can be realized in combination with practice *D3b: Co-determine metrics and results*. *D3b* describes the continuous identification and refinement of metrics and results to facilitate a mixed top-down and bottom-up coordination of development efforts. As each objective should be connected to key results and beliefs and bets are to be backed by data and insight, *D3b* can provide a more specific perspective to provide the required information.

Sources

L3b: Co-determine objectives was inspired by Conway (1968), Brooks (1975, 1995), Gruver (2015), Drews et al. (2017), Corso et al. (2018), who together describe the necessity of changing traditional coordination approaches in the context of innovative settings; Steiber and Alänge (2013) and Steiber (2014), both of whom present Google OKR as an approach to coordination in innovative settings; Klau (2013) and Doerr (2018), both of whom provide details on utilizing Google OKR; and Kniberg (2016), who provides information on a comparable approach, namely Spotify Rhythm.

Practice D3b: Co-Determine Metrics and Results

Identifier	Competency	Tier	Discipline
D3b	**Co-determine metrics and results**	**3: Exploit**	**Guiding data**
Short Description			
D3b: Co-determine metrics and results describes the joint top-down and bottom-up determination of metrics and results for guiding the development of the digital product or service produced by a DIU from a data perspective.			

Table 36. *D3b: Refine metrics* (own depiction).

Introduction

All stakeholders in a DIU must be able to understand whether they are on the right track towards achieving a common goal (see Jackson 2017). Gauging progress is enabled by taking constant measurements and implementing feedback systems (Mankins and Garton 2017). As the needs of customers and users, as well as those of a digital product or service, are prone to change in environments characterized by high degree of uncertainty, such feedback systems must be continuously adapted to changing circumstances.

"The importance of metrics shifts over time.
Some may become obsolete, while new metrics need to be considered.
We need to check and adapt continuously."

– Head of DIU analytics

Activities

D3b: Co-determine metrics and results refers to the continuous examination, adaption, and redefinition of metrics and results. The co-determination of metrics and results can relate to individual team outcomes, the overall performance of a digital product or services as visualized in a digital journey (see D3a), or derived from co-determined objectives (see *L3b*). *D3b* connects different points of interest within a DIU to provide guidance from a data perspective.

Mixed top-down and bottom-up coordination approaches can enable teams to efficiently maintain the alignment of a DIU with a fast-changing environment. Through their bottom-up emphasis on identifying coordination needs, both Google OKR and Spotify Rhythm enable teams to maintain a feedback system based on metrics and results (see Google OKR) or data and insights (see Spotify Rhythm), that can not only reflect the status quo but also indicate vectors for future development.

Indicators

Indicators for assessing whether a DIU is co-determining metrics and results are whether the teams of a DIU are co-determining metrics and results (or data and insights, depending on the adopted coordination approach) based on the outcomes of prior experiments. This enables teams and the leadership to identify potentials for development in general, opportunities within the context of a digital journey (see *D3a*), the degree of the achievement of objectives (see *L3a*). Furthermore, results and metrics or data and insights must be communicated, reviewed, and further co-determined with the teams on a regular basis.

Synergies

Different synergies can be realized in combinations of the co-determination of metrics and results (*this practice*) with other practices included in the N2DIU model. A **processual synergy** can be realized in combination with practice *W3b: Establish a common way of working*. *W3b* describes the bottom-up identification and definition of de facto standards regarding development approaches; therefore, it creates transparency and reduces variance on a process level. *This practice* creates transparency from a result achievement and metrics perspective. Understanding the relation between specific development processes as defined in *W3b* and the outcomes of such processes displayed through metrics (*this practice*) enables teams and leadership accumulate knowledge on how well a particular process in its current form works.

An **organizational synergy** can be realized in combination with practice *L3b: Co-determine objectives*. *L3b* describes a coordination mechanism based on a bottom-up and top-down definition of objectives. As each objective should be connected to results (or each bet should be connected to data and insights, depending on the adopted coordination model), *this practice* can provide a more specific perspective on co-determining and realizing objectives as defined in *L3b* (see also *L3b*).

A **technological synergy** can be realized in combination with practice *D3a: Maintain digital journey*. *D3a* describes the definition, communication, and maintenance of a high-level data view that describes the customer and user's journey when using a digital product or service. *D3a* can support identifying desirable results or insights that would be worth leveraging in the future, while *this practice* can support the purposeful transformation of a digital journey and the continuous updating of relevant metrics.

Another **technological synergy** can be realized in combination with practice *D4: Learn systematically*. *D4* describes how insights gained concerning customers and users are processed to identify new business opportunities or improvements to an existing business opportunity. The metrics and results or data and insights as provided by *this practice,* can fuel *D4* by providing input.

Sources

D3b: Co-determine metrics and results was inspired by Mankins and Garton (2017) and Jackson (2017), who highlight the importance of having a feedback system in place that can be used to purposefully guide development efforts (they further describe the necessity of continuously updating this feedback system); Dorr (2018) and Kniberg (2016), both of whom provide information on constructs, specifically, *results* and *data* and *insights*, that can be used in establishing such a feedback system.

4.3.2.4. Tier 4: Engage

Tier 4: Engage describes how knowledge transfers at the boundaries of a DIU can enable engagement with adjacent ecosystems by drawing on the accumulated knowledge that has developed over the course of developing a DIU. The target of this tier is twofold: to further develop a DIU and also to support driving the digital transformation of a firm concentrically from a DIU outwards. As opposed to the other tiers in the N2DIU model, the fourth tier does not introduce any further disciplines.

Tier 4: Exploit, however, introduces seven practices. The seven practices are positioned at the top of each discipline (see **Figure 33**; see also **Figure 26** for a view of the whole model). The seven practices are

- *V4: Explore new visions*
- *L4: Transform ecosystems*
- *I4: Guide skill lifecycles*
- *W4: Engage communities*
- *T4: Integrate digital channels*
- *D4: Learn systematically*
- *S4: Open platform*

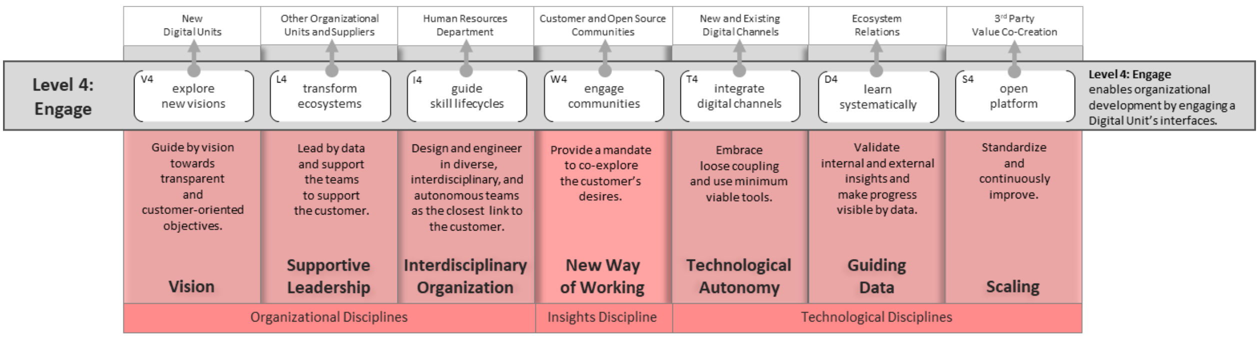

Figure 33. The *N2DIU* model: focus on *Tier 4: Engage* (own depiction).

The seven practices of tier 4 can be seen as hypotheses for the future extension of the model. They are thus far hypothetical. Foundations in the sense of scientific or practitioner knowledge are limited. The practices of tier 4 can be viewed as the logical consequence of utilizing the knowledge gained over the course of developing a DIU to further engage with the boundaries of a DIU's ecosystem. The representation of each practice is kept short. The usual information constructs, for instance, *indicators* or *synergies*, are not used to describe practices included in tier 4.

Practice W4: Engage Communities

The practice *W4: Engage communities* describes the engagement of further communities, for instance the engagement of open-source communities or developer communities in general, by forging alliances with such communities, hosting events, or bestowing awards (see van Kemenade 2016). As they define an organizational interface, the processes defined in *W3b* can support quickly realizing collaborative undertakings. A further opportunity is the realization of C2C communities to enable customers and users to support each other (see Fidor 2009).

The realization of a C2C community increases the level of expertise of some customers and users and therefore makes them valuable sources of knowledge for further developing a digital product or service. C2C communities can be implemented in combination with incentive systems to nurture customer to customer interaction. Incentive systems can also be a suitable indicator for identifying experienced customers and users, as these systems often track and quantify charitable behavior. The identification of experienced users can be relevant for conducting experiments.

Practice I4: Guide Skill Lifecycles

Attracting new talents is an ongoing challenge. A grown and scaled DIU can be used to emit a signaling effect; NWoW combined with innovative organizational and technological structures can be used to strengthen the employer brand of a company. In collaboration with the company's human resources department, the skills required by a DIU can be identified with the assistance of the practice *I3b*, and campaigns intended to ensure a smooth skill lifecycle can be initiated.

Practice T4: Integrate Digital Channels

The practice *T4: Integrate Digital Channels* describes the integration of the various digital channels to provide a seamless customer and user experience across various devices (see also Hansen and Sia 2015). Besides providing a seamless customer and user experience, the integration of different devices can enable the design and development of new services. For instance, location, mobility, camera, microphone and other functions of small form factors can be integrated with the comfort of devices with larger screens and advanced input and output channels. Therefore, services that consider and leverage the various beneficial functions of different devices can be designed to improve the customer and user engagement.

The integration of different digital channels can also be viewed from a different perspective. Instead of providing a digital product or service across various different channels, the services offered by other providers within the adjacent ecosystem can also be considered for integration. Such integrations can be beneficial from various perspectives; for instance, they can be used to acquire further potential customers and users, to enrich the value proposition of the own digital product or service, or to nurture customer and user retention. Depending on the design of the ecosystem to be integrated, alliances can be forged, and contracts must be signed.

Another benefit of integrating various digital channels lies in the improved ability to re-enact the customer and user journey; the flow of customers and users across different channels and services can be modeled and quantified with increased accuracy due to the availability of additional information.

The added structural maturity that stems from selectively automating structures (see *T3b*) can support integrating various channels or services of an ecosystem; the integration of channels and services requires a certain degree of quality and reliability to ensure that each partner can rely without compromising the quality of its own offering.

Practice L4: Transform Ecosystems

Over the course of developing and scaling a DIU, leadership will develop a profound understanding of how to establish NWoW and what establishing such lean and agile ways of working can entail. This knowledge can be leveraged to transform the interfacing structures of a DIU such as processes within departments within third-party service providers, to drive the digital transformation of a firm concentrically from a DIU to the boundaries that company's ecosystem.

A striking example is Toyota. Toyota involves third-party companies at an early stage in research and development activities by forming joint organizational structures and drawing on the concept of co-location (see Volk 2017). Driving transformational efforts at the boundaries of a DIU can be supported by defining joint objectives in collaboration with relevant stakeholders (see *L3b*). Relying on the existing coordination mechanism of a DIU brings several benefits: First, knowledge transfer is induced by teaching and using the prevalent coordination mechanism together with a partner to collaborate; second, using the same coordination concept for driving outwards transformation as for driving the transformation of a DIU enables to re-use the existing resource estimation processes; and, third, the coordination mechanisms of *L3b* allow for objectives to be defined on different levels of abstraction, therefore, the coordination mechanism of a DIU can be linked to the high-level targets of a company.

Practice D4: Learn Systematically

Over the course of the development of a DIU and its digital product or service, a plethora of customer and user insights can be gathered. The process of gathering these insights must be adapted to changing market circumstances, for instance by adapting a relevant set of metrics (see *D3b*). This data can be processed using various technologically supported approaches, such as big data, machine learning, or artificial intelligence in general, to identify trends and marketing opportunities or opportunities to develop new features. Furthermore, depending on the available data, it can also provide insights into improving the internal efficiency of a DIU.

Practice V4: Explore New Visions

Over the course of developing a DIU and a digital product or service, many ideas are developed, explored, instantiated, dismissed, or delayed. Some ideas become part of the developed digital product or service, some are tested and discarded, and yet others can seem be promising but be outside the scope of the existing digital product or service. The latter class of ideas can provide a basis for forming new visions and hence developing a new DIU. The journey of developing a DIU and its digital product or service can be started again from *Tier 1: Explore*.

Practice S4: Open Platform

Becoming an open platform is the most ambitious target when scaling a digital product or service. Developing a platform requires a profound understanding of the surrounding ecosystem, a central position within this ecosystem or the opportunity to create a central position, initial experiences with the technological integration of services, increased degrees of standardization, the provision of options for customizing the own digital product and service to third parties, and a further decrease in quality variance, as third-party providers will rely on the digital product or service provided by a DIU.

Providing standardized services with options for customization can lead to a new level of scaled value co-creation, as third-party service providers can also develop an interest in scaling the ecosystem in question. Another option that should be considered when striving for platform status is the provision of deeper access to the APIs of digital products or services; this can enable third-party service providers to explore and develop their own completely new services based on the original digital product or service.

5. Evaluation

Following the PDR approach, this chapter is divided into two sections (see **Chapter 3.2**). The first section (see **Chapter 5.1**) summarizes our (i.e., the research team's) empirical inquiries within the scope of the intra-organizational shaping. The second section summarizes how inter-organizational transfers (see **Chapter 5.2**) shaped the design of the N2DIU model.

5.1. Intra-Organizational Shaping

In the following, I present an overview of our empirical inquiries within the scope of intra-organizational shaping. More information on additional formative evaluation activities is provided in **Chapter 3.3.3**.

Lean Startup Interventions in a Digital Innovation Unit

We intervened in a DIU by implementing the LS method to replace the existing Scrum approach (see **Chapter 3.3.3: s1**). **Table 38** below (see pages 266-267) provides an overview of the empirical inquiries conducted within the frame of the LS interventions. The research team became part of the organization over the course of implementing these interventions.

The table includes 38 interviews and workshops, all of which can be further clustered. Table items 1–5 describe the initial process of acquiring knowledge to understand the status quo in the DIU and developing and communicating an initial concept of an artifact with the target of its instantiation. Items 6–12 describe the familiarization of the research team with the development of the digital product or service of the examined DIU, the discussion and planning of the implementation of the LS approach, and the formation and organization of an interdisciplinary team. Items 13–14 relate to the provision of initial method training with the interdisciplinary team. Items 15–26 describe the execution of the method in two iterations and ongoing method coaching activities. Items 19, 26, and 31 present dedicated reflections on aspects that drove or impeded the instantiation of the initial concept (see **above**: table items 1–5). Finally, the last activities (29–38) of the LS interventions focused on a further transfer of method knowledge within the unit and the creation of knowledge artifacts that were tailored for the use within the specific DIU.

Re-Assessment of a Digital Innovation Unit

After our first interventions (see **above: Lean Startup Interventions**), we returned to the DIU approximately one year later. Our target was to re-assess the status quo, review what changed since we have driven our initial interventions within the DIU, and identify implications for further development. We conducted three interviews and a workshop (see **Table 37**). The initial interview, which had a duration of two hours, proved suitable for the purpose of assessing the status quo. The second interview, which had a duration of one hour, suited the purpose of reviewing the changes that had been made to the IT architecture since our previous assessment. We continued by discussing different options for further development with the head of the DIU and then conducted a workshop to initiate some of the planned initiatives.

#	Date	Type of Inquiry	Topic	Interviewees / Participants
1	17.04.2018	Expert interview	Re-assessment: first overview	Head of DIU
2	12.05.2018	Expert interview	IT architecture landscape	Head of IT systems
3	04.06.2018	Expert interview	Discussing different implications	Head of DIU
4	28.06.2018	Workshop	Backend automation	Head of DIU, head of IT systems, diverse

5.2. **Table 37.** Empirical inquiries within the scope of re-visiting a DIU (own depiction).**Inter-Organizational Transfers**

In the following, I summarize our (i.e., the research team's) empirical inquiries within the scope of inter-organizational transfers.

5.2.1. t1: Expert Interview

To initiate our inter-organizational transfers, we arranged a 60-minute interview with an expert from a large, globally active enterprise. Within the enterprise, the expert holds the role *head of IT* in Germany. At the time of the interview, the company had successfully developed and operated a DIU. At the time of writing, the company plans to employ the structures utilized in its DIU throughout the organization.

We used our current model version (see **a3** in **Chapter 3.3.2**) as a guideline for the interview. The interview was initiated by an introduction to the model, which took approximately 15 minutes. We presented its purpose and architecture and subsequently deep-dived the individual disciplines and practices to induce a discussion comparing the experience of the expert against the individual elements of the model. We recorded and transcribed the interview. The expert was able to draw on rich experiences ranging from the initial attempt to build a DIU 10 years ago to the operation of a scaled DIU at the time of the interview. The interview confirmed our basic idea, the discipline-based architecture, and the stage approach. Still, the interviewee provided detailed feedback concerning our specific implementation of the stage logic, the positioning of individual practices within the model, and the absence of additional relevant practices. We deemed all feedback

#	Date	Type of Inquiry	Topic	Interviewees/Participants
1	14.12.2015	Expert interview	Development process	IT supervisor DIU
2	12.01.2016	Expert interview	Platform and analytics tools	IT supervisor DIU, analytics expert
3	13.01.2016	Expert interview	Organizational structures and roadmap process	Head of DIU
4	14.01.2016	Expert interview	Organizational structures and roadmap process	Head of DIU
5	05.02.2016	Workshop	Kick-off: Interventions	IT sponsor of DIU
6	08.02.2016	Expert interview	Team roles and development process	Pilot team lead
7	18.02.2016	Expert interview	The concept for the loyalty program	CRM expert
8	18.02.2016	Expert interview	Development process and room for improvement	Head of concept and UX
9	24.02.2016	Expert interview	Lean startup for concept development	CRM expert
10	03.03.2016	Expert interview	Consumer journey	Head of concept and UX
11	09.05.2016	Floor talk	Recruit interdisciplinary team	Head of DIU
12	26.05.2016	Expert interview	Concept for personalization	CRM expert
13	02.06.2016	Expert interview	Teams: Structure and process change	Head of DIU
14	07.06.2016	Workshop	How to apply lean startup	Pilot team lead, CRM expert, digital marketing expert
15	09.06.2016	Floor talk	User testing	Pilot team lead
16	15.06.2016	Workshop	Ideation, BML iterations planning, enterprise dependencies	Pilot team lead, CRM expert, digital marketing expert, concept and UX expert 2, concept and UX expert 3
17	23.06.2016	Expert interview	Metrics for BML	Pilot team lead, CRM expert
18	28.06.2016	Expert interview	User testing	Pilot team lead
19	28.06.2016	Expert interview	Enterprise dependencies and lean startup	Head of DIU
20	29.06.2016	Expert interview	Reporting and metrics	Pilot team lead
21	04.07.2016	Workshop	The structures and benefits of an experiment-driven development approach	Employees in the DIU

22	07.07.2016	Expert interview	Reporting and metrics	Pilot team lead, CRM expert
23	08.07.2016	Expert interview	KPI and metrics DIU	Head of analytics
24	13.07.2016	Expert interview	User testing	Analytics expert
25	26.07.2016	Expert interview	Reporting and metrics	Pilot team lead
26	11.08.2016	Expert interview	Enterprise dependencies and lean startup	Pilot team lead
27	11.08.2016	Expert interview	Learning and documentation formats and tools	Pilot team lead
28	25.08.2016	Expert interview	Development process	Head of DIU
29	08.09.2016	Expert interview	"Lean Startup in a Large Enterprise" process	Head of DIU
30	20.09.2016	Expert interview	Lean startup and large enterprises	Pilot team lead
31	05.10.2016	Workshop	Workshop: Enterprise dependencies and lean startup	Pilot team lead, CRM expert, digital marketing expert, concept and UX expert 1, concept and UX expert 2, concept and UX expert 3
32	17.10.2016	Expert interview	Roles in a team and the lean coach	Pilot team lead, CRM expert
33	19.10.2016	Expert interview	Customer factory	Head of analytics
34	20.10.2016	Expert interview	Process definition *lean startup* and metrics selection tool	Head of DIU
35	20.10.2016	Expert interview	Process definition *lean startup* and metrics selection tool	Pilot team lead
36	24.10.2016	Expert interview	Role definition *lean coach* and method selection tool	DT expert
37	03.11.2016	Expert interview	Process definition *lean startup* and metrics selection tool	Head of analytics
38	05.12.2016	Workshop	Artifact presentation *disciplines model* and summary of insights	CIO, IT sponsor of DIU, IT lead of DIU

Table 38. Empirical inquiries within the scope of the lean startup interventions (own depiction).

obtained during the expert interview as being relevant and changed the artifact design accordingly. **Table 39** provides an overview of the changes and their grounding within the interview.

#	Change	Grounding
1	Revision of the model architecture: we refined the flat stage structure to a constructive tier structure, resulting in the introduction of certain topics before others are addressed.	“I like the model because it represents a growth model that reflects our own growth journey. However, today, I would address the topics *teams and skills* and *data* earlier within the model” (expert 1, translated by the author). “I would say the topic *teams and skills* should be introduced very early […]. […] I would address this topic very very early because, otherwise, your unit will not grow” (expert 1, translated by the author). “Today, I would recommend that every company address the data level early. […] Prioritize measures that evidently lead to changes in the customer experience” (expert 1, translated by the author).
2	Added model element: we added the customer within the model	“Where is the customer in this picture? It is all about the customer and co-creation with the customer. The customer must be included” (expert 1, translated by the author).
3	Added principle: “manage skill profile”	“One thing that I am missing is – well, you have it addressed here with *teams* – the whole topic of *skills*. […] We introduced Dreyfus-based skill profiles very late. The Dreyfus model defines standards for the skills an employee should have on each level. It includes hard and soft skills to provide a complete profile. This enabled us to plan what skills we should have in which quantities. […] We concluded that it requires a diamond-shaped distribution of novices and experts. […] Today, I would say that we introduced this topic too late” (expert 1, translated by the author).
4	Re-arranged principle: “develop internal skills” is now addressed early in the model	“You won’t be able to build and scale a digital innovation unit with the outsourcing of, for instance, 70% of the required personnel. You need most parts of your team onshore and being employed by your own company. If you work with, let’s say, only 30% of your personnel being employed by your company, you can also cancel the digital innovation unit. You need your own organization” (expert 1, translated by the author).
5	Refined dimension description: we refined the description of the *teams* dimension to express their interdisciplinary and diverse nature	“Sorry, but I don’t think that a homogenous team of…, let’s take an extreme example, 10 men between 20 and 25 cannot design the customer experience required by a target group of 70-year-old retired females” (expert 1, translated by the author).
6	Refined dimension descriptions: we renamed the dimensions to better people and technology, business, and IT.	“The customer experience is a shared responsibility of business and IT. […] You can also group according to people, process, and technology” (expert 1, translated by the author).
7	Refined principle and dimension descriptions: we renamed dimensions and related principles to highlight the importance of data and insights into a customer-driven approach.	“I think that data is a core topic within the model. You need to start your development from the perspective of the customer. You need to measure the minimum viable activities that impact customer experience. I think this is underemphasized and also is addressed too late within the model” (expert 1, translated by the author).

Table 39. Impact of the expert interview on the model’s design (own depiction).

5.2.2. t2: Expert Circle

We arranged an expert circle, to whom we presented the modular model for evaluation. The expert circle consisted of six c-level executives, four of whom were from IT consultancy firms and two of whom were from a user company. While the expert interview (see above) provided us with sufficient time in which to introduce and discuss the model's architecture, functionality, and practices in detail, the format of the expert circle required us to convey the idea and content in a 15-minute presentation. However, we subsequently a 30-minute feedback session. We received positive feedback in general. We noted that every expert was able to understand and follow the basic idea intuitively and that the feedback was rich and multi-faceted.

The feedback provided focused less on the architecture and practices of the model and more on the details, indicating that the model design itself had achieved a certain degree of maturity. In particular, the audience noted the balance between leadership and data, a feature that makes it possible for leaders to base decisions on hard facts rather on gut feel or opinions (see also Ries 2011).

Further feedback included a request for a basic logic explaining the relations and interfaces among the individual practices. Such a logic could be employed to explain how one practice builds on the other or how practices form synergetic relationship with each other to further in-crease the intuitiveness of the admittedly somewhat complex model. In addition, the audience requested added clarity regarding the tiers; they suggested that the model should present the differences between the tiers more prominently and also explain what differentiates one tier from another.

Further questions related to applying the model included, for example, "what if a DIU is well-developed in one area (when measured against the model) but underdeveloped in another area?", how does a well-developed state in one area impact the development of adjacent but under-developed areas, and what are the thresholds between the tiers (i.e., when is a DIU ready to advance to the next tier)?

Towards the end of the feedback session, two very specific points were noted: The first point related to the naming of the pivotal dimension *method*, which the interviewees suggested should rather be named *way of working* or something similar, and the second point related to the practice *skill model's* name not being intuitively understandable. Both specific points showed that we adopted an excessively academic or rather abstract mindset when determining the nomenclature. We adopted both suggestions by renaming *method* to *way of working* and renaming *skill model* to *skill profile* to further increase the model's practitioner-orientation.

We considered the other feedback points regarding the differences between tiers, the relations among practices, and the application process behind the model as crucial suggestions that would add to the overall artifact design; implementing these suggestions required varying degrees of effort. Implementing superficial changes to the representation of the tier logic was easily done. However, carving out the basic logic that describes the positioning of the individual practices and their relations required effort; at that point, we had already identified a basic logic (see **Chapter 2.2**) that also influenced the design of the shown artifact version, but elaborating on this logic in light of the artifact representation required more effort. In a similar vein, an implicit application process existed, but making this implicit process explicit and accessible for a community of practice was a demanding undertaking. Thus, we had to make a trade-off at this point and opted to continue our evaluations with an artifact version that considered the feedback provided regarding the superficial representation of our model while continuing our development on the representation of the basic logic and the application process in the back-office.

The expert circle closed with a discussion initiated by the consultancy firms regarding further transfers of the artifact to other organizational contexts and potential licensing models for using the artifact, which we interpret as a proof of value and, moreover, as the first step towards a proof of use.

5.2.3. t3: Initiation of External Instantiation

With the goal of achieving a proof of use, we initiated two experiments involving transferring our artifact to other organizations. Both experiments yielded negative outcomes but provided us with valuable insights for the future.

First Transfer Attempt: Local German Insurance Company

Inspired by Nunamaker et al.'s (2015) recommendation to strive to achieve a proof of use, we attempted to make the first transfer for instantiating our latest artifact version to an organizational context that had not been exposed to our prior research activities. Furthermore, our attempt at transferring our artifact was inspired by the insights we had gained from creating different artifact versions; that is, we were aiming to achieve a practitioner commitment by identifying paying customers who would participate in an artifact-based assessment of a DIU in the form of a consulting service.

The target of this step was to gather further information on whether there would be paying customers for artifact-based consulting services and how such a customer could be reached. We conducted a qualitative experiment by communicating the idea to the IT chairman of a German insurance company and his assistants. We did so with the help of a slide deck consisting of 14 slides (see **Figure 34** for an excerpt from the slide deck).

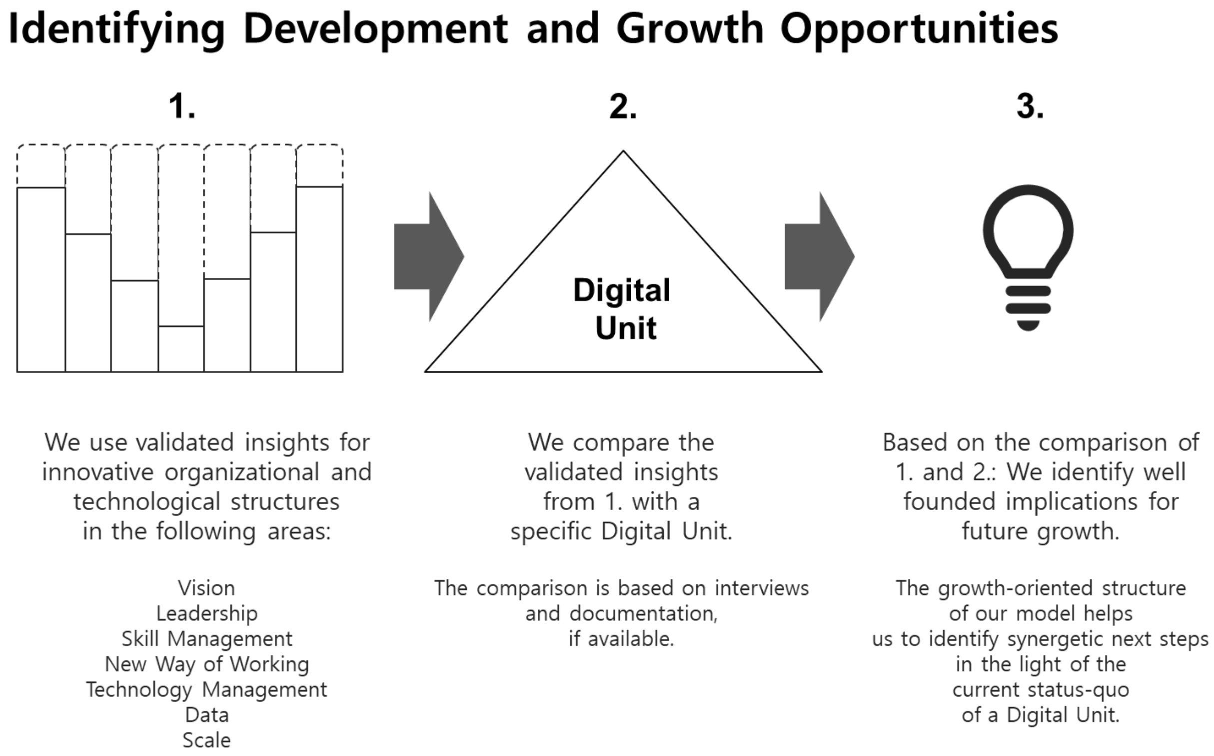

Figure 34. Excerpt from the slide deck for communicating the idea of an artifact-based service (own depiction).

In light of the expected outcome of the experiment, that is, the successful initiation of an artifact-based consulting service, it can be said that the experiment failed. Nevertheless, we gained some valuable insights: For example, we realized that our slide deck did put enough emphasis on business benefits. We concluded that we need to re-design our slide deck in order to provide our contact persons with information and arguments that facilitate persuading other stakeholders within a company to buy into the idea of supporting the development of a DIU with an external consulting service. The development of a DIU usually involves a joint business-IT endeavor. When pitching an artifact-based consulting service, it is thus necessary to consider and address the interests of both sides.

Second Transfer Attempt: Global Insurance Company

Motivated by our first artifact-transfer attempt in the form of providing an artifact-based consulting service (see **above**), we initiated a second transfer attempt. Based on the insights obtained from our first transfer attempt, we determined that we must motivate the value behind applying the artifact from additional perspectives that are potentially involved in building a DIU.

We created a slide deck from scratch and used the deck to communicate the value of providing an artifact-based consulting service. We presented the deck to two leading employees of the DIU of a globally active insurance company. In comparison with our first transfer attempt, we did not specifically attempt to sell the service but left the outcome more open. This led to the identification of a new approach.

The main target when creating a DIU is the establishment of an NWoW. Usually, driving this transformation is the responsibility of the IT department, a business function, or both. This may create a struggle for power. However, the process of establishing NWoW can be also considered from a perspective that differs from those traditionally used for developing a DIU, namely the perspective of the human resources department. The acquisition of future talents is a fundamental activity in the digital transformation of a firm.

A human resources department aims to establish ways of working that appeal to talents, for instance by enabling trust-based working hours or working from one's home office. An NWoW, however, as described by our model and established within a DIU, can provide a new level of depth to establishing appealing ways of working within a company. Positioning the HR department as the main driver of a firm's digital transformation can prevent a potential power struggle between two groups that might share a common history.

Compared with our first attempt at an external instantiation, the more open-ended approach provided us with more open ideas for first designing and then positioning future ways of communicating and experimenting with our artifact-based consulting service.

Summary

We initiated two trials involving the instantiation of our artifact in new organizational settings. We were not able to achieve a proof of use, however. Both trials provided us with precious feedback that we plan to use for developing a series of experiments towards creating a proof of use. We firmly believe that the modular, robust, structured, and constructive approach of our artifact can provide practitioners with valuable and unique guidance concerning the design and creation of DIUs.

6. Contributions, Limitations, and Future Research

The concept of DIUs is still emerging. There is still a lack of a widely accepted definition of a DIU, but these units are increasingly being adopted by practitioners (see Simon 2014, Westerman et al. 2014, Galbraith 2014, Amberti 2015, Hearn 2016, Hess et al. 2016, Kaufmann and Horton 2015, Chanias and Hess 2016, Rieß et al. 2016, Drews et al. 2017, Swaminathan and Meffert 2017, vom Brocke et al. 2017, Åkesson et al. 2018, Duerr et al. 2018, Gimpel et al. 2018, Harpham 2018, Miyazaki and Sato 2018, Osmundsen et al. 2018, Ross et al. 2018, Fortmann et al. 2019, Weingarth et al. 2019). Thus, a scientific contribution to DIU research was timely.

The results of my research expand the boundaries of both the ways in which practitioners can create DIUs and the scientific body of knowledge regarding the foundations and structures of DIUs. Guided by my research questions (see **Chapter 1**), this thesis provides both theoretical and practical contributions.

The theoretical contributions are provided by the presentation of a state of the art regarding the concept of DIUs (see **Chapter 2.1**), the review and summary of pertinent literature in the field of socio-technical organizational design (see **Chapter 2.2**), and the introduction of PDR as a new design research approach (see **Chapter 3.2**).

Practical contributions are provided by the artifact resulting from my design research, that is, the N2DIU model for developing DIUs (see **Chapter 4**), the provision of orientational knowledge on the positioning of DIUs (see **Chapter 2.1**), and three design principles for developing DIUs and for developing models that can guide the development of a DIU (see **Chapter 4.2**). This thesis closes by identifying limitations and opportunities for future research.

6.1. Theoretical Contributions

This thesis provides two theoretical contributions: First, it presents the very first review on the state of the art of DIUs in general, and, second, it explored the literary trajectory of Conway's law in pertinent and peer-reviewed scholarly articles.

The State of the Art of Digital Innovation Units

This thesis provides the first summary of the state of the art of developing DIUs (see **Chapter 2.1**). This presentation of the state of the art considered practitioner and scholarly sources to increase the relevance of the literature review outcomes (see also Marrone and Hammerle 2016). The state of the art of DIUs was structured by adapting Strauss' (see Strauss in Böhm 2004) coding paradigm for social science research; in addition to the actual phenomenon being investigated, Strauss' coding paradigm provides high-level code categories for contextualizing that phenomenon by identifying causal conditions, context and intervening conditions, action strategies, and the consequences of a phenomenon. The adoption of this coding paradigm enables the reader of our findings to gain knowledge concerning the phenomenon of DIUs, to understand the role of DIUs within the context of a firm's digital transformation, gain information concerning the positioning of DIUs within an organization, understand DIUs in the context of new roles and new models for organizational alignment in the digital era, and, finally, to understand the risks and benefits related to developing a DIU. Furthermore, applying Strauss' coding paradigm (see Strauss in Böhm 2004) to the phenomenon of DIUs enables future researchers to position their research within the overall context of the topic of DIUs.

While DIUs have been established in many companies, they are still somewhat of an emerging phenomenon. Firms require both explorative and exploitative activities (Tushman and O'Reilly 1996) to ensure their long-term survivability. DIUs can carve out a space for establishing innovative socio-technical structures intended to guide the development of an innovative product or service from exploration towards growth, and, eventually, exploitation. Research on dedicated, innovative business-IT organizational units should be intensified. Galbraith (2014) recommended that global companies should even employ several DIUs; we anticipate the establishment of various DIUs in the future based on different digital products or services or springing from different IT-business collaborations, for instance between marketing and IT or sales and IT. I hope to fuel future research on this pivotal organizational structure by providing a first base upon which future researchers can base their work.

The Trajectories of Conway as Prescriptive Socio-Technical Knowledge

Following the literary trajectories of Conway's law (1968) provided a broad and in-depth understanding of the design of the design of socio-technical structures. While investing the trajectory of Conway's concept in literature, I identified four different research streams (see **Chapter 2.2**). These four research streams motivate and emphasize the importance of understanding and designing socio-technical structures in an intentional and purposeful way. The four research streams all cover the same topic but do so from different perspectives: While one stream views the socio-technical interplay of structures from an ecosystem perspective, another stream focuses on team and development productivity. Overall, following the research streams has uncovered a plethora of socio-technical relations and dependencies of different types related to a socio-technical system's performance.

The trajectory of the literary reception of Conway's law led to the creation of an overview of the four different research streams that were identified and their different views and levels of abstraction. The overview serves as a suitable starting point for design-based research that aims to leverage the rich accumulated knowledge of these four research streams to design artifacts that incorporate socio-technical thinking in the form of prescriptive design knowledge.

This thesis summarizes the trajectory of Conway's law in the literature in a usable form. The resulting prescriptive design knowledge was incorporated into the N2DIU model to facilitate the intentional socio-technical design of DIUs. Specifically, the foundational architecture of the model is socio-technically shaped by proposing matched pairs of social and technical practices. Furthermore, central practices in the model are fundamentally designed to make it possible to utilize socio-technical knowledge within a DIU to ensure a high level of development productivity; the practices *W2b: socio-technical inquiry* (see **Chapter 4.3.2.2**) and *W3a: socio-technical architecting* (see **Chapter 4.3.2.3**) draw on the accumulated knowledge provided by the literature review and present it in a form that can be used in DIUs.

Progressive Design Science Research

This thesis introduced a prototype for a new research method. The new research method is named after its progressive approach to artifact design. We call it progressive design research or PDR (see **Chapter 3**). PDR draws on an review of selected scientific meta-literature on research design (Merton 1968, Gregor and Jones 2007, Peffers et al. 2007, Sein et al. 2011, Gregor and Hevner 2013, Nunamaker et al. 2015).

PDR can effectively mitigate the criticisms that have been directed towards ADR (Sein et al. 2011) and DSRM (Peffers et al. 2007). In addition, it proposes a progression from material artifacts (see Gregor and Jones 2007) towards the creation of a mid-range theory (see Merton 1968) through the definition of research stages that assemble different artifact abstraction levels (see Gregor and Hevner 2013, Nunamaker et al. 2015).

PDR solves the struggle associated with creating practitioner-relevant solutions and conducting scholarly deliberations that lead to generalized solution approaches for solving a class of problems. PDR balances the expectations of both sides and provides an efficient research approach for researchers.

6.2. Practical Contributions

A Model for Guiding the Development of Digital Innovation Units

The artifact presented in this thesis is grounded in the outcomes of triangulated research activities. The artifact is based on the presentation of the current state of the art regarding DIUs, a forward literature review of the literary trajectory of Conway's law (1968), the iterative reciprocal shaping of an artifact and a DIU, and various transfer activities intended to consider the artifact in light of the perceptions of practitioners who are interested in reviewing and discussing the artifact as a class of solutions to a class to the development of a DIU.

The N2DIU model is the first of its kind; at the time of writing, there is no other artifact in the practitioner or academic literature that is dedicated to guiding the development of a DIU. Stakeholders from business and IT can use the artifact to communicate and plan joint change initiatives. The congruence of socio and technical structures further enables business and IT to not only communicate and plan joint change initiatives but also to understand the value of aligned socio-technical structures and thus provides a joint business-IT perspective that is fundamentally based on mutual appreciation.

The Positioning of Digital Innovation Units

Dedicated research on DIUs as pivotal organizational structures for driving firms' digital transformations has not yet been conducted. The process of designing, creating, and operating DIUs is challenging. A new organizational unit that is often guided by a new role, that of the CDO, claims new ground within a company. Resources can be drawn and provided with high priority. The status quo of existing structures might be threatened. Being aware of the impact of integrating DIUs in an existing organizational setting and how an existing organizational setting might impact the growth of DIUs is important for balancing expectations. Understanding and balancing impact and expectations requires a profound knowledge of the focal concept and the possibility of communicating and planning joint development initiatives.

This thesis provides insights into the phenomenon of DIUs and their internal structures. It further provides knowledge on the positioning of DIUs within the context of action strategies and other organizational units; it can also inform the actual process of positioning and developing a DIU within a firm. Our research further uncovers the benefits and drawbacks of instantiating a DIU and can effectively strengthen the arguments for or against establishing a DIU within a given context. Therefore, the accumulated knowledge, especially that presented in **Chapter 2.1,** can inform and guide decisions concerning the establishment of DIUs within firms.

Design Principles for Developing Digital Innovation Units

This thesis leveraged socio-technical knowledge to structure and complement the literary (see **Chapter 2**) and empirical insights provided (see **Chapter 3.3** and **5**) with the goal of guiding the iterative emergence of the N2DIU model. Over the course of the artifact's development, the research team reflected on what guided the design of the model in order to identify the underlying design principles. As recommended by Sein et al. (2011), the team specifically reflected on the change moments of the artifact development, that is, the moments that marked fundamental design changes within the model. Three design principles are the result of these reflections.

The first principle refers to the principle of *continuity*. Continuity is required not only to align a DIU with its surrounding ecosystem but also to continuously develop internal structures in a way that enables external alignment. The second principle is achieving *congruence*. Congruence is required to achieve a balance between organizational and technological development in such a way that both kinds of structures support each other in reaping the benefits of socio-technical congruence. The third principle recommends embracing *modularity*. Modularity is required to break the broad and complex task of developing a DIU down into individual change initiatives and in the subsequent establishment of ongoing practices, to allow a DIU to be developed and coordinated in a robust and stepped way, even should individual change initiatives fail or extend the initially planned time it requires to establish them (see **Chapter 4.2**). Accordingly, I recommend that future models that aim to guide the development of a DIU should consider the extracted prescriptive design knowledge described above.

6.3. Limitations and Opportunities for Future Research

Future Instantiations of the Artifact and Design Principles

We conducted an in-depth instantiation of our artifact within a case setting. A case setting is considered to be a valuable and valid source of information concerning the design of an artifact (see Sein et al. 2011). However, due to the complexity and scope of our artifact, we argue that further instantiations in additional organizational contexts could further support the empirically based argumentation behind the model.

We discussed our results with stakeholders who shared an interest in solving the same class of problem as our initial case, that is, determining how a DIU should be guided and structured in a communicable way. The reflections of these external experts provided us with knowledge from different perspectives and further nurtured the development of our various artifact versions, thus contributing to the development of a generalized artifact as a class of solutions. Still, future transfers involving instantiating the model (or parts thereof) in further organizational contexts should be conducted to achieve additional proofs of use outside of the initial organizational setting. Similarly, I recommend future instantiations of our derived design principles (see **Chapter 4.2**).

Artifact-Detailing and Industry-Specific Sub-Versions

The N2DIU model does not consider a budget perspective, nor does it present detailed structures, for instance, in the shape of specific pre-defined processes. These degrees of freedom ensure that the artifact, as a class of solutions, is suitable for solving a class of problems. Every organization and, more specifically, every organizational context that embeds a DIU is different; for instance, driving experiments in companies that are part of information-intensive industries can require a completely different perspective on budgeting than when driving experiments in industries that are primarily physically driven. Therefore, providing this level of detail within the artifact did not appear to be reasonable given its generalized nature.

However, future research could provide more detailed and industry-specific perspectives on different manifestations of the model and, furthermore, initiate research on incorporating a budget perspective within the artifact.

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Contribution: planning, conducting, and analyzing interviews; model design; writing.

Declaration on Oath / Eidesstattliche Erklärung

Hiermit erkläre ich,

Corvin Meyer-Blankart, geboren am 26.03.1986,

an Eides statt, dass ich die vorliegende Dissertationsschrift

“A New Way to Design Digital Innovation Units:
A Model for Growing New Ways of Working in Established Enterprises“

selbst verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe.

I hereby declare, on oath, that I have written the present dissertation by my own and have not used other than the acknowledged resources and aids.

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City, Date Signature