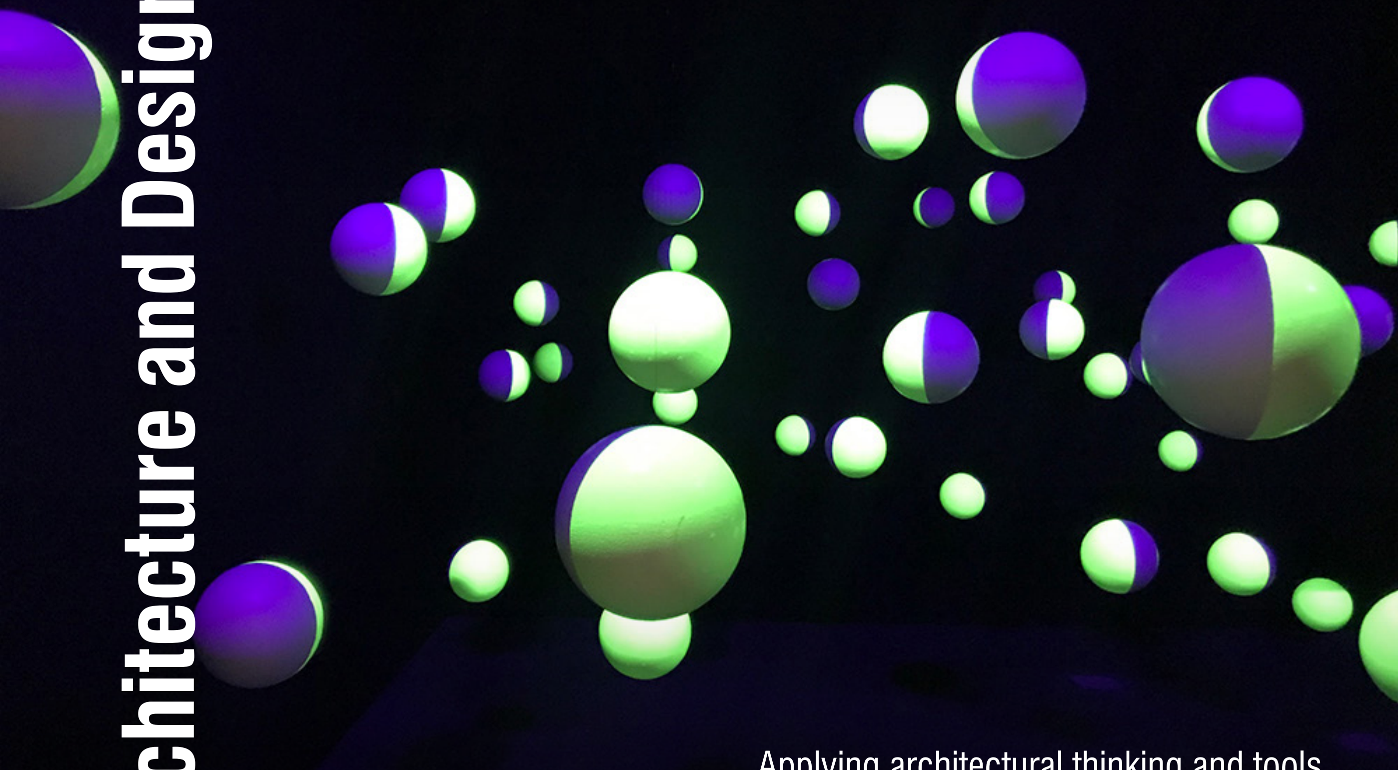
Christos Chantzaras

Architecture and Design of Innovation Processes



Applying architectural thinking and tools
to the understanding and design of innovation processes
in innovation management

Cover Picture: "Kugelkabinett" by artist group Effekt (Dieter Hacker, Karl Reinhartz, Helge Sommerrock, Walter Zehringer). Installation and light installation with styrofoam balls, fluorescent paint, light and black light, electronic light control. Exhibited at ZKM | center for art and media Karlsruhe (ZKM, 2022).
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TECHNISCHE UNIVERSITÄT MÜNCHEN
TUM School of Engineering and Design

Architecture and Design of Innovation Processes –

Applying architectural thinking and tools to the understanding and design of innovation processes in innovation management

Christos Chantzaras

Vollständiger Abdruck der von der
TUM School of Engineering and Design der Technischen Universität München
zur Erlangung des akademischen Grades eines

Doktors der Ingenieurwissenschaften (Dr.-Ing.)

genehmigten Dissertation.

Vorsitzender:
Prof. Dr. Benedikt Boucsein

Prüfer der Dissertation:
1. Prof. Dr.-Ing. Frank Petzold
2. Prof. Dr. Oliver Alexy

Die Dissertation wurde am 14.02.2022 bei der Technischen Universität München eingereicht
und durch die TUM School of Engineering and Design am 23.06.2022 angenommen.

To Evangelia & Zikos Chantzaras

Acknowledgements

The work on this thesis began unconsciously with a journey that started over two decades ago, with my studies of business administration at the University of Mannheim. In a conversation with Konrad Stahl, by that time professor at the Faculty of Economics and Statistics, I raised the question of why he had left the discipline of architecture, in which he had graduated, for the discipline of economics. He replied that after his studies in architecture and urban planning he had realized that housing shortages were not an architectural matter, but a matter of economics. In my own search for structure and tangible expression of theory, I switched from business administration and economics to architecture. I graduated as architect and began my professional career in design and planning of interiors and buildings. With the increasing scale of projects I was engaged with, e.g. for innovation or research & development centers, I came to an opposing conclusion to Professor Stahl. My working hypothesis for the years since has been that issues of organizational processes are as much an architectural matter as they are a matter of management. To investigate and research this hypothesis further, I returned to the Technical University of Munich, where I studied architecture, and through architecture I returned to the field of management. The present thesis documents this return.

It would have not been possible without the encouragement, support and interest of my supervisor Prof. Dr. Frank Petzold and my mentor Dr. Gerhard Schubert from the Chair of Architectural Informatics. Their interdisciplinary mind-set and openness to relating architectural thinking and its tools at a systemic level to other fields deserve my sincerest gratitude. In particular, Gerhard Schubert's frequent and generous advice over the past few years has provided me with essential and valuable guidance. I would also like to express my sincerest gratitude to Prof. Dr. Oliver Alexy, Professor for Strategic Entrepreneurship at the TUM School of Management, who supervised the thesis from the management studies side. His interest in the subject and references to research in the field of innovation were an important source of inspiration and theoretical underpinning.

As case studies for the thesis, I drew on my professional experience and two projects in which I was involved in practice. My thanks are owed to Dr. Gunter Henn, founder of the architectural practice HENN and Professor Emeritus of the Chair of Industrial Buildings and Design at the Technical University of Dresden, and Andreas Fuchs, Partner for Programming at HENN, for their support and permission to reference results from practice. Equally, I wish to thank Thilo Brandel, Head of Facility Management at WITTENSTEIN Group, for his support and permission to reference pre-design works on the WITTENSTEIN Innovation Factory. Additionally, I would like to thank Dr. Dirk Haft, founder of attocube Systems AG and Peter Kraemer, CEO, for their support and permission to reference pre-design works on the attocube headquarters building.

I also offer my most cordial thanks to the experts from Gensler, Zaha Hadid Architects, BCG Digital Ventures, Accenture, Ottobock and SAP, whom I interviewed to evaluate findings and proposals arising from my work. Their answers were of great value for critical reflection.

Over the course of my research and my teaching at the Chair of Architectural Informatics, I have had the chance work with exceptional scholars, colleagues and students. A special acknowledgement goes out to Chris Ford and Jan Auernhammer, PhD, from the Department of Mechanical Engineering, Center of Design Research at Stanford University, and the fruitful discussions, as well as to Roberto Verganti, Professor of Leadership and Innovation at the Politecnico di Milano, for his inspirational suggestions. Also, my special thanks are owed to the students who contributed to particular parts of this thesis with their course projects and are referenced in the Appendix.

Finally, I wish to sincerely thank my parents and family, who have supported me since well before the journey started, who have kept supporting me from beginning to end with their unstinting confidence. My wife Mara Hirschmüller and our recently born daughter Nika kept me motivated and focused throughout. These few words can hardly express my gratitude.

Christos Chantzaras
February 2022

Abstract

Architecture offers innovation management in organizations a new approach to understand and design innovation processes. Its thinking and tools allow stakeholders to see these processes as multi-dimensional, dynamic, and spatial systems, that can be constructed, modelled and visualized accordingly. Challenges in managing innovation processes require new models to account for increasing complexities, for social proximities and interactions between the actors involved. Innovation processes become a matter of design and the subject of a design process.

This thesis transfers architectural thinking and its tools to the analysis and design of innovation processes in organizations. Based on a literature review in the disciplines of architecture as well as innovation research and innovation management, the thesis develops an extended process view of innovation. This view is characterized by multi-level complexities, social proximities and interactions, and process design with a design attitude. In the field of innovation research and management, the thesis analyses models of innovation processes and reviews applications in the practice of enterprises. In the field of architecture, the research is based on a literature review and two case studies from practice. It works out the various characteristics of architectural thinking, of an architectural design process and its tools, which address challenges in innovation management

Based on these analyses, this thesis develops the methodology of *Architectural Innovation Design* as an interactive and a constructive design approach to innovation processes. It outlines the capabilities that qualify architects to co-create and design innovation processes with their counterparts in the management of organizations. It further proposes a tool prototype for application of the methodology in practice. The methodology and tool prototype are critically assessed in interviews with experts from innovation management and architecture. The thesis concludes with implications retreived from the interviews, with the consideration of a global pandemic and with an outlook how to develop the methodology further: as a new spatial thinking about organizations and their processes.

Zusammenfassung

Architektur bietet dem Innovationsmanagement in Organisationen einen neuen Ansatz, um Innovationsprozesse zu gestalten. Architektonisches Denken und dessen Werkzeuge ermöglichen es, die Prozesse als mehrdimensionale, dynamische und räumliche Systeme zu betrachten und diese als solche zu konstruieren, veränderbare Modelle zu bilden und zu visualisieren. Herausforderungen im Management von Innovationsprozessen erfordern neue Modelle, die eine zunehmende Komplexität, die soziale Nähe und die Interaktionen der beteiligten Akteure abbilden. Innovationsprozesse werden Gegenstand und Aufgabe eines Entwurfes und Gestaltungsprozesses.

Die Arbeit überträgt architektonisches Denken und Werkzeuge der Architektur auf die Analyse und die Gestaltung von Innovationsprozessen. Ausgehend von einer Untersuchung der Literatur in den Disziplinen der Architektur sowie der Innovationsforschung und des Innovationsmanagements erweitert die Arbeit den Begriff des Innovationsprozesses. Dieser umfasst Komplexität auf mehreren Ebenen, soziale Nähe und Interaktionen zwischen Akteuren, sowie die Gestaltung von Prozessen mit einem entwerferischen Denken. Im Bereich der Innovationsforschung und des Innovationsmanagements untersucht die Arbeit Modelle von Innovationsprozessen und betrachtet deren Anwendung in der Praxis von Unternehmen. Im Bereich der Architektur untersucht die Arbeit Eigenschaften des architektonischen Denkens, des damit verbundenen Entwurfsprozesses und der Werkzeuge, die geeignet sind, Herausforderungen im Management von Innovationen zu adressieren. Dies erfolgt auf Basis einer Analyse von Literatur und einer Analyse zweier Fallbeispiele aus der architektonischen Praxis.

Aufbauend auf den Analysen wird in dieser Arbeit die Methodik des *Architectural Innovation Design* entwickelt – ein interaktiver und konstruktiver Gestaltungssansatz für Innovationsprozesse. Er stellt die Fähigkeiten heraus, die es Architektinnen und Architekten ermöglichen, gemeinsam mit ihrem Gegenüber im Management von Organisationen Innovationsprozesse zu gestalten. Der Ansatz stellt einen digitalen Prototyp vor, um die Methodik in der Praxis anzuwenden. Methodik und Prototyp werden in Interviews mit Experten aus den Bereichen Innovation und Architektur kritisch reflektiert. Die Arbeit schließt mit Implikationen aus den Interviews, mit einer Betrachtung der Auswirkungen einer globalen Pandemie und mit einem Ausblick, die Methodik weiterzuentwickeln: als ein neues räumliches Denken über Organisationen und ihre Prozesse.

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1 – Time and Space of Innovation Processes

Architecture looks differently at innovation. As profession and discipline it has been linked to the growth and development of industries, economies and societies (e.g., Nerdinger & Böhm, 2012; Rumpfhuber, 2013, p. 11). The design and planning of office buildings, research facilities or production plants, for example, require a profound understanding of the underlying existing process or the processes, which are projected or need to be newly created (Chantzaras, 2019b, p. 542). The activities of architects, and their scope of work in such kind of projects, are related and connected to the management of companies. Architects consider a company's organization and its interactions in alternative ways. In practice, the final result of a building is seen among architects, architectural scholars, and non-architects as the main outcome of architectural work (Bouman, 2007, p. 96; Samuel, 2018, pp. 154; 161). The immaterial work, the creative thinking process and structured approaches to understand, design and realize new processes for an organization, which precedes the planning, has received limited attention (Kühn, 2007, p. 104; Awan, Schneider, & Till, 2011; Samuel, 2018, p. 154). This thinking and preceding work contains a value for management, and in particular for the research and management of innovation (Boland & Collopy, 2004b, p. 17).

Companies are facing rising complexity in markets and societies, in services, products and processes. New forms of collaboration and co-operation blur organizational boundaries; new technologies are transforming or substituting existing development, manufacturing, distribution processes; creativity is emphasized as major source and driver for innovation, besides knowledge and financial resources (Agars, Kaufman, Deane, & Smith, 2012, p. 271; Shalley, Hitt, & Zhou, 2015, pp. 1–2). Companies create and look for new perspectives on how innovations occur in regard to questions of when and where ideas and inventions emerge, by whom and under which circumstances. Innovation – preliminarily described as a novel idea, turned into an invention and successfully applied or implemented in scaled products, services or processes – is becoming more dynamic, open, creative and driven by human interaction (Dodgson, Gann, & Phillips, 2015b, pp. 13–18; Hauschildt, Salomo, Schultz, & Kock, 2016, pp. 3–5). Definitions and conceptions regarding innovation are extended, new approaches to analyze, describe and develop processes leading to innovative outcomes are developed (Dodgson et al., 2015b, pp. 18–24). Literature since the turn of the millennium has emphasized methodologies, methods, tools and techniques for dealing with innovation, and managing, fostering, and accelerating it in changing, complex, uncertain and unknown environments (Keeley, Pikkel, Quinn, & Walters, 2013, pp. 10–13; VanPatter & Pastor, 2016, pp. 16–23). Yet the different approaches emphasize innovation projects and innovation outcomes in terms of performance over time. The question of how the processes of innovation take place in organizations as a whole, how the processes can be visualized appropriately and how they can be designed with a design attitude remains secondary (Cross, 2008, p. 36).

In this field, architecture offers a new approach. Instead of placing the assignment for design and planning of a physical structure as central scope of architectural thinking and work, this doctoral project sees the innovation process itself as subject of design. It directs the interaction between the two disciplines of management and architecture from physical buildings to organizational systems and their processes. Similar proposals to re-define and extend the profession of architecture have been made in the past (Fisher, 2015a, pp. 226–227; Koolhaas

& McGetrick, 2004b, p. 20; Shamiyeh, 2007a, pp. 9–10). But so far, an academic foundation for the architecture and design of innovation processes has not been elaborated in the field of architecture. The thesis addresses this gap.

1.1 Motivation & Objectives

Architecture has been engaged with the process of innovation throughout the assignment of architectural projects in different industries (Allen & Henn, 2007, pp. 2–3; Sancho Pou, 2013, p. 21). With its emphasis on physical results it has not developed a theoretical base of innovation research to access innovation management. Management, on the other side, has not fostered a design perspective to develop innovation processes with intuitive, visual and constructive principles of thinking and reframing their complexity in spatial models (Boland & Collopy, 2004a, pp. 3–4; Buchanan, 2015, p. 8). The design notion and design thinking conception present in management literature and practice differs in specific and relevant aspects from the design understanding and design work in architectural thinking. The central argument throughout this thesis states that the differences are relevant to the design of innovation processes.

Architectural thinking and the architectural design process can contribute with their distinct form of reasoning and making. The thinking is optimistic, oriented towards a betterment of a situation. It embraces complexity and contradictory requirements, combines abductive, visual and imaginary thinking, it is integrative and constructive with non-verbal means, and seeks through synthesis for application and implementation of a developed idea (Chantzaras, 2020, p. 690). With its spatial intelligence architectural approaches can add space as a dimension for analysis and design, where innovation management emphasizes a performance over time. The main hypothesis, followed by two sub hypotheses, is stated as follows:

> ***H1:*** *Architectural thinking and the tools of architecture can facilitate the creation of new and needed perspectives on the understanding and design of innovation processes.*
>
> ***SH1:*** *Architectural thinking offers a non-linear, multi-dimensional (3-dimensional plus) approach to analyzing and designing innovation processes as dynamic systems, for which existing managerial approaches reach limits.*
>
> ***SH2:*** *Architectural thinking and tools uncover a company's informal process of innovation and add a third, spatial dimension for its understanding and future organization.*

The author's experiences and observations in practice as architect and consultant for many years are part of the motivation to develop a new frame for architectural thinking and its design process. The practical work, which is integrated and reflected by two case studies in this thesis, has revealed potential points of contact with innovation management. At the same time, it exposes a gap in the research. With the author's academic background in architecture and business administration, and with experience in both fields, a double-sided view and consideration of this gap is possible. The new frame will on the one hand provide an access for architects to frame their thinking and tools, their capabilities and skills differently, in order to relate them to challenges of innovation management. On the other hand, it will offer an access to innovation managers and management executives, to extend their conception of architecture beyond building design purposes. In this interplay between two disciplines and academic backgrounds, some aspects may be familiar to innovation management, while they may be new to the discipline of architecture. The intended application of architectural thinking to the design of innovation processes, consisting of an alternative conceptualization of innovation processes, a particular architectural methodology and tool will be new to both fields. The relevance of architectural innovation design derives from design and consulting projects at the interface of architecture, organization design, change and innovation management. Experiences and observations from architectural and consulting practice as well as discussions and interviews with entrepreneurs, innovators, management executives, researchers, architects and engineers are combined with a literature review to lay a theoretical foundation. The doctoral thesis poses the research question of how an architectural design process with intuition, abductive reasoning, visual thinking and the use of a particular kind of non-verbal models can be theoretically justified for managerial tasks. It investigates the demands for change in the behavior and perception of architects and innovation managers and consultants. It addresses how the disciplines of architecture and management can work integratively and collaborate on the design of innovation processes for an organization. The doctoral thesis elaborates the requirements a methodology has to meet for an architectural innovation design and its accompanying tools. This methodology is developed to be applied, tested, evaluated in practice and refined. A first evaluation is conducted by qualitative analysis through interviews with experts. They critically reflect the new themes proposed in innovation processes, the hypothesis stated and the feasibility of the methodology and tool. Testing the methodology and its tool in practice exceeds the scope of this thesis and remains subject for further research. The doctoral thesis contributes to a conception of architecture as an innovation design discipline that may be welcomed and invited into the field of innovation research and management. The two objectives are, to integrate architecture at a strategic level of innovation process design and to draft a methodology and tool that enable this transferability and integration.

1.2 Focus

The thesis focuses on three areas: the innovation systems of enterprises; the models, methodologies, methods and tools of innovation management and research to develop and represent these systems; and the thinking and design process of architectural practices. In the first area, processes in enterprises are considered whose continued existence depends on their capabilities to innovate. Innovation systems appear at different levels and scales from policies and national programs, to ecosystems and networks, to single firms and technological processes (Fichter, 2014, pp. 77–79). At a national, regional or sectoral level, innovation systems deal with the economic and legal aspects and the areal-spatial, infrastructural dimension between people, organizations, public institutions, authorities and policy makers (Blättel-Mink & Ebner, 2009; Edquist, 2005, pp. 1–4; Fichter, 2014, pp. 77–79). At the level of companies and institutions, innovation systems refer to inter-organization collaboration and value-generation, and to the ways in which ideas, research and knowledge are exchanged between firms and contribute to novel outcomes. At the company level, a company's specific innovation system comprises its strategic and operational innovation management, the inner organization of innovation processes as well as its innovation capabilities and culture. Throughout this thesis the company level of an innovation system will be central.

Regarding the different types and sizes of enterprises, an architectural innovation design addresses large-scale, multinational and global firms, as well as small-and-medium-sized enterprises (SMEs). The first group has been foregrounded in academia and innovation management practice. The enterprises innovate differently than SMEs of less than several hundreds of employees (Brunswicker & van de Vrande, 2014, pp. 135–137; Frank, Lueger, & Korunka, 2010, p. 4).[1] SMEs are important drivers of innovation and support larger corporations with innovative ideas, products, services or systems (Stern & Jaberg, 2010, p. 344). They show advantages in being more innovative compared to large organizations. They have flatter hierarchies, shorter lines of communication and a higher agility in approaching, adopting and integrating advancements of new technologies and processes (Frank et al., 2010, p. 4; Parker, 2011, pp. 357–359). In SMEs employees are more likely to be self-organized and to collaborate throughout the entire firm and outside (Parker, 2011, p. 358; Rüggeberg & Burmeister, 2008, pp. 31–32). Decisions are expected to be made faster, the entrepreneurial spirit supports access to available resources, risk-seeking behavior is reported to change existing business models or challenge successfully established firms and facilitate entering new markets (Frank et al., 2010; Mascia, Magnusson, & Björk, 2015, p. 102; Parker, 2011, pp. 357–359). The relevance and influence of technology- and sciences-based start-ups has grown in the past years (Brunswicker & van de Vrande, 2014; Mascia et al., 2015, p. 102). And lastly, their number exceeds the number of large companies. Disadvantageous in SMEs is the lack of a designated innovation or R&D department and lower investments in innovation management (Frank et al., 2010, pp. 3–4; Nasiri, Alleyne, Yihui, & Nisar, 2016, p. 3). Knowledge base and innovation processes are less structured, financial and physical resources difficult to access, people's availability and capabilities limited, routine processes prioritized (Çokpekin & Knudsen, 2012, p. 312; Frank et al., 2010, p. 4). A limited systemic view on innovation processes, unstructured communication and procedures, as well as deficits in methodological understandings, methods and tools to foster innovation, is becoming a major challenge for SMEs (Scozzi, Garavelli, & Crowston, 2005, pp. 121, 124–125). The heterogeneity of small companies, requires an individual, case- and context-dependent approach (Frank et al., 2010, p. 4). To achieve a close and intense collaboration, it is important to support and directly communicate with client and further stakeholders as employees, shareholders, assigned consultants, partners of the company, suppliers, customers and clients of the company, municipalities and authorities, associated institutions, and – in particular cases – the public.

At second, the field of innovation research and innovation management is focused. It has developed and applied models, methodologies, methods and tools for enterprises to manage and foster innovation. Examples of these developments will be reviewed to extract how they address new challenges for the design of innovation processes and what further development steps they predict. The multidisciplinary nature of innovation management looks for

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[1] Brunswicker & van de Vrande (2014) classify SMEs as companies with less than 250 employees, following the definition of the European Commisson. The Institut für Mittelstandsforschung IfM Bonn (2019b) defines SMEs in Germany as those companies with less than 500 employees. Gelbmann, Vorbach, & Zotter (2004) consider a clear separation according to a specific number as not feasible. Altmann (1998) subsumes the SMEs as 'Mittelstand' firms with up to 500 employees, while the IfM Bonn (2019a) does not define a limit for number of employees in its use of the term 'Mittelstand.' See also Altmann (1998, p. 340); Gelbmann et al. (2004, pp. 249–252).

contributions from other fields to gain deeper understandings and to develop new methods and tools for practice (Dodgson et al., 2015b, pp. 10–11; Fichter, 2014, p. 78). While large-scale enterprises have been broadly covered in academic research in the past, attention is increasingly shifting to SMEs. In this regard, an architecturally rooted methodology can extend existing approaches and applications in innovation management and cover innovation challenges in enterprises of different sizes. For small and medium sized enterprises, an architectural innovation design may be especially of value. Architectural practices in Germany belong themselves to the group of SMEs, with 90% of offices consisting of less than ten employees (BAK Bundesarchitektenkammer, 2019, p. 53). The practices work in close interaction with their clients. With their small-scaled structure they could offer a new kind of innovation management consulting especially for SMEs.

The third focal area are architectural practices and architectural design processes. Though architectural practices are already becoming involved in the sphere of organizational transformation, the conception, self-image, capabilities, skills and scope of their work are largely related to the built environment. The thesis elaborates arguments which have been raised in vague terms by the architectural profession and have received limited academic consideration. It researches the potentials and transferability of architectural thinking and its tools to areas besides building design. The thesis outlines capabilities residing in architectural education and practice for addressing innovation challenges. The consulting work for two projects, in which the author was involved, showcases an architectural approach to innovation processes. The approach serves as a basic method, which illustrates how architectural thinking and tools can be applied in practice to the challenges of innovation. The approach is made explicit, in order to understand its elements and structure, and review it in its suitability for a broader application. Its evaluation by distinct criteria offers implication for the development of an integrative methodology. The companies addressed in the two case studies belong to the group of the German “Mittelstand” (IfM Bonn, 2019a) with one SME and one larger, family-owned company.[2] In the end, the thesis drafts a methodology that is applicable to larger enterprises and further levels of innovation systems. It demonstrates a process for architectural practices to design innovation processes jointly with demands from the field of management.

1.3 Structure of Work

To address challenges of innovation processes with an architectural innovation design, elements from two disciplines need to be integrated. The thesis uses different methodological approaches to consider the themes of innovation, innovation management, architecture, architectural practice and the approach of an architectural innovation design. In the following chapters the methodological approaches are applied to varying degrees. Chapters 2, 3, 4, 5 and 7 are based on a literature review with abductive reasoning and based on experiences and observations from the author's architectural and consulting practice. The abductive search process combines designerly ways of thinking with scientific analysis. This “guessing for very specific reasons” (Clarke, 2016, p. 91) make it possible to narrow the broad field of literature and maintain lateral references to

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[2] The term ‘Mittelstand’ enterprise is defined by the IfM Bonn (2019a) as the unity of ownership and management, where “up to two natural persons or their family members (directly or indirectly) hold at least 50% of the company shares and these natural persons also belong to the management of the enterprise” (ibid.).

different disciplines. Chapter 6 uses a case study analysis and post-evaluation of conducted architectural consulting projects. Chapter 10 conducts a qualitative data analysis based on semi-structured expert interviews. The content and goal of each chapter are as follows.

Chapter 2 describes the basic process view of innovation and extends its conceptualization with emerging requirements for its management and design. The experiences and observations from architectural practice and consulting are combined with a literature review of contributions in academia and gray literature from the years 1999 to 2019 according to specific domains and keywords (see Table 1). The recurring topics of uncertainty, wickedness, creativity, collaboration, systems thinking, emergence and visualization are clustered in three main areas: complex environments, social interactions and process design. The areas indicate a new set of criteria which – as hypothesized – innovation management has to address through new models, methods and tools. The areas serve also as a frame with which to assess existing approaches in management (Chapter 3, 4) and architecture (Chapter 6, 7). The chapter concludes with an extended process view of innovation.

Table 1: Literature Review

Literature review by domains, keywords and periods of time considered.

	Extending the Process View on Innovation 1st Dimension	**Management of Innovation Processes** 2nd Dimension	**Architecture of Spatial Innovation Processes** 3rd Dimension
	Chapter 2 text-focus	**Chapter 3+4** time-focus	**Chapter 5+7** space-focus
Domain	INNOVATION RESEARCH INNOVATION MANAGEMENT INNOVATION PROCESS ORGANIZATIONAL DESIGN SYSTEMS THINKING DESIGN THINKING COMPLEXITY CREATIVITY SOCIAL SYSTEMS ARCHITECTURE	INNOVATION RESEARCH INNOVATION MANAGEMENT INNOVATION PROCESS INNOVATION CONSUTLING ORGANIZATIONAL DESIGN SYSTEMS THINKING DESIGN THINKING COMPLEXITY CREATIVITY SOCIAL SYSTEMS INFORMATION TECHNOLOGY	ARCHITECTURE RESEARCH ARCHITECTURE & INNOVATION ARCHITECTURAL DESIGN PROCESS ARCHITECTURAL PROGRAMMING SYSTEMS THINKING DESIGN THINKING COMPLEXITY CREATIVITY SOCIAL SYSTEMS
Keyword	INNOVATION ORGANIZATION COLLABORATION DESIGN PROCESS VISUAL THINKING VISUALIZATION ABDUCTION UNCERTAINTY MODELS BOUNDARY OBJECTS DYNAMICS COMPLEXITY WICKED PROBLEMS SYSTEMS THINKING SYSTEMS INTERACTION EMERGENCE SOCIAL NETWORKS SPATIAL PROXIMITIES RELATIONAL PROXIMITIES	INNOVATION ARCHITECTURE DESIGN COLLABORATION ORGANIZATIONAL DESIGN INNOVATION CONSULTING UNCERTAINTY VISUAL THINKING VISUALIZATION MODELS BOUNDARY OBJECTS METHODOLOGIES METHODS TOOLS DIGITAL APPLICATIONS INNOVATION MANAGEMENT SOFTWARE COMPUTER-AIDED INNOVATION DYNAMICS COMPLEXITY WICKED PROBLEMS SYSTEMS INTERACTION EMERGENCE SOCIAL NETWORKS SPATIAL PROXIMITIES RELATIONAL PROXIMITIES	INNOVATION ORGANIZATION COLLABORATION DESIGN PROCESS VISUAL THINKING VISUALIZATION ABDUCTION UNCERTAINTY MODELS BOUNDARY OBJECTS ARTIFACTS METHODS TOOLS NEW FIELDS CONSULTING DYNAMICS COMPLEXITY WICKED PROBLEMS SYSTEMS INTERACTION EMERGENCE SOCIAL NETWORKS SPATIAL PROXIMITIES RELATIONAL PROXIMITIES
Period (Core)	1999-2019	1999-2019	1970-2019
Period (Partially)	1950-2000	1970-2000	1950-1970

In Chapter 3, the field of innovation management is researched through its response to the extended process view on innovation. Advanced and novel sequential models as well as systemic models are described based on a literature review from the period from 1999 to 2019 with an adjusted set of domains and keywords. Partially earlier publications from the 20th century are considered. The chapter works out the relational, sequential and time-dependent understanding of innovation processes in innovation management. It explains development and use models and selects types of models and methods, which are relevant for this study. It investigates how the selected models address the criteria from Chapter 2 and concludes with an evaluation.

Chapter 4 adds the perspective of practice of innovation management. It reviews digital and analog methods and tools that transfer conceptualizations and models of innovation processes – as explained in Chapter 3 – into practical use for enterprises and organizations. For the selection of examples scientific and gray literature of the past decade, websites of consultancies and service providers as well as webinars and personal interviews are analyzed. The examples are grouped in company tools, innovation management software and consulting methods. They are evaluated by the criteria developed in Chapter 2. The innovation management perspective of Chapter 3 and 4 allows a comparison with approaches in architectural thinking and uncovers similarities (e.g., in problem formulation, capabilities or ways of working) which have not been made explicit to architects and management executives before.

Chapter 5 researches the architectural design process and its special characteristics. The characteristics are developed from experiences in practice as an architect from 2007 to 2017, observations and a literature review of selected publications from 1970 to 2019 according to a specific set of domains and keywords (see Table 1). The architecture of spatial innovation processes is defined as the systemic understanding of organizations and their processes with architectural methods originating from building architecture design. The use of non-verbal tools and 3-dimensional boundary objects introduces an alternative view and model of organizational processes. Architecture of spatial innovation processes is compared with the criteria for an extended process view on innovation from Chapter 2.

To showcase innovation management in the discipline and profession of architecture, Chapter 6 describes an architectural innovation management by two case studies from practice. In both projects, which have not been made explicit in this way so far, the architectural work deals with issues of organizational change. The projects were conducted between 2009 and 2015 with the author's involvement as team consultant in 2009 and lead consultant in 2015. Data, information and knowledge in both projects is retrieved from assignment briefs, project documentations and project designs, which were provided by the client and the architectural practice for the purpose of this thesis.[3] Informal interviews in 2018 and 2019 were conducted with client representatives (i.e. the companies consulted in the case studies). The material obtained is structured according to the extended process view on innovation introduced in Chapter 2: how are multilevel complexities considered, how are social proximities integrated, how is a process design applied. The chapter concludes with an evaluation of the extent to which the criteria for a model, for a method and for a tool have been met.

Existing approaches, methods and tools supporting an architectural innovation design are examined in Chapter 7. The approaches from the fields of architecture, management and sociology center the relation between space, behavior and the development of novel ideas. Their evaluation according to criteria for methods and tools provides implication for a new methodology.

In Chapter 8, deficiencies from the fields of innovation management (Chapter 3, 4) and architecture (Chapter 5, 6, 7) are explained and summarized. From this, requirements are deduced for an architectural innovation design.

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[3] For reasons of confidentiality only excerpts of the material are shown in Chapter 6.

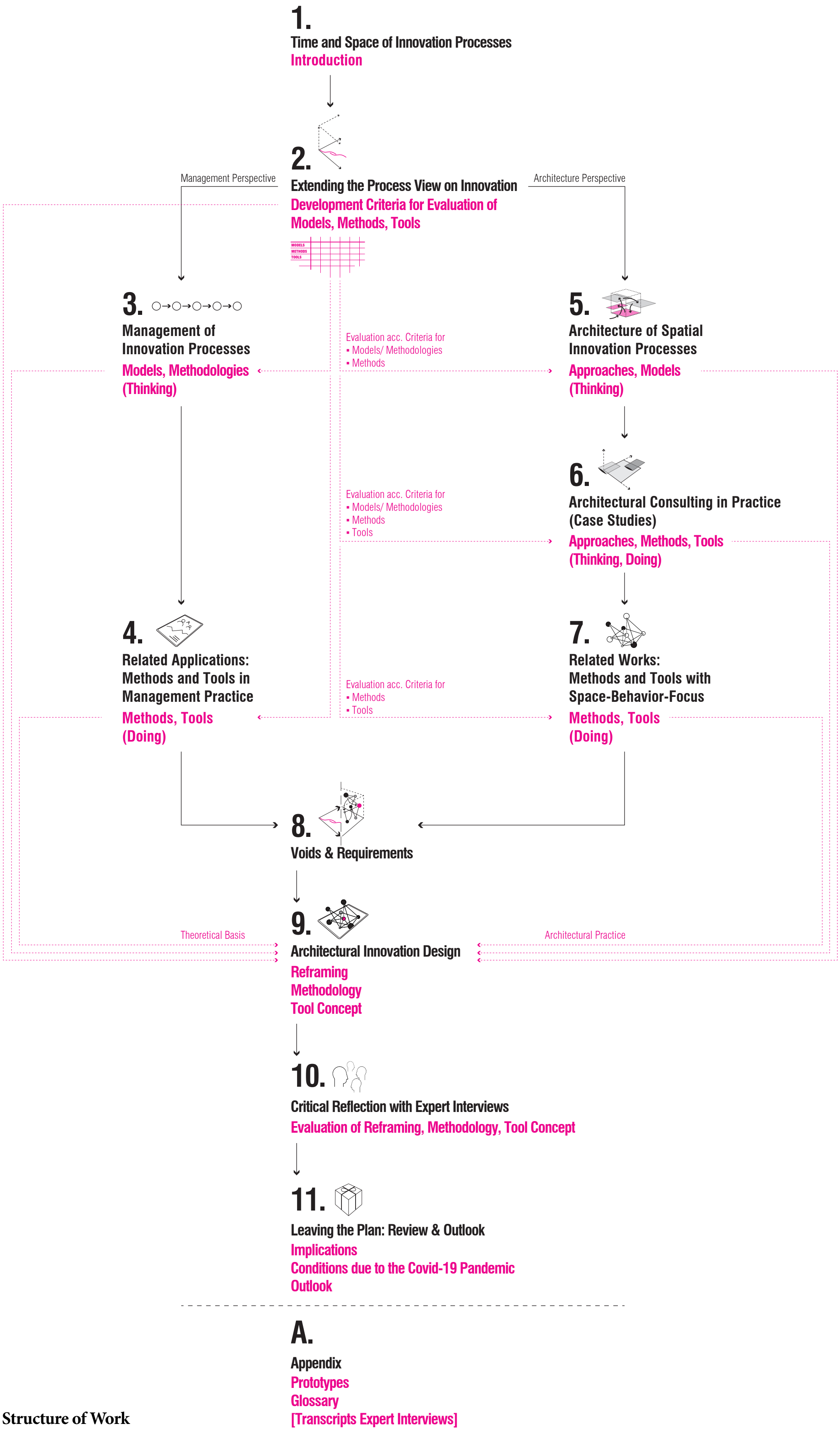

Figure 1: Structure of Work

Chapter 9 formulates the approach for an architectural innovation design. It consists of three parts: a reframed conception of architectural work, a methodology with capabilities and design phases to be performed, and a prototypical digital tool, to transfer the methodology in a tangible and actionable practice.

The proposed model of architectural innovation design is critically reflected by expert interviews in Chapter 10. The interviews with executives from architectural practices, innovation management consulting and innovative enterprises serve as a first evaluation. The interviewees' responses are evaluated by a qualitative data analysis. With a system of codes for the areas of an extended process view, the architectural innovation design methodology, the prototypical tool and the hypothesis are evaluated and interpreted.

Chapter 11 finalizes the thesis with a review and outlook. It concludes implications retreived from the findings and expert interviews to further develop the methodology and tool concept. It reviews the thesis against the background of the Covid-19 pandemic and outlines its applicability to changing modes of work and innovation. It suggests further steps to redefine the value of architectural thinking and work, and argues for a new understanding of organizations as spatial configurations.

2

2 – Extending the Process View on Innovation

Understandings and terms of innovation in architecture and design vary with subjective interpretations (Aksamija, 2016, pp. 12–19; Ednie-Brown, Burry, & Burrow, 2013, p. 11). Definitions in design disciplines do not share a “high degree of commonality” (Cruickshank, 2010, p. 23) as innovation studies from the fields of economics, sociology, engineering, management and sociology do (Cruickshank, 2010, p. 17; Salter & Alexy, 2015, p. 26). The communication between architects and their counterparts in management is not necessary built on the same understanding of innovation, its processes and characteristics. At the same time, definitions and conceptions of innovation and innovation processes are subject to change (Fagerberg, 2005; Salter & Alexy, 2015, pp. 37–38). Recurring themes are broadened by new courses of action observed in practice, and new findings in academic research (Dodgson et al., 2015b, p. 13–18). In this chapter new aspects are researched that extend the view on innovation processes and pose new demands for its management and design. The extended view defines the understanding of innovation processes in this thesis. At the same time, it also outlines the criteria to select and evaluate models, methods and tools in innovation management and architecture.

The chapter explains the basic process view of innovation and its extension by new areas. In the first part, the analysis summarizes different views of innovation. It is based on scientific and gray literature in the fields of management, social sciences and design from the years 1999 to 2019, with selected contributions from 1970 to 2000. In the second, third and fourth part, areas which are receiving wider attention and are gaining relevance in the management of innovation are outlined. Multi-level complexities, social proximities and process design are added to the basic process view of innovation.

The first area of multi-level complexities summarizes an organization’s complex environment, the particular kind of problems an organization is confronted with and the complex nature of the innovation processes itself. The second area covers the growing value of people in an organization, their creativity, awareness and interactions for innovation processes. The third area deals with the design of processes, the systemic view on non-linear events and its constructive creation. The research on these areas is based on scientific and gray literature from the same periods of time. The publications have been researched on the basis of keywords as listed in Table 1 (e.g., complexity, systems, interaction, social networks, spatial and relational proximities, models, dynamics, design processes). The selection of literature on innovation and innovation processes and its intersection with architecture and design is driven by experiences, observations and projects from the author’s practice as architect and consultant.[4] The literature has been reviewed with an abductive search process. Based on keywords and the experience in practice, this abductive approach, or informed guessing, made it possible to search in the broad and diverse field of innovation and to select contributions from innovation research, innovation management, architecture, design, engineering sciences, and partially in sociology and psychology.[5] In the concluding section of this chapter a set of

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[4] Two projects from practice at the interface of innovation management and architectural design serve as case studies in Chapter 6.

[5] Abduction and abductive reasoning will be explained in Chapter 2.4.2. Besides deduction and induction, abductive reasoning is seen as a “third way” (Clarke, 2016, p. 93) in research, to proceed with a preliminary hypothesis based on previous knowledge, experience, visual and diagrammatic thinking and intuition. The hypothesis is tested in a back-and-forth process, adjusted if necessary, or assumed as preliminary support. See also Reichertz (2013).

criteria and requirements is developed to evaluate conceptualizations, models and methodologies as well as methods and tools for innovation management.

2.1 Basic Process View

Innovations are present throughout the history of human development and economic growth (Bullinger, Auernhammer, & Gomeringer, 2004, p. 3339; Mumford, 2012, pp. 481–483; Salter & Alexy, 2015, pp. 28–29). They mark a discontinuity in established forms of work, production and offerings of a company, when something different is introduced and leads to improvements in existing settings that are already successful (Dodgson, Gann, & Salter, 2011, pp. 26–27). It is a distinguishable and useful newness in relation to existing solutions, processes, experiences or environments (Fagerberg, 2005, pp. 5–9; Godin, 2008, pp. 8, 43; Hauschildt et al., 2016, pp. 3–5). In general, innovations are understood as outcome and as process, with key characteristics independent of their occurrence in time, sector and place (Bullinger et al., 2004; Dodgson et al., 2011, pp. 27–38). Innovation implies change; it is multiple, transformative, and is the result of a process.

Innovation is change in social behaviors and experiences, in growth and wealth of economies and enterprises; it is change in the technological perspectives of engineering; it is change in management views to ensure a competitive advantages (Burr, 2014b; Corsten, 1989; Dodgson, Gann, & Phillips, 2015a; Fagerberg, Mowery, & Nelson, 2005; Mortati, 2015). For the field of design, innovation is the creation of a coherent new whole with a meaningful improvement – and thus change – of a situation (Nelson & Stolterman, 2012, pp. 12, 93–94; Verganti & Dell'Era, 2015, pp. 141–143).

Innovation is multiple. It occurs in any field, in different areas of value creation and businesses and to different degrees. Types of innovations relate to markets, industries and societies, to products, process and services, to technological or administrative areas. Innovations differ according to their degree of novelty, the qualitative difference they make and their significant change they introduce. Innovations can be categorized by their content (what is new), their subjective perception (for whom), and the duration of existence (for how long) (Damanpour & Aravind, 2012, pp. 490–492; Hauschildt et al., 2016, pp. 5–23; Salter & Alexy, 2015, pp. 37–38). They can address new configurations affecting the business model and organization; they can constitute new offerings in addition to the actual product or service of the company; they can create new experiences for a customer and the larger business system. This "vast array of different types of innovation" (Salter & Alexy, 2015, p. 38) may be extended still further in future.

Innovation is transformative. How and to what extent an innovation impacts on an existing situation ranges from incremental to radical, from evolutionary to revolutionary, from sustaining to disruptive degrees (Hauschildt et al., 2016, p. 13; Salter & Alexy, 2015, pp. 37–38). In incremental, evolutionary or sustaining innovations, the novelty introduced results in modest changes while the structure of the business and the market are retained. In innovations perceived as radical, revolutionary or disruptive, a major impact occurs for the organization itself and for the industry (ibid.; Trott, 2017, p. 10). Radical innovations represent a change of frame and are important drivers for growth and competitive advantage (Norman & Verganti, 2014, p. 82). Disruptive innovations result from a new course of action. They can consist of existing technologies from distant fields, which are applied in new environments and challenge incumbent firms (Christensen, 2016, pp. xix–xxi). Since the end of the 20th century, the attention to and awareness of radical, revolutionary or disruptive innovations has increased. Innovation of this kind challenges the capacity of existing approaches to remain competitive, and it results in a situation where industry leading enterprises as well as markets face transformations in shorter time-periods, especially when driven by technological advancements and digitization (Bullinger et al., 2004, pp. 3337–3339; Dodgson et al., 2015b, pp. 13–18; Trott, 2017, p. 10).

Innovation is not a single or discrete event, but a result of a process, which has started or has been initiated before the moment of awareness is reached (Berkun, 2007, pp. 1–15; Dodgson et al., 2011, p. 26). The process view of innovation is elemental. It seeks to answer "the fundamental question for innovation research" (Fagerberg, 2005, p. 9) – how innovations occur, what elements foster or hinder their generation, and why the processes often fail (Hunter, Cassidy, & Ligon, 2012, p. 518). The process view of innovation outlines actions and interactions, the time and people needed for the generation of a creative and novel idea, and its transformation into a different reality (Cheng & Van de Ven, 1996, p. 593; Tidd & Bessant, 2013, pp. 48, 91). It is considered as a process of discovery, an act of re-combination, a process of different phases, and a learning and social process (Fagerberg, 2005; Salter & Alexy, 2015, pp. 29–30). As a process of discovery, it implies creative search and exploration, which are iterative, dialectic and may take large time spans of collection and incubation (Buchanan, 2015; Johnson, 2010). "Slow hunches" (Johnson, 2010, p. 77) or "prelinguistic intuitions" (Moldoveanu in Martin, 2009a, pp. 10–11) for example, can persist as from years to decades until they constitute a radical idea or complement a picture for innovation. The "directly observable facts do not necessarily make sense at the time they are gathered" (Shamiyeh, 2010a, p. 9). The phases of exploitation describe the transformation of the idea into an invention and an actual use, a product, service or process of economic or organizational value.

As process of different phases, innovation spans from origination of an idea and its development to its implementation and diffusion (Damanpour & Aravind, 2012, pp. 484–485; Godin, 2017, p. 46). A three-phase description divides the process into the stages of idea, invention and implementation (Garud, Tuertscher, & Van de Ven, 2013, p. 774; Godin, 2015a, p. 223). The inventive phase turns the idea into a working concept, the implementation or application phase transfers the working concept into the context of the organization or markets, and scales the invention from a prototype to a product (van der Duin & Ortt, 2020, p. 2). The organization combines and aligns ideas, people, resources and transaction to a successful introduction of a new product, service or process (Dodgson, 2018, p. 18). The process is also decribed as a path through a knowledge funnel with three stages (Martin, 2009a, pp. 7–9): the stage of "mystery" (ibid., p. 7) is the discovery of something interesting or an idea; the stage of "heuristic" (ibid., p. 8) is the systemic condensation of the fuzzy ideas to a point where they become manageable; the stage of "algorithm" (ibid., p. 9) is the operational stage of development of implementation. The distinction between defined phases is difficult, as innovation is a "continuous process" (Fagerberg, 2005, p. 5) with iterations, changes, implementations and improvements of the idea initially launched (ibid., pp. 4–5). As a learning process, innovation combines a high level of involvement and interaction between people for the creation of something not-yet-existing (Hidalgo & Albors, 2008, p. 115; Jörg & Hughes, 2013, p. 11). Information is shared, explicit and tacit knowledge is exchanged, new knowledge is developed (ibid.). The learning occurs during the generation of novel ideas, through experimenting, testing and inventing, and during the implementing phase of a new product, process or service. From its first conception to its implementation and diffusion, innovation is a 'systemic phenomenon,' resulting "from continuing interaction between different actors and organizations" (Fagerberg, 2005, p. 4). Innovation as a learning process is necessarily a social process within an organization (Mumford, Hester, & Robledo, 2012, p. 5). It involves a diversity and broad range of people (Damanpour & Aravind, 2012, pp. 484–485). Inside an organization and between organizations, innovation processes are social processes as interpersonal joint actions, which "usually involve[s] collaboration of two or more parties" (Salter & Alexy, 2015, p. 34). Outside organizational settings, innovation is a social process of acceptance, behavioral change and adoption by a group, a market or society (Blättel-Mink, 2006, p. 52; Garud et al., 2013, p. 774). As "innovation almost always implies change" (Dunne & Dougherty, 2012, p. 569) at an individual, industrial or societal level, it alters the structures of thinking, interacting and acting of the entities involved.

The sequences of events and actions are non-linear and complex; the process is fuzzy in the beginning and remains often unstructured until a direction emerges (Herstatt & Verworn, 2007a, pp. 5–6); its progress is uncertain, its final outcome contains a high-level of risk, as the success will depend on the actual adoption and use (Berkun, 2007, p. 59; Fagerberg, 2005, pp. 8–9). Innovation is a "non-routine" (Dodgson, 2018, p. 18), which requires a thinking and managing different to the normally applied actions for operational tasks (Dodgson, 2018, p. 18; Haller, 2003, pp. 81–82; Hauschildt et al., 2016, pp. 47–48).[6] While operation focuses on the performance of existing and functioning processes, innovation is directed to the incremental or radical changes of thinking and doing things differently, within a given frame or by creating a new frame for action (Norman & Verganti, 2014, p. 82).

In an abbreviated form, the basic process view of innovation consists of three phases: idea generation, invention and implementation. But in a more diverse perspective, as described above, the process view implies aspects of complexity, search, discovery, reflection, learning, interaction, exchange, creativity, awareness, dynamic, agility and change. These are recurring and evolving themes which extend the simplified and abbreviated process view of innovation on the one hand and require new approaches for its management and design on the other (Dodgson et al., 2011, pp. 2–3; Hidalgo & Albors, 2008, pp. 116–117). Before concentrating further on innovation processes, a preliminary definition summarizes the aspects already introduced: Innovation is a social process of understanding, learning, creativity and interaction; it is process of analysis and synthesis, causing change through the creation of a different new whole. Organizations need to consider the new aspects and additional factors that have influenced innovation processes since the turn of the millennium. In the following, these factors are investigated in depth. Organizations face complexities at multiple levels. They are increasingly dependent on social proximities and social interactions. And they are required to incorporate design approaches in the development of their innovation processes. These three areas are based on the literature review on innovation, but are also present in architectural thinking and design, as will be shown in Chapter 5 and 6.

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[6] Hauschildt et al. (2016, p. 47) describe innovation as follows: "Innovationen sind nicht Routine, sollen es aber eines Tages werden. Es ist daher eine strategische Aufgabe, Innovationsmanagement und Routinemanagement zu trennen und wieder zu verknüpfen. Es ist die These dieser Schrift, dass das Management von Innovationen andere Instrumente erfordert als das Handeln im betrieblichen Alltag."

2.2 Adding Multi-level Complexities

In innovation and innovation processes, companies are confronted with different kinds of complexities. They need to cope with an environmental complexity in the system they are embedded in; they deal increasingly with complex, open, or wicked problems that they attempt or are asked to solve; and they need to manage a complex process from idea to implementation, especially when dealing with a radical, disruptive or revolutionary initiative. Complexities impact the design of innovation processes, as companies and its employees need to reframe complex challenges and find new configurations in a dynamic environment (Fjeldstad et al., 2012, p. 738; Garud et al., 2013, p. 801; van der Duin & Ortt, 2020, pp. 13–14). By seeing patterns in dealing with complexity organizations see opportunities to act, detect a gap or develop an idea for invention and innovation (Holland, 2014, pp. 9–10; Senge, 2006, pp. 68–73). Reducing complexities may lead to simplified conclusions. Innovative companies, instead, approach complexities actively at an environmental, problem and process level.

2.2.1 Environmental Complexity

Complexity describes a situation or state, in which a multitude of interrelated parts interact in a non-linear and emergent way (Axelrod & Cohen, 2000, pp. 15–16; Holland, 2014, pp. 3–6). Complexity entails a variety of elements, connectivity in interdependent relations, and a dynamic in the behavior of these elements and actions that cannot be predicted (Schoeneberg, 2014, p. 14). It requires a systemic approach to deal with the properties of complex systems – non-linearity, emergence, self-organization and unpredictability (Dunne & Dougherty, 2012, p. 579; Meadows, 2009, pp. 79–80; Mowles, 2018, p. 1243; Scogna Wagner, 2018, p. 814). “Complexity […] is about processes more than static events, and it is about the flow of information within those processes” (Marion, 2012, p. 464). Complexity science has contributed with analytical tools, numerical simulations, techniques of forecasting and strategic planning for dynamic environments and environmental complexities (Senge, 2006, p. 71). However its applicability to innovation processes has been questioned (Dooley, 2004, p. 370; Gharajedaghi, 2011, p. xiii; Senge, 2006, pp. 71–72). By foregrounding the detailed or underlying complexity of products and services it stands in the way of “seeing patterns and major interrelationships” (Senge, 2006, p. 72) for the creation of radical improvements in business (ibid., pp. 71–72; Fichter, 2014, p. 72). In “fighting complexity with complexity” (Senge, 2006, p. 72) and extending a “paradigm of control” (Mowles, 2018, p. 1249) complexity science gives a false impression of being able to make complex processes manageable and to model their details. Furthermore human agency as elemental source of innovation is not considered adequately:

> *“Despite its apparent ability to generalize many of the more specific characteristics of models of organizational change, complexity science is still lacking in one important regard—it does not have theory or models that explicitly incorporate the most human of exchanges in a complex adaptive organization, namely, discourse. Without discourse, organizational systems would not exist, or at least they would not be very interesting. Discourse in the form of both conversation and text is the lifeblood of social systems*

> *(Boden, 1997). It is through discourse that organizational members coordinate their intentions, goals, and actions; but it is also through discourse that organizational members construct reality, define what is important and what is not, create alternatives, and create order amidst confusion, ambiguity, uncertainty, and equivocality (Weick, 1995).”*
>
> *(Dooley, 2004, p. 370)*

The focus on complexity in this thesis is concerned with constantly changing themes, developments and interactions among people, which have an impact on the dynamics and performance of company initiatives and cannot be captured mathematically (Schoeneberg, 2014, p. 16–19).[7] The properties of non-linearity, unpredictability, interrelation, emergence and self-organization are relevant for an extended process view on innovation (Boehnert, 2018, p. 360; Dodgson, Salter, & Gann, 2008, pp. 10, 312; Senge, 2006, p. 71). Uncertainty is seen as an element of complexity. It occurs in complex environment, in wicked problems and in the innovation process itself (Padalkar & Gopinath, 2016, p. 689). Uncertainty is a state of perceived or acknowledged inadequacy of information, which hinders predictions about actions and their consequences (ibid.; Walker et al., 2003, p. 8). Uncertainty describes unknown unknowns, an epistemic lack of knowledge, which cannot be further reduced.[8]

At the environmental level companies are under pressure from increasing globalization, digitization, growth and availability of information (as processed data), division of labor, technological advancements, new ways of working and changing needs (Fichter, 2014, p. 65; James & Drown, 2012, p. 17; Schoeneberg, 2014, pp.16–19). Organizations and companies seek to localize and interpret developments (Mascia et al., 2015, p. 102) in order to react and act upon observed or anticipated changes. Environmental complexity can be further grouped with societal, market and technological complexity (ibid,; Hauschildt et al., 2016, p. 45; Hidalgo & Albors, 2008, pp. 116–117). Societal complexity concerns values, regulations, political frames, legal and ecological aspects, which require organizations to react and adapt, or offer opportunities to act (ibid.; KPMG, 2011). Market complexity is characterized by an increasing complexity in customer demands and needs; by a growing complexity in competition from existing and entrant firms from other industries; by a complexity in alternative ways of sourcing, processing and producing (Gann & Salter, 2000, p. 956; Schoeneberg, 2014, p. 17). Technological complexity increases by technological change, by new technologies substituting for those already existing, by a convergence of different technologies, by the availability of technologies and by the “sophistication” (Hauschildt et al., 2016, p. 60) of people in an organization to learn and integrate new technologies in processes and offerings (Schoeneberg, 2014, p. 17). Summarizing, organizations face changes in society, markets and technologies, which need to be observed, assessed and explored. To consider an environmental complexity as described an organization requires awareness, continuous reflection, interpretation and selection. But time competition and

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[7] Complexity theory and complexity science analyse the interrelations and interdependencies of a large set of variables, which formerly were supposed to behave randomly, but have an inherent structure of performance (Lima, 2011, p. 45; Marion, 2012, p. 463). For an overview of the fields of complexity research see Bachmann (2012, pp. 61–76) and Axelrod & Cohen (2000, pp. 15–17).

[8] In contrast to uncertainty risk can be estimated or calculated with a probability based on facts and knowledge; ambiguity describes a situation in which an openness to interpretation allows for multiple meanings and a lack of clarity persists; see Best (2008, p. 677); Perminova (2011, p. 42); Hansson (2009, pp. 1169–1173).

resource constraints in innovation do not allow collection of all the information required (Fagerberg, 2005, p. 9). People in an innovative organization need therefore to interpret and make sense of their environment. Within their complex environment they need to pursue a direction, which leads to a further kind of complexity at the level of the problem to be addressed.

2.2.2 Wicked Problems

Innovation problems are often not clearly defined. They are fuzzy in the beginning, when the breadth of aspects needs to be analysed, understood and assessed. During an innovation process, information and knowledge grow, as well as the number of stakeholders (e.g., employees, partners, suppliers, customers) involved (Tidd & Bessant, 2013, p. 331; Verworn & Herstatt, 2007a, p. 14). Discrepancies, contradictions and conflicting goals may become visible. On the one hand, between individuals collaborating on the problem. On the other hand, between the idea and the requirements to be met for implementation. Innovation challenges change during the process and may be pivoted in their direction. They are ambiguous as the interpretation of individuals, a team or organization differ and determine opposite paths for development. The interpretation of a problem, the assessment of needs and requirements and the intended purpose and meaning of an innovation adds to the complexity of the challenge. As the intended outcomes cannot be predicted or anticipated, uncertainty grows. As "[m]ost corporate strategy problems and governmental policy problems are at least as ill structured as problems of architectural or engineering design" (Simon et al., 1986, p. 29) an extension of this analogy is suggested: the problems of innovation are often as ill-defined or wicked as the problems of architectural or engineering design.

Following the introduction of wicked problems by Rittel & Webber (1973) management and design scholars have re-formulated the characteristics of wicked problems for managerial challenges and emerging tasks in society and industry (Christensen & Conklin, 2009; Dorst, 2015; Rith & Dubberly, 2007; Martin, 2009a; Rittel & Webber, 1973; 1984): Wicked problems have no definite formulation. Their formulation depends on the level of information and interpretation. The definition of the problem is part of the problem and depends on the context and the problem solver's ability for sense-making. In contrast to the use of equations in the natural sciences to resolve well-defined problems, neither the solution nor the path to it is visible at the beginning and alters during the process of problem definition. Accordingly, there is no one finite solution to these kinds of open problems. The different perspectives of the parties involved reveal different understandings of a problem and raise further questions. Working on a wicked problem will reveal another problem or open a new direction to solve or improve a situation. As the understanding improves with iterations and adjustments, an ongoing process is initiated. Since a complete resolution is not possible, the planner has to stop the work at a satisfying point, or on the basis of external financial or time constraints. Wicked problems are not governed by a stopping rule. The solutions to a wicked problem are not true-or-false, but good or bad. The elaborated or invented solution to a wicked problem needs to be applied or implemented in real-world circumstances in order to observe the consequences. Therefore, a wicked problem is "essentially unique" (Rittel & Webber, 1973, p. 141). The solution of a wicked problem is influenced by the perspectives taken, which can be multiple and diverse in an infinite number of ways. The set of potential solutions cannot be counted, and the choice of explanation determines the nature of the wicked problem's resolution.

Becoming aware of the nature of wicked problems has implications for approaching and solving them – preliminary, as further insights may be gained through the solution. Wicked problems require creating a shared understanding between the stakeholders involved. To discover the underlying nature of a wicked problem, different perspectives and disciplines are needed. To address wicked problems, step-by-step approaches, stage-phased problem solving processes, standardized tools are limited in their applicability. Innovation problems similarly do not have a determinate solution. They are neither right nor wrong, are unique and novel to an organization, and a "one-shot operation" (Rittel & Webber, 1973, p. 139), against a background of accelerated competitiveness in industries and markets. Alternative solutions can hardly be applied or executed at the same time; furthermore, to deepen the understanding of a complex managerial problem, only preliminary solutions offer better access to the problem space, and need to be applied, iterated and evaluated (Camillus, 2008; Christensen & Conklin, 2009, p. 19; Riel in Martin, 2009a, pp. 94–95; Martin, 2009b, p. 3). Summarizing the issue with four characteristics, Dorst (2015, pp. 9–12) frames contemporary problems – and problems of innovation – as being “open, complex, dynamic and networked” (ibid., p. 12): an open problem does not have a clear boundary indicating what should be included for consideration and what excluded. The context is a moving line and permeable simultaneously to further understanding of the problem. The variety and number of elements as well as its interrelationships drive the problem‘s complexity. The problem changes its shape over time; it evolves dynamically and surpasses organisational systems. As a networked problem, it can hardly be solved by one organisation. Accordingly, to deal with the open, networked, dynamic and complex characteristics of innovation problems, a design approach is suggested to management (Liedtka, 2004, p. 196; Riel in Martin, 2009a, pp. 94–95). However, the related problems and challenges are to different extents complex. In incremental, evolutionary, or sustaining innovations well-defined or moderate challenges may be addressed. For radical, revolutionary, or disruptive initiatives the characteristics of wicked problems may apply. For these, stakeholders and managers need to develop an appropriate approach depending on the nature of the expected innovation. The processes need to be capable and adaptive to cope with wicked problems and to provide intermediate solutions to ill-defined tasks. As Rith & Dubberly (2007) put it:

> *“Solving simple problems may lead to improvement—but not innovation. For innovation, we need to re-frame wicked problems.”*
>
> *(Rith & Dubberly, 2007, p. 73)*

2.2.3 Process Complexity

Reframing wicked problems is in itself a complex process. In context of innovation, it requires the integration of understandings and interpretation of different stakeholders, as the employees of an organization, users, external consultants, suppliers, researchers or authorities. The process may not follow a pre-structured path or phasing; it may alter or change direction according to new occurrences, demands or findings. The hybridization of products, services and processes, the division of labour, global sourcing and advancements in information technology increase the process complexity inside an organization, and between organizations and further stakeholders (e.g., users, researchers, authorities). An innovation process in this regard is complex. It shows the properties of complex systems such as non-linearity, feedback loops and iterations. It shows adaptive behaviors, openness and the dynamics of changing states over time. It entails the occurrence of leverage or tipping points, moments of serendipity, break-outs of path dependencies, and the possibility of emergence, when the interactions of its elements as a whole surpass the capacities of its single parts (Boehnert, 2018, p. 360). Against this background, innovation processes shift from function-orientated to project-oriented structures (Martin, 2009a, pp. 118–121). Principles, e.g., of being adaptive, agile or capable of coping with ambiguity, uncertainty and contradictory demands, increase in importance. Precise formulation of a task and the exact conduct of process steps decrease. As a consequence, an innovation process which is successfully applied in one situation may be limited in its applicability for other challenges. Prototypical and customer-individual solutions may become more relevant (ibid.; Prahalad & Krishnan, 2008, pp. 26–27). Therefore a continuous adaptation is needed to develop innovation ‘routines‘ (ibid., pp. 26–30; Tidd & Bessant, 2013, pp. 623–624).

Organizations need to provide structures to approach and cope with complexities at different levels. At the level of the environment, companies and employees need to observe and be aware of changes, trends and transformations, and reframe their course of actions. At the level of the problem, its complexity needs to be acknowledged as wickedness and treated accordingly in an agile and adaptive, complex process, which is difficult to predict and manage.

> *“These messy and complex processes require us to reconceptualise the process of innovation, because the observed processes cannot be reduced to a simple sequence of stages or phases as implied with the stage gate model that is used in many organizations for managing the innovation process”*
>
> *(Van de Ven, 2017, p. 40).*

Before such models of innovation processes are discussed, the second extensions to the process view of innovation will be explained. Innovation processes depend on human action, their intentions and the initiatives for change (Bitar, 2003, pp. 11, 16; Damanpour & Aravind, 2012, p. 486; Hauschildt et al., 2016, p. 5). They can be sparked by external factors such as, e.g., reaction to a demand or gap, or internally driven by, e.g., a vision or goal (Norman & Verganti, 2014, p. 95; Trott, 2017, pp. 2–47). In both cases, social interactions take place, and need to be taken into account.

2.3 Adding Social Proximities

Innovation is a social process by people interacting in and outside an organization, in formal and informal ways (Drexler & Janse, 2013, p. 128; Garud et al., 2013, p. 774; Hidalgo & Albors, 2008, p. 116). The interactions occur on multiple levels: between individuals, within a team, department or unit, within a network of partners and stakeholders, or openly with new actors. The social interactions foster people’s creativity, their awareness and understanding of problems, challenges and opportunities, their communication, collaboration and co-creation processes. While formal organization in enterprises has been foregrounded in the past century, informal environments and spatial proximities are increasingly valued for shaping and fostering the interactions that promote innovation (Mascia et al., 2015, pp. 102–104; Perry-Smith & Mannucci, 2015; pp. 205–207; Pentland, 2015, pp. 87–104). Employees and colleagues are no longer regarded as inhibitors, who need to be trained in overcoming their resistance and ignorance in relation to change (Corsten, 1989, p. 11; Hauschildt et al., 2016, pp. 27–62). They are treated as creators of transformation, who communicate, exchange ideas and knowledge, engage and collaborate in more dynamic and self-organized ways. Social factors, individual and team performances are positive, pro-active and constructive elements in organizational innovation (Dodgson et al., 2011; Gilson, Lim, Litchfield, & Gilson, 2015; Haller, 2003, pp. 33–35; Zhou & Hoever, 2014). In this regard, the informal organization, personal relationships, and physical proximities – along with the questions of who interacts with whom and where – are increasingly important (ibid.; Groves & Marlow, 2016; Lundberg, Sutherland, Blazek, Habicht, & Penzenstadler, 2014; Sørensen & Mattsson, 2016). At the same time, the complexity and interrelatedness of challenges and solutions deconstruct the "lone genius" (Godin, 2008, p. 45) as the key agent for innovation (Berkun, 2007, pp. 67–79; Perry-Smith & Mannucci, 2015, p. 205).

The capability of a company to innovate is constituted by its organizational context, structure, knowledge and processes on the one hand, and by its people, culture and social network on the other (Autio, Kenney, Mustar, Siegel, & Wright, 2014, p. 1100; Bitar, 2003, p. 11; Chantzaras, 2019b, p. 539). The process view of innovation needs therefore to be extended by this social perspective and by proximities of a relational and spatial kind. They are built by creativity and awareness, by informality and spatiality. Creativity as human process and outcome is the "starting point for innovation" (Amabile, Conti, Coon, Lazenby, & Herron, 1996, p. 1155; Damanpour & Aravind, 2012, p. 486; Amabile, 1988; Mumford, et al., 2012; West & Sacramento, 2012). Awareness, understanding and interpretation of the environment are essential capabilities to achieve distinction and difference (Birkinshaw et al., 2010; Lockwood & Papke, 2018; Nelson & Stolterman, 2012; Verganti, 2009). The informal organization in which people collaborate beyond their occupational roles and departmental belonging influences their success in ideation, invention and implementation (Pentland, 2015, pp. 87–104; Perry-Smith & Mannucci, 2015. pp. 209–212; Waber, Magnolfi, & Lindsay, 2014). Spatiality and 3-Dimensionality is the conceptual, Euclidian space for comprehending and conveying the complexity of social proximities.

2.3.1 Creativity & Awareness

The increase in complex challenges affects the suitability and applicability of traditional management approaches and tools (Agars et al., 2012, p. 271; Boland & Collopy, 2004b, p. 4). Being creative has become "one of the most relevant skills needed in the future of business" (Shalley et al., 2015, p. 2). A creative workforce – the creativity of individual employees and teams – is considered as a fundamental organizational commodity for a company's success (Agars et al., 2012, p. 271; Bissola & Imperatori, 2011, p. 79; Dodgson et al., 2015b, p. 17; West & Sacramento, 2012, p. 359). Consequently organizations have started to educate and promote creativity as "regularly occurring possibilities in organizations" (Agars et al., 2012, p. 273) rather than exceptional situations (Agars et al., 2012, p. 275; Dodgson et al., 2015b, p. 17; Zhou & Hoever, 2014). As an "emergent outcome," creativity can be fostered as well as it can be damaged and blocked (Leonard & Barton, 2014; Marion, 2012, p. 472; Soriano de Alencar, 2012). Understanding creativity, its components and processes is therefore essential in the design of innovation processes.

Creativity is defined as the ability to produce new ideas, which are novel and useful for accomplishing desired goals (Amabile, 1988; James & Drown, 2012, p. 18). The ideas appear as original and elegant answers to creative challenges, which are characterized as ill-defined problems: they are novel, complex, demanding and exploitable (Mumford, Hester, & Robledo, 2012, p. 40). The explorative nature of creativity is a "complex and dynamic network of discoveries" (Auernhammer, 2012, p. 32; and Paulus et al., 2012, p. 328). Creativity is a distinct concept from innovation and design, necessary in the conception of the other, but not sufficient (Amabile, 1988, p. 125; Damanpour & Aravind, 2012, p. 486; Johansson-Sköldberg, Wodilla, & Çetinkaya, 2013, p. 131; Mumford et al., 2012, p. 5; Nelson & Stolterman, 2012, pp. 4–5, 173; Salter & Alexy, 2015, p. 35). Creativity leads to the phase of discovery by an individual or team (Auernhammer, 2012, p. 37; Damanpour & Aravind, 2012, pp. 484–488; Paulus et al., 2012, p. 328); innovation focuses on implementation and change in the configuration of a unit or organization (ibid.); design integrates comprehensive, creative thinking and the actions performed for synthesis and realization (Nelson & Stolterman, 2012, pp. 4–5, 127). Creativity in the organizational context of a company is as a subset of innovation (Damanpour & Aravind, 2012, pp. 484–488; Shalley et al., 2015, p. 2; West & Sacramento, 2012, p. 359). It depends on different cognitive and mental factors at an individual level, on social interactions and on group composition at a team and organizational level (Auernhammer, 2012, p. 22; Woodman, Sawyer, & Griffin, 1993, p. 295). Team and individual creativity contribute to an organizational creativity, which is defined as "the creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system" (Woodman et al., 1993, p. 293).

Creativity is influenced by elements and components of individuals, teams and organizations and their relation to each other. The systems, component and interactionist approaches differ in the way they value the relevance of social interactions for creativity.

The systems view defines creativity by its environment of occurrence, and "where" creativity "is" (Csikszentmihalyi, 2013, pp. 27; 27–36). Creativity emerges during the interaction of three components in a system: the individual, who introduces a novelty, the domain, in which the individual acts, and the field, which judges the creative impulse of the individual (ibid.; Csikszentmihalyi, 2014, p. 103; Simonton, 2012, pp. 68–70). Value and judgement by gatekeepers in the field ensure on one hand the quality of creative outcomes and performances; on the other hand, they can inhibit and block creative ideas from emerging and changing a domain. The aspect of value is questioned as determinant of creativity. As value systems change over time, the acceptance and acknowledgment of a product, artifacts or research as creative may change accordingly (Weisberg, 2006, pp. 63–66). Creativity is then considered as "intentionally produced novelty" (ibid., p. 66) separted from its value to and for others.

The componential view of creativity focuses on the components and influences relevant to the creative processes of individuals in firms (Amabile, 1988). Three internal components and one external element constitute individual creativity for the team and organization (Rigolizzo & Amabile, 2015). The domain-relevant skills represent the knowledge and experience of an individual necessary for the capability to act in a domain. The creativity-relevant skills outline mental capacities, cognition and abilities required to approach a challenge creatively, i.e. with divergent, lateral, intuitive and abductive thinking. The intrinsic task motivation as third internal component is key for "what that individual actually does" (Amabile, 1988, p. 156). Because creativity or "human creation does not occur in a vacuum" (Weisberg, 2006, p. 56), it is related and influenced by its environment and other people. This social environment, e.g., the work environment in a firm, represents the fourth and external component (Rigolizzo & Amabile, 2015, p. 62). All four components need to be considered for creative and subsequently innovative initiatives in company.

The interactionist view of creativity relates the componential model of individual elements to a team setting and organizational environment (Woodman et al., 1993). Creativity is the "the result of a complex interplay of (a) stable or transient characteristics of an actor (individual, dyad, or team) and (b) contextual factors" (Zhou & Hoever, 2014, p. 335) between the person and the situation (West & Sacramento, 2012, p. 362). Individual creativity is influenced by "antecedent conditions, cognitive styles and abilities, personality, motivational factors, and knowledge" (Woodman et al., 1993, p. 301). It flows into a group and constitutes the group creativity, when composition, processes and characteristics of the group favour the creative process and contextual influences are considered (ibid., p. 304). The group's creative behavior drives the organizational creativity. Contextual influences of the environment are integrated, and eventually a creative outcome is achieved, which is distinct and of high quality. The components in the interactionist view are related to each other across individual, group and organizational level. A component that is inhibited or neglected may affect the organizational creativity as a whole (ibid., pp. 296, 310).

A process view of innovations should consider social interactions for creativity at an individual, team and organizational level. This also contributes to reducing the factors that constrain creativity in an organizational environment (Soriano de Alencar, 2012, pp. 95–105):[9]

- limited awareness, visibility and transparency
- lack of alternative ways for exploration, exchange and collaboration
- lack of autonomy and hierarchical structures
- institutionalism and isomorphism in organizations
- absence of meaning and purpose

Creativity has a constructive nature and requires an organizational environment to be cultivated and spaces to unfold across an organization. It is a fundamental driver for innovation, but not sufficient. Employees and teams need to be aware of changes, opportunities and processes in their environment. They are required to understand the situation in order to act in a way that leads to innovative outcomes (Amabile, 1988, p. 131; Csikszentmihalyi, 2013; Dorst, 2015). They need to develop an understanding for open, interrelated and wicked problems, as well as an understanding of the ways to approach them; they need to interpret the problems creatively in order to develop a promising innovation or one that responds to an imminent disruption caused by new entrants, by technological changes or new external circumstances in regulations or society (Boland & Collopy, 2004b; Dodgson et al., 2015b, pp. 13–15, 23). Awareness in

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[9] For a detailed overview of facilitating and inhibiting factors on creativity see Soriano de Alencar (2012, pp. 95–105).

this regard means to be attentive, to consciously notice changes in the outside, regarding context, environment, clients and users, but also to the inside, regarding organization, colleagues, teams, processes and applied technologies. These changes may require or may invite the employee or team to engage in communication and ongoing processes. It may require or invite them to initiate new ideas, to develop an invention or to support its implementation (Allen & Henn, 2007, p. 85; Kulick, Quarch, & Teunen, 2017, pp. 340–343). In order to contribute actively to innovation, individual behaviour needs to comprise awareness and sensitivity as well as openness and knowledge (Haller, 2003, pp. 111–112). In the words of Norman & Verganti (2014):

> *"Again, recognizing the potential for a new higher hill [i.e. innovation, author's note] requires an explicit act of interpretation of patterns, rather than just random creativity."*
>
> *(Norman & Verganti, 2014, p. 96).*

2.3.2 Informality & Exploration

The exchange of thoughts, ideas and knowledge in a firm are processes of social interactions. They can be formally organized and structured, or they evolve informally and remain liquid.[10] People interact across levels and departments. Their involvement and motivation, their way of collaborating, co-creating and, especially, confronting each other with diverse perspectives, guides the development of an invention and its implementation (Chantzaras, 2019b, p. 538; Nasiri et al., 2016, p. 4; Reiter-Palmon, Wigert, & Vreede, 2012, p. 303; Van de Ven, Polley, Garud, & Venkataraman, 1999, p. 30). Team creativity has been found to outperform individual creativity in the context of multi-level complexities, which require diverse skills and perspectives (Bissola & Imperatori, 2011, p. 77; Pentland, 2015, p. 91; Reiter-Palmon et al., 2012, pp. 295–296). In contrast, a team can also impede the generation of novel, radical ideas by its group cohesion or silo structures (Leonard & Barton, 2015, p. 127). Driving and impeding interactions can occur within formal or informal organizations. While the formal organization can be identified e.g., in organizational charts, codified regulations and guidelines, the second often remains hidden and tacit. In order to leverage interactions towards innovation organizations need to consider their formal as well as their informal social networks and the elements influencing their occurrence and continued existence (Drexler & Janse, 2013, p. 128; Kastelle & Steen, 2015, pp. 108–109; Rizova, 2006, pp. 54–55). For a deeper understanding of informal organization and the way people interact with each other, the relational and spatial proximities that exist between them and the simultaneous consideration of other processes are relevant.

The type of interaction differs between individuals, and between individuals and technology, facilities, and machines (Allen & Henn, 2007, pp. 27–30). New technologies and the progress of digitization shrink distances (Waber et al., 2014). Knowledge work becomes independent from the physical presence of

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[10] The term liquid is used in the context of innovation in Johnson (2010) or Boland & Collopy (2004a). Johnson (2010, pp. 58–65) describes liquid networks as essential for innovation. Creativity and ideas evolve in close and open interactions of people that behave liquid and change over time. Boland & Collopy (2004a, pp. 17–18, 273) emphasize the liquid state of a design process, in order to deal with changing requirements of a problem or occurring new insights.

people; co-located collaboration occurs in remote environments; people work flexibly together in physical and digital spaces, regardless of the job they do and the department they belong to (Chantzaras, 2019b; Kastelle & Steen, 2015). Their interactions foster creativity, awareness, understanding; they drive the dialectic discourse, the confrontation and art of criticism, which is important, to generate ideas, inventions and innovations of high quality and value (Allen & Henn, 2007; Buchanan, 2015; Pentland, 2015; Verganti & Norman, 2019; Verganti, 2017b). Direct face-to-face communication, synchronous, but remote communication via voice, and asynchronous communication through digital means contribute differently to creativity and the generation of novel ideas; they vary in their value for innovation (Allen & Henn, 2007, pp. 26, 58–61; Pentland, 2012; Waber et al., 2014).[11] Besides the digital transformation in working processes, direct interaction face-to-face has remained of primary value for novel ideas and has received a similar value during the global pandemic that started end of 2019 (Chantzaras & Ford, 2020; Coscia, Neffke, & Hausmann, 2020).[12] While coordinative and informative aspects of communication and interaction are "well represented by organizational structures" (Allen & Henn, 2007, p. 29), the interactions to deal with complex problems and develop new approaches to their resolution are more difficult to frame, capture and foster. Informal patterns of employees' behavior and communication, and the informal organization itself, is becoming important for the way a company innovates. The evolving informal structure beyond the formally planned and managed organization, is regarded as driver for improving innovation processes, but can also inhibit them (Hargadon, 2015; Kastelle & Steen, 2015; Wecht, 2014, p. 254).

The importance of physical interactions outlines the importance of spatial proximities between actors (Allen, 1995, pp. 234–240; Kastelle & Steen, 2015, pp. 108–109; Waber et al., 2014). Chance encounters, informal meetings, intended and unintended explorative endeavours are more likely when the actors are in physical proximity. Being "out of sight" (Waber et al., 2014) may lead to be "out of sync" (ibid.) with a working process (Birkinshaw et al., 2010, p. 45; Pentland, 2015, pp. 48–50).[13] Consequently, companies have begun to reconsider spatial proximities in addition to the relational structures depicted in their organigrams. To cope with dynamic environments, for which traditional management tools of operation and optimization appear rigid, companies foster adaptive formation of teams and enable their self-organization by rethinking and redesigning the spatial proximities (Groves & Marlow, 2016; Katsikakis, 2017; Sawyer, 2008, pp. 33–37, 164–166). Temporary and project-oriented work for innovation depends on integrating disciplines relationally and physically. It promotes experiences and the conveyance of tacit knowledge in direct interaction. Hunches or creative sparks in the interactions with different and diverse people may have an impact on the innovation process and "make sense" (Shamiyeh, 2010b, p. 9) at later date, when the possibility of an invention or innovation takes shape (Johnson, 2010, p. 83). Interactions through networks among employees provide "opportunities for exchange and serendipity to happen" (Birkinshaw et al., 2010, p. 45). Social networks have become of interest

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[11] Wiertz, Ruyter, Keen, & Streukens (2003, p. 2) offer a categorization of different interaction channels in service systems: "Today, customers have many different alternatives in which they can interact with a company. In addition to the traditional service delivery format (face-to-face), companies are using voice-to-voice (toll-free telephone support) and bit-to-bit (on-line service delivery) modes, as well as combinations thereof, to deliver their services."

[12] The impacts of the Covid-19 pandemic on office work, collaboration, creativity and innovation will be touched in the expert interviews in Chapter 10 and addressed in Chapter 11.5. Concept and work on this doctoral thesis begun prior to the pandemic. In Chapter 11.5 the hypothesis, the proposed methodology and the evaluation resulting from the expert interviews will be reflected against this background.

[13] Pentland (2015, p. 48) supports the importance of spatial proximities by stating: "Idea flow sometimes depends more on seeing what people actually do than on hearing what they say they do."

in the study of innovation processes, which will be detailed in Chapter 3. At this point, the importance of relational and physical proximities, of informal structures, of strong and weak ties between individuals and teams is emphasized (Zenk & Behrend, 2014, p. 214). While strong ties of employees tend "to form redundant clusters" (Perry-Smith & Mannucci, 2015, p. 209) in which similarity increases, weak ties in an organization allow connections to unrelated fields or access to pockets of information which otherwise would not have been noticed. These new connections, that for example bridge structural holes in an organization, lead to novel combinations and the generation of non-redundant knowledge for the firm and eventually innovation (Burt, 2001, pp. 34–37; Oldham & Baer, 2012, p. 406).

Research on creativity and innovation emphasizes the relevance of exploration by employees and teams; it relates exploration synonymously to discovery, tinkering or bricolage (Johnson, 2010, p. 29; Pentland, 2015, pp. 96–104; Sanchez-Burks, Karlesky, & Lee, 2015, pp. 93–95; Weisberg, 2006, pp. 55–57). In "liquid networks" (Johnson, 2010, pp. 52), for example, the innovator is continuously able to form new connections, discover and follow hunches or ideas, to exchange thoughts or receive support. The density of these networks encourages individuals to become more creative and innovative, especially through the possibility of information spillover (ibid., pp. 53–54). Similarly, research in the field of social physics emphasizes that engagement within a team and exploration outside the team contribute to team performance on productivity, creativity and innovation (Pentland, 2015, pp. 93–99). The engagement within a team is driven by trust, co-operation and interaction leading to a collective intelligence. It reflects the argument for team creativity. The exploration outside a team is driven by exploring contrarian views and experience diversity in approaches; it develops a social learning outside the existing environment, which – when integrated with the team's work – supports performance even further. The perception of contrarian views and conflicts, especially influences creativity and the quality of innovation (see Figure 2; Santos, Uitdewilligen, & Passos, 2015, p. 648; Verganti, 2017b, pp. 13–15; Verganti & Norman, 2019).

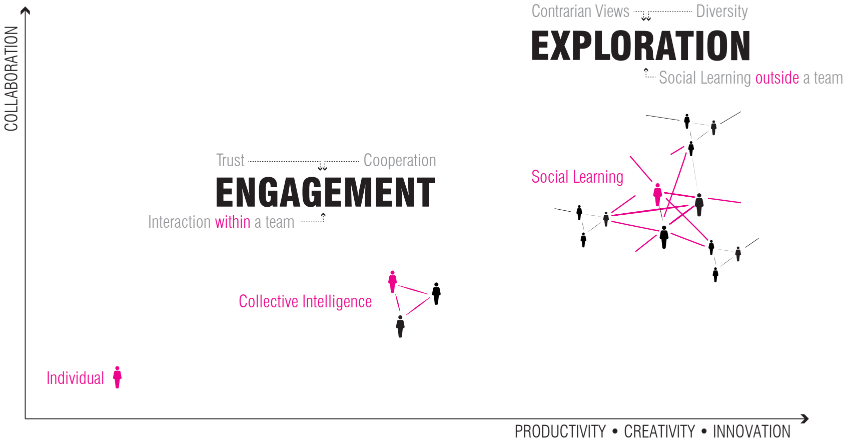

Figure 2: Social Interaction and Innovativeness

Engagement and exploration are characteristic for successfully collaborating teams. They equally contribute to the increase productivity, creativity and innovativeness of teams. Author's developed representation based on Groves & Marlow (2016, p. 162) and Pentland (2015, pp. 87–104).

Companies seek to build engaged and motivated teams which continue to explore, connect and learn outside their team setting. In an extended process view on innovation, informality, engagement and exploration need to be considered.

2.3.3 Spatiality

Thinking about organizations and their processes entails thinking with mental images. "Implicit images or metaphors", as Morgan (1997, p. 4) states in his research on organizational life, "lead us to see understand and manage organization in distinct yet partial ways."[14] Of interest for this study are externalizations with non-verbal means that show the structure of an organization and its main principle of operation. At this point, the importance of imagery for an organization is limited to three aspects: firstly, how the imagery displays the principle structure of organization; secondly, how it captures the social proximities and interactions with their relational and spatial dependencies; thirdly, how it remains comprehensible to human cognition. In the latter aspect, the spatial intelligence of human cognition is emphasized. In addition to visual communication with signs and 2-dimensional graphics, communication in spatial representations enables people to perceive the complex relations of an organization's different elements to each other and enter into a deeper understanding (Gardner, 2011, pp. 201–202; Tzonis, 2004, p. 70). For the visual representation and communication of organizational structures mostly 2-dimensional graphics known as organigrams or organizational charts are used (Lassl, 2020, p. 4; Wöhe & Döring, 2013, pp. 110–111).[15] Occupational roles, divisions and departments are represented by nodes, relations and dependencies by lines connecting the different nodes. The visual representations convey favored organizational configurations as „the optimal form for a group to fulfil its purpose and strategy so it can reach its intended outcomes" (Cichocki & Irwin, 2014, p. 17).

Hierarchical formations are for example visualized in pyramidal shapes. The line is considered here as one-dimensional, as it only connects one node with another and constraints "spatial conception […] to a linear track." (Arnheim, 1974, p. 218). Matrix structures of organizations are represented as rectangular grids. The second dimension allows us to visualize elements in relations to each other in two-dimensional planes. Network organizations in this planar view appear as a random arrangement of nodes with multiple intersecting connections. With the addition of a spatial dimension, a network organization receives further possibilities for its representation. The relational and spatial proximities of its nodes can be represented simultaneously with different degrees of geometrical depth. The complex structure of a firm and its processes can be then untangled and represented for better cognition and understanding. Arnheim (1969, 1974) addressed spatiality and the third dimension his research on visual thinking – which will be addressed further in the subsequent chapters:

> *"Three-dimensional space, finally, offers complete freedom: shape extending in any perceivable direction, unlimited arrangements of objects, and the total mobility of a swallow. Beyond these three spatial dimensions visual imagery cannot reach; the range can be extended only by intellectual construction."*
>
> *(Arnheim, 1974, p. 218)*

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[14] Morgan (1997) investigates in his work 'Images of Organizations' the imagery and metaphors used to describe organizations, for example as machines, organisms, brains or as flux and transformation.

[15] Lassl (2020) argues also for a systemic and holistic view of organizations and speaks of an "Organization in 3-D" (ibid., p. 3). He proposes a Viable System Model approach, originating from cybernetic theories and the works of Stafford Beer, to represent organizations closer to reality. This field will not be investigated in the scope of this thesis.

The ’fourth’ dimension of time is represented by changes of the nodes in 3-dimensional space, representing, for example, their location, size and form, or changes in the connections in relation to their direction, strength and type. Spatial representations with representation of time are advantageous for an extended view on innovation processes. Processes leading to innovation are complex. They often occur and evolve in parallel, intersect each other, roll back or merge (Kastelle & Steen, 2015; Van de Ven et al., 1999). On one side, innovative developments depend on real-life occurrences, interactions and explorations in physical space (Johnson, 2010, pp. 60–65; Waber et al., 2014). On the other side, they evolve tacitly, intangible and invisible to others. The relationships and interdependencies remain crucial. The addition of geometrical 3rd dimension could improve an extended view of innovation processes, as “[t]o see an object in space means to see it in context” (Arnheim, 1969, p. 54).

Different elements in an organization – individuals, teams and departments – can be viewed in their formal dependencies, but also in their informal relations to each other. Who interacts with whom on what, can be represented simultaneously together with questions of when and where interaction occurs, where novel ideas arise, where knowledge is combined, developed or kept separated and isolated (Allen & Henn, 2007, pp. 14–20; Chantzaras, 2019b; Johnson, 2010, p. 61; Kastelle & Steen, 2015, p. 108). The spatial dimension enables different processes and parallel configurations to be captured at the same time. It allows the depiction of different streams and developments, real-time interactions, the occupational roles covered, hidden teams or disconnected departments of a company. With a spatial dimension several aspects of informality, exploration and engagement can be represented. Interactions may become more visible in a 3-dimensional representation.

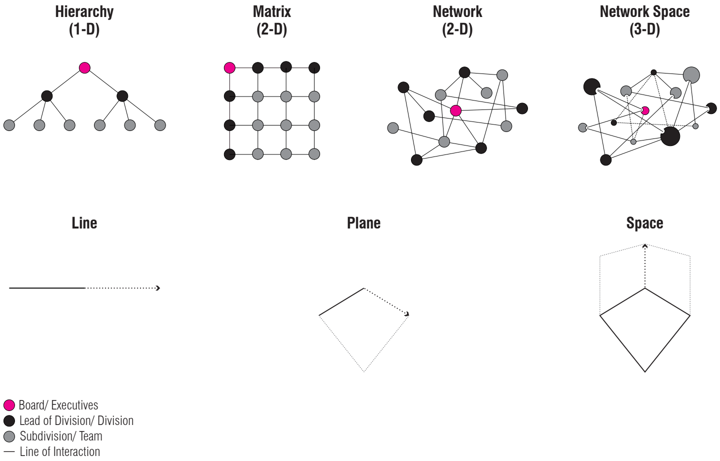

Figure 3: Organizational Structures and Visual Representation

Hierarchical organizations represented as line, one-dimensional configurations. Matrix organizations represented as two dimensional and two-directional grids. Network organizations represented in a multi-directional, plane view and as 3-dimensional space with consideration of relational and spatial proximities. Author’s own representation in reference to Allen & Henn (2007, p. 87) and HENN (2009a).

The informal organization of how people and different teams interact creatively and collaborate in relational and spatial proximities can be jointly viewed with the company’s formal structure. In this regard, distances between people can be analysed, silo structures or unconsidered spillover effects localized, strong and weak ties or structural holes investigated – from an individual, team or organizational level. As a consequence, innovation processes viewed with a spatial dimension as a liquid network of interacting parts require a non-linear approach. They become a subject of design (Chantzaras, 2019b, pp. 539–540).

2.4 Adding Process Design

In innovation, companies are confronted with dynamics of a process, which is complex, fuzzy, messy, unique, and with dependent social interactions for creativity, awareness and collaboration (Herstatt & Verworn, 2007a; Mascia et al., 2015). Analytical approaches to defining and developing processes are effective for stable environments, but have a limited application in complex, dynamic and changing surroundings (Boland & Collopy, 2004b; Lockwood & Papke, 2018; Martin, 2009a; Verganti, 2009). Tools for screening, for market and technology research, are becoming less feasible when radical, disruptive or open innovations transform an environment in unpredicted directions (Burgelman, Christensen, & Wheelwright, 2009, pp. 846–854; Olesen, 2017, p. 95; Russell, Still, Huhtamaki, & Rubens, 2016; Sørensen & Lapenta, 2017). Quantitative metrics for accounting, measuring and promoting innovation, e.g., with existing key performance indices, are constrained in capturing promising initiatives, and can hinder or stop them; hence, to actively understand, guide and foster the dynamics of innovation processes, new approaches and tools are required and sought after, by the management of a company and by its employees (Brem & Viardot, 2013, pp. 351–352; Burgelman et al., 2009, pp. 846–854; Gharajedaghi, 2011, p. 157; Hauschildt et al., 2016, p. 56; Watt, 2008, p. 70).

Innovation processes need to be seen holistically with a systems view, framing the complexities described and taking into consideration the social interdependencies and interactions. They have been the subject of methods for efficient organization and optimization. But they are now also becoming the subject of a design approach. A design approach synthesizes multiple, conflicting or contradictory parts, and responds to the dynamics and emergence of an innovation process. It requires a systems view, a reflective and constructive practice, and the use of non-verbal boundary objects.

2.4.1 Systems View

The systems view on a firm shows the interrelations, connections and dependencies of people, technology, machines and facilities. A system is a set of different parts with multiple relationships and behaviors, which has a property – or "a function or purpose" (Meadows, 2009, p. 11) as a whole that its individual parts have not (Ackoff in Brant, 2010, min: 4:04; Checkland, 1981, p. 3). A complex system, like an organization, is further characterized by properties of non-linearity, adaptation, emergence, openness, instability and stability, feedback-loops, leverage and tipping points (see 2.2; Bitar, 2003, p. 23; Boehnert, 2018, pp. 350; 360; Holland, 2014, pp. 5–6; Laloux, 2014, p. 211; Meadows, 2009, pp. 188–189). For improvement in performance, a system needs to be considered as a whole, not as the sum of parts, or "the sum of the behavior of it's parts", as Ackoff emphasizes in 1994 (Ackoff in Brant, 2010, min: 5:17).[16] These behaviors can not be independently optimized (idid., min: 5:27). A system view on organizations differs from views externalized by organizational charts with

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[16] Russel Ackoff (1919-2009), researcher and educator in systems thinking and operations research, focused after a bachelor in architecture on applying systems thinking to managerial and organizational issues (Ramage & Shipp, pp. 141–142). His views on systems thinking referred to here are retrieved from a recorded speech in 1994, accessible online in Brant (2010). In an essay Ackoff stressed the danger of improving only the performance of parts of a system: „Here is a very small sample of the obvious things I have found to be wrong: Improving the performance of the parts of a system taken separately will necessarily improve the performance of the whole. False. In fact, it can destroy an organization, as is apparent in an example I have used ad nauseum: Installing a Rolls Royce engine in a Hyundai can make it inoperable. This explains why benchmarking has almost always failed. Denial of this principle of performance improvement led me to a series of organizational designs intended to facilitate the management of interactions: the circular organization, the internal market economy, and the multidimensional organization." (Ackoff, 1999, pp. 1–2).

static departmental entities in linear 1- or 2-dimensional directions. It depicts an organization as a self-managed, adaptive and evolutionary system (Laloux, 2014, p. 56) or as living systems (ibid.; Senge, 2006, p. 267). The systems view is a continuous consideration of elements, the relations between them, and their mutual proximities and dynamics (Meadows, 2009). It introduces new mental models and images of an organization that shape the thinking and actions of the people linked to this organization. It considers the performance of a system as a whole in relation to the performance and influence of its parts and its surrounding context. A systems view enables an understanding of the complexity of an organizational structure as a whole and allows individuals to localize themselves in relation to this structure. These aspects relate to the visual-spatial perception and thinking about organizations explained above.

In organizational theory, this kind of systems view has been incorporated into a discipline of system thinking (Senge, 2006, pp. xii–xiii, 12). To create learning organizations systems thinking "integrates" other disciplines "into a coherent body of theory and practice" (ibid., pp. 11–12). System thinking according to Senge (2006) is necessary to align the discipline of "personal mastery" (ibid., pp. 7–8, 131) of the people in an organization, the discipline of the mental models these people use, the discipline of building a shared vision among the people and the discipline of team learning, where people engage in a dialogue as "thinking together" (ibid., p.10) in order to learn and grow. This concept of a system thinking discipline is based on several arguments that are of relevance for this thesis. As will be later elaborated in Chapter 5 and 6, they can also be found in the architectural thinking and design process. System thinking as a discipline of learning organizations encompasses:

- the view of "interrelationships" and "processes of change" (Senge, 2006, p. 73)
- a "long-term view" of the consequences of actions and effects (ibid., p. 91)
- a "reflective practice" (ibid., p. 177)
- a work with "virtual world […] for experimentation" (ibid., p. 241)
- the concept of "leader as designer" and as a "designer of the ship" (ibid., p. 321)

Applied to an organization and its innovation processes the systems view in this study considers the complexity of the organizational environment and the social interactions that lead to ideas, inventions, and innovations. It 'sees' the relational and spatial dependencies between the elements and supports to recognize patterns of interactions and behaviors between them. To the inside of an organization, a systems view allows to discuss boundaries within a company's structure and experiment with alternative configuration. To the outside of an organization, it provides information, to open and connect the structure to external stakeholders (Chesbrough, 2003; Senge, 2006). By integrating spatial proximities, as emphasized before, a systems view takes visually the areas into account, where people work as individuals, teams, and departments, where resources and knowledge reside, where ideas initiate and new developments evolve, or where processes are hindered (Bitar, 2003, p. 26; Russell et al., 2016, p. 49). An innovation process in this view is a system in a 3-dimensional space that changes continuously over time. The process of innovation unfolds in multiple interactions in- and outside the organization. In a strictly linear perspective, the process is a sequence of consecutive steps over time. In a 2-dimensional understanding, the process is a sequence of consecutive steps over time with iterations, loops, direct connections, short-cuts and possible new interactions. In a 3-dimensional view, the process is understood as system of simultaneously occurring non-linear interactions between nodes. Social interactions and the flow of activities are blended with the organization's structure of relational and spatial proximities. In reference to visual perception with mental images and models, thinking of organizations and their processes in systems, is thinking of them spatially. The dimension of time is represented in the dynamics of interaction as change e.g., by the growth, movements, combinations and transformations of nodes and connections (Russell et al., 2016, p. 53).

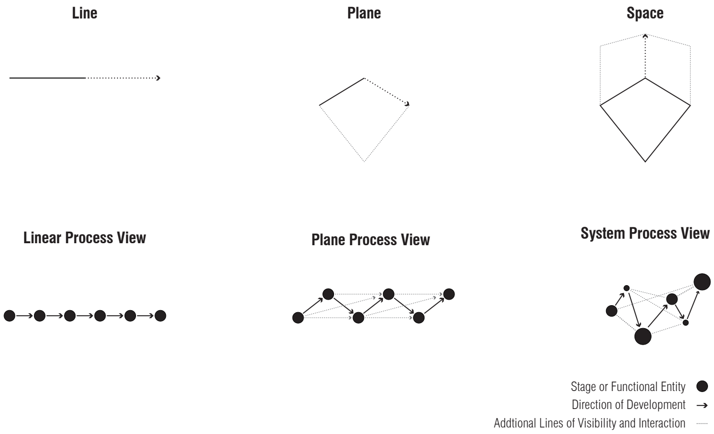

Figure 4: Spatial View on Processes
A spatial (Euclidian) 3rd dimension offers a systemic view on processes. In difference to linear and 2-dimensional plane views,further connections and iteration between different process phases or functions can be depicted.

In an extended process view of innovation, a systems view captures complexities and interactions holistically. It embeds a separated linear process sequence in an organizational environment of interacting and mutually influencing parts (Buchanan, 2001, 2015; Senge, 2006). Through this it provides a new mental model to understand and develop innovation processes differently. To create this mental model, a process of design is needed, as suggested by Boland & Collopy (2004a) and Senge (2006). It is based on a reflective and constructive practice and the use of non-verbal boundary objects.

2.4.2 Design as Reflective & Constructive Practice

Practice is considered here as the performance of an activity in a professional situation.[17] A reflective practice is characterized by a "reflection-in-action" (Schön, 1983, p. 49) process, where activities for the creation of an idea, product or service are subject to reflection and reveal unintended and unexpected insights, which in turn influence and direct subsequent actions (ibid., pp. 49–56; Johansson-Sköldberg et al., 2013, p. 124). In reflecting on one's actions and being attentive to 'surprises' occurring in the actions, existing "frames and theories" (Schön, 1983, p. 328) as well as the "definition of the task" (ibid., p. 337) in an organization are questioned. On the one hand, this may result in a disruption of the prevailing organizational system; on the other hand, it may

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[17] Schön (1983, p. 60) distinguished the term practice as "performance in a range of professional situatuons" e.g., an architectural practice, a lawyer's practice, and practice as "preparation for performance" in the sense of training.

lead to advancements in organizational learning. A constructive practice is characterized by a continuous thinking and creating of preliminary and final artifacts, which represent the status of thought of the practitioner and proposes a future, preferable reality (Cross, 1982, p. 224; 1982, p. 224; Nilsson, 2013, p. 3). The construction overcomes the "separation of words and things, or theory and practice" (Buchanan, 1992, p. 20) and integrates the thinking about a solution with the actual making of it. This active creation of a solution co-evolves with the understanding, framing and formulating of the problem itself (Cross, 2008, pp. 41–42; 2013, pp. 75–78, 123; Dorst & Cross, 2001, p. 434). Reflective and constructive practice are essential activities in the process of design.

Design can be preliminary paraphrased "as a way of organizing complexity or finding clarity in chaos" (Kolko, 2010, p. 15).[18] The process of design is a constant commute between analysis and synthesis, between the problem space and the solution space (Buchanan, 2015; Lawson, 2005; Schön, 1983). It analyzes with a "systems approach" (Cross, 2013, p. 75) the complexities of a situation, the multiple elements and their relations, their proximities and interactions, their mutual support and conflicts, and synthesizes them into a new whole, while remaining open and adaptive to changes in context and content (Lawson & Dorst, 2009, pp. 42–44; Nelson & Stolterman, 2012). In design synthesis the designer creates a new whole as his or her subjective and interpreted answer to an ill-defined or wicked problem (Cross, 2001, p. 53). "Synthesis is an abductive sensemaking process," (Kolko, 2010, p. 17) characterized by

- reflection-in-action,
- visual construction of thought (Reichertz, 2013, p. 30)
- professional discipline and expertise (Huppatz, 2015, p. 38),
- intuition and "best guess" (Kolko, 2010, p. 20).

The outcome of a design process constitutes a new meaning through the way it puts parts together. Applied in this understanding to the design of organizations, design aims for change in the behavior of people (Buchanan, 2015, p. 6). In the present thesis, design aims for change in the behavior of people dealing with innovation challenges.[19] A design synthesis in this regard is an integrative new whole that displays holistically the behaviors of actors across an organization, and concretely offers individuals possibilities to see and localize themselves in this new whole. The outcome constitutes 'why' and 'how' a company operates and innovates by embodying its organizational values in its configuration and form.[20] This can positively "shape organizational culture" which in turn is a vital source for innovative initiatives (Buchanan, 2015, p. 21; Chantzaras, 2019b; Nelson & Stolterman, 2012; Verganti, 2009). To reach this synthesis, the reflective and constructive character of a design process is necessary. Through reflection and exploration, a designer discovers and plays with existing knowledge, resources, relationships and interactions. Through

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[18] Human actions conducted in the process of design consist in „conceiving, planning and making products" - of communication, of construction, of interaction and of integration – that serve "individual and collective purposes" (Buchanan, 2001, p. 9; and Buchanan, 2015, pp. 10, 14).

[19] Design for organizations is understood here as the practice of designing with a design attitude. A definition for organization design is provided by Galbraith (1977, p. 5) as "the search for a coherence or fit" between strategy, organizing mode and integrating individuals.

[20] Cichocki & Irwin (2014, p. 17) consider the development of a configuration as organization design: „The organization design process aims is to identify the optimal form for a group to fulfil its purpose and strategy so it can reach its intended outcomes. The resulting configuration is the organization design – the concepts, outlines and blueprints for the future organization and ultimately the changed organization."

construction, the designer creates a preliminary structure of understanding of the organization. She or he adds, removes, modifies its elements, proposes a new configuration as a design solution and assesses it with the design problem.

However, the design approach is not "culturally neutral" (Verganti, 2009, pp. ix, 152, 228). It is driven by values, visions and convictions the designer – a commissioned professional individual, team or the client – has and the interpretations she or he makes (ibid.; Rehn, 2019). It is an alternative, abductive way of dealing with the complexity of innovation processes with "informed guesses" (Clarke, 2016, p. 91) rooted in the design expertise (Kolko, 2010, p. 21). It does not scientifically define this complexity and calculate the complex situation, but reframes and represents the complexity of innovation processes with means of design and its interpretative function (Cross, 2007, pp. 33–38; Dorst, 2011, p. 524, 2015; Kolko, 2010, p. 23). A design approach does not conclude with a final shape for innovation processes by analysis alone (Cichocki & Irwin, 2014; Lawson, 2005, p. 37). The design outcome co-evolves with the formulation of the organizational problem over the design process. The design approach uses "non-verbal, graphical/spatial media" (Cross, 2007, p. 38) in addition to and in place of verbal discourses (ibid.; Buchanan, 1992, p. 20). As will be later described in Chapter 2.4.3, the design understanding in this thesis does not apply a positivist view of design as a rational problem-solving activity independent of the characteristics of a discipline or profession practicing design (Hatchuel, 2001, p. 261; Hobday, Boddington, & Grantham, 2011, p. 8; Huppatz, 2015, p. 38). As Schön already noted in 1983:

> *"[W]e risk ignoring or underestimating significant differences in media, contexts, goals and bodies of knowledge specific to the professions. But we may also discover, at a deeper level, a generic design process which underlies these differences."*
>
> *(Schön, 1983, p. 77)*

If innovation processes are dynamic, messy and complex, their architecture and design need to be capable of resembling their dynamics, messiness and complexity. It is necessary to apply a process of reflection-in-action in order to "deal with situations of uncertainty, instability, uniqueness and value conflict" (Schön, 1983, p. 50). Innovation processes designed in this way as dynamic systems can support the emergence of ideas and their evolution into innovations alongside descriptive project management schedules and management directives (Chantzaras, 2019b, p. 540). The self-organization of teams, as discussed earlier, which have the capacity for purposeful action and response to changing needs can be addressed by a design approach with a systems view (Dunne & Dougherty, 2012, p. 579; Gharajedaghi, 2011, p. 155; Meadows, 2009, p. 79).

> *"This ability to design depends partly on being able to visualize something internally, in the 'mind's eye', but perhaps it depends even more on being able to make external visualizations."*
>
> *(Cross, 2008, p. 9).*

For a process design of innovation in the context of this thesis, the creation and use of visualizations and alternative means of media and „boundary objects" (Star, 2015, p. 251; and Boland & Collopy, 2004b, p. 268) are essential. Non-verbal means allow us to communicate, engage, integrate, and interact with the people involved and stakeholders in designing innovation processes and to take part in the design process itself (Cross, 1992, pp. 225–226; Eppler & Hoffmann, 2013, pp. 10–11; Russell et al., 2016, pp. 51–53).

2.4.3 Visual Thinking & Non-verbal Boundary Objects

Visual thinking as well as the creation and use of visualizations are distinctive in the design practice (Cross, 1992, pp. 225–226; 2008, p. 9; Lawson, 1997, p. 258; Lawson & Dorst, 2009, pp. 52–54, 104). The mode of thinking and the medium adopted support the reflection-in-action and constructive practice of design. They allow us to understand, communicate and act on complexities, interactions, and relations in non-verbal ways, that reside for example in innovation processes (Borja de Mozota, 2013; Fichter, 2009). Visual thinking is based on the mutual influence of perception and cognition or thinking, which are "indivisibly intertwined" (Arnheim, 1969, p. v) in the creative process. Visual perception and visual imagery shape the thinking of individuals and accordingly the production of thought (Lawson, 2005, p. 290; Reichertz, 2013, pp. 26–27).[21] In a context of design, visual thinking is the conscious and subconscious application of mental imagery or externalized graphical, non-verbal means to reflect upon a situation, develop an understanding and create a new image for its future state. "Expert visual thinkers," – professionals from the arts, architecture and industrial design – practice "three kinds of imagery" (McKim, 1980, p. 8) in an interactive way, involving seeing, imagining and drawing.

> *"Visual thinkers utilize seeing, imagining, and drawing in a fluid and dynamic way, moving from one kind of imagery to another. For example, they see a problem from several angles and perhaps even choose to solve it in the direct context of seeing. Now prepared with a visual understanding of the problem, they imagine alternative solutions. Rather than trust to memory, they draw a few quick sketches, which they can later evaluate and compare. Cycling between perceptual, inner, and graphic images, they continue until the problem is solved."*
>
> *(McKim, 1980, p. 9)*

The transfer of design approaches to business purposes entails the intensified use of visualizations. With rising complexities and decreasing attention spans, externalized visual representations support the comprehension, clarity and awareness of organizational challenges, their context and interdependencies (Förster, 2014, p. 21; Eppler, Kernbach, & Pfister, 2016, pp. 10–16; Russell et al., 2016). Information and network visualizations, for example, translate verbal or

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[21] Abductive reasoning and the construction of new thoughts according to Charles Sanders Peirce are driven by the use of diagrams and visual imagery; see Reichertz (2013, p. 26).

numerical data, information and tacit knowledge into a visual representation for human cognition to gain new insights which could not be seen before (Burkard, 2005, pp. 239–244; Zenk & Behrend, 2014, p. 226). Observer and designer are enabled to see patterns of activities and proximities, to access details of organizational interdependencies, to detect commonalities and connections, to identify irregularities and voids (Russell et al., 2016, pp. 51–53). Network visualizations offer companies a deeper analysis by representing individuals, teams and departments with their relations and interactions (Kastelle & Steen, 2015, pp. 115–117). They provide a visual basis for identifying critical areas and nodes in an organization where ideas and inventions increase or knowledge and inspiration reside; to reveal successful but hidden teams; and they can contribute to revealing structural holes between different areas of resources (Dodgson et al., 2015b, p. 10). The visual transparency supports the depiction of the informal organization, the mapping of actual activities and dependencies, which have not been codified or explicitly recorded in organizational protocols, guidelines or diagrams. In network visualizations the dynamics and fluidity of collaborations, teams and departments can be traced. If interactive and parametric elements are considered in the design of the visualization, changes in the network can be shown, as they occur in reality. Or they can be simulated, as they are proposed for the future. By finding “design strategies that reveal detail and complexity” (Tufte, 1998, p. 53) the noise of information can be reduced and relevant signals amplified.

Visually externalized data, information, knowledge and thought function as boundary objects to bridge communication between people of different disciplinary background and between different stakeholders (Boland & Collopy, 2004b, p. 268; Jönsson, 2004; Star, 2010, pp. 604–605). Moreover, these kind of boundary objects can integrate people in a design process by reflecting and constructing on these objects. Visualizations extend the thinking outside an individual’s head and constitute a “reflection-in-action” (Schön, 1983, p. 50) on innovation processes for an individual and for others (Cross, 2007, p. 58; Täuscher & Abdelkafi, 2017, p. 161). They function as an “external memory aid” (Cross, 2007, p. 58) or “external storage” (Täuscher & Abdelkafi, 2017, p. 161) for executives and stakeholders, provide a preliminary structure of content and relationships, and offer a cognitive ease to access and process the represented information in additional sense modalities (ibid.). Transferred to innovation processes, an appropriate visualization turns the innovation processes itself into a boundary object. It firstly represents understanding and knowledge about the process. The visualization supports the development of a shared understanding regarding the organizational challenges of innovation (i.e. the problem space). Secondly it can be explored, transformed and tested against the problem to be solved. The visualization aids the creation of shared mental models about how a company will innovate in the future (i.e. the solution space). In this kind of visualizations as boundary objects, designers as well as clients can explore the details and dynamics of interactions in innovation processes. They can simulate different configurations of collaboration and observe their consequences. They can design innovation processes similarly to product or building developments, where simulation technologies are in use to “facilitate novel relations in inter-organizational projects, by enabling experimentation that would often be physically impossible or prohibitively expensive to undertake in reality” (Mainemelis & Dionysiou, 2015, p. 125).

Aside from this holistic and strategic view on innovation processes across an organization, visualizations can be useful at the individual level of an employee. They can be communicated and shared. Employees can localize and re-locate themselves relationally and spatially in ongoing or new innovation processes. They can gain awareness of the innovation processes and engage in the transformation of the processes across the organization (Allen & Henn, 2007; Chantzaras, 2019b; Lockwood & Papke, 2018). At a holistic and at an individual level, executives and employees can participate in a visual collaboration on the design of innovation processes and experience the process of sense-making – why, when and where an innovative action should be taken (Beucker, 2016, p. 39; Russell et al., 2016, p. 55). This aspect also touches the relation of organizational culture to innovation and how employees align their actions and behaviors to this culture (Phillips, 2015, pp. 487–488). The use of boundary objects in this field supports overcoming a bounded rationality. By thinking and seeing processes in designerly ways, by being reflective in action and be being constructive, contexts and relationships are considered as a whole, which rationally cannot be viewed jointly. They are viewed creatively.[22]

Making an invisible process as the process of innovation tangible can become a regular practice through the development of appropriate visual constructions. Systems view, reflective practice and the use of non-verbal boundary objects contribute to a constructive, explorative and adaptive design of an innovation process.

2.5 Requirements of an Extended Process View of Innovation

In this chapter, three arguments extend the process view of innovation. They constitute a thinking model, representing how innovation processes are considered in the scope of this thesis. First, complexity at different levels questions whether the implementation of innovation process in an organization as a stable and repeatable sequence of actions is sufficient. Environmental complexity, the complexity of the innovation challenge and the complexity of the process itself require a company to provide a particular organizational structure as a whole for innovation processes. Executives, employees and further stakeholders of an innovation process need to be aware of changes in their environments and professional context; they need to perceive and approach innovation challenges in their complex, ill-defined nature and act in explorative, experimental and iterative ways; they need to be able to self-organize and adapt their course of action, to reflect and construct the process of innovation. To literally see and address the different levels of complexities, a company requires thinking and tools that reframe the complexities and represent them in abstract, yet workable ways. The term 'workable' refers to feasibility, such that executives, stakeholders and other people involved can understand, immerse, reason and reflect on, collaborate, act upon, model, modify, design and test these representations (Schubert, 2021, pp. 21–23, 34; Szopinski, Schoormann, John, Knackstedt, & Kundisch, 2020, pp. 475–477).

Second, social proximities are essential in the understanding and design innovation processes. The human aspect of individuals, teams and departments, and their interactions according to type, intensity and proximity to each

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[22] In explaining the dimensions of creativity Florida (2014) states a shift from homo economicus to homo creativus with a quote from economic historian Joel Mokyr: "Economists and historians alike realize that there is a deep difference between homo oeconmicus and homo creativus. One makes the most of what nature permits him to have. The other rebels against nature's dictates. Technoligical creativity, like all creativity is an act of rebellion." (ibid., p. 19; and also Huppatz, 2015). Because of human's bounded rationality creative thinking and design marks an escape from rational problem solving heuristics (Hatchuel, 2001, p. 263). It can lead to unexpected or uncalculated proposals or solutions. Herbert Simon's understanding considers creativity and intuition as cognitive processes, which can be analyzed and modeled (e.g., Simon, 1988; 1992; see also Chapter 1.1.1). This view is not followed here.

other influence the innovation performance. In social proximity creativity and awareness of people, processes and challenges evolve. Executives and employees need to be aware of other's ideas, knowledge, presence and activity. Their innovative actions benefit from seeing patterns of interaction, gaps of communication and opportunities to create new connections between people and resources. Social proximities represent the informal structure of an organization and enable exploration outside one's individual field of knowledge, outside one's team, department or organization. And social proximities imply spatiality. Seeing companies as socio-technical systems, people interact with other people, with technology, machines, places, and objects in spatial ways. A person's spatial location influences the probabilities for exchange of ideas and tacit knowledge, for spill-over effects, for engagement and random encounters. Accessibility and visibility to other peers in physical facilities such as labs, workshops, production or distribution areas – and access to these areas and resources – have a positive impact on innovative initiatives and processes (Marinova & Phillimore, 2006, p. 50). Employees are related to spatial configurations in ways which are difficult or undesirable to replace by digital means. In the first case, for example, making and testing physical prototypes may depend on the collaboration of others, tools and technical facilities. In the second case, direct personal interaction with an object, and interaction face-to-face foster a reflection-in-action and the wider use of human senses. Social proximities in this regard, need to be considered in the design of innovation processes. The combination of creativity, available knowledge and technological expertise leads in an act of synthesis to novel ideas, inventions and innovation. Thus, "[b]uilding a capability for synthesis" (Pisano, 2019, pp. 136–144) needs to be promoted in an organization, where people reflect about "the right combination of "ingredients" " (ibid., p. 142) required for innovation and design their processes and structure.

Third, the innovation process itself becomes subject and outcome of a design process. This design process is characterized by a systemic view of an organization's elements and their interrelations; it is a reflective, explorative and constructive practice; it applies visual thinking, creates and uses non-verbal boundary objects to produce a new imagery of innovation processes. Making invisible activities and relations visible, showing how people innovate and how they will be enabled to innovate in future, is central to architecting and designing innovation processes. As considered in the discussion of social proximities, for employees exploration and "learning outside of work may be more useful than formal training and job development that occurs within the constraints of the workplace" (Rigolizzo & Amabile, 2015, p. 75). The employees' creativity, as well as their approaches to innovation, benefit from an open and transparent organizational structure (ibid.). Hence, innovation processes are seen as a flexible structure rather than a predefined and prescribed sequence of steps to execute.

In conclusion, the extended process view in this thesis defines an innovation process as a multi-dimensional system – consisting of three spatial dimensions, the dimension of time and further parameters, which are not referred to as dimensions – that represents relational and spatial proximities between human actors, and between human actors and non-human elements, which interact, explore, assemble and implement change through the creation of a different new whole. To develop a framework for the architecture and design of innovation processes, the thinking, modeling and making stages need to be developed differently. Thinking refers to conceptualizations on how we think about innovation processes. Modeling refers to methodologies how to begin and conduct a design process. Making refers to tools and the actual construction of boundary objects to support the design process. Thinking, modeling and making have different requirements to meet as displayed in Figure 5. The conceptualization of how we think about innovation processes needs to:

- **frame complexity** of environment, problems and processes;
- **integrate social proximities** in the interaction between people considering aspects of creativity and awareness, of informality, engagement and exploration, and of spatiality;
- **design a process** with a systems view, and a reflective and constructive practice through creation and use of non-verbal boundary objects.

The design approach, as explained in Chapter 2.4.2, is considered as a dialectic process and constant commute between problem and solutions space. The people involved explore with abductive thinking the nature of the innovation processes in an organization as a system of spatial and relational proximities and interdependencies. They reflect on the innovation process from different perspectives with spatio-visual means and construct a frame for fluid and dynamic sets of combinations.

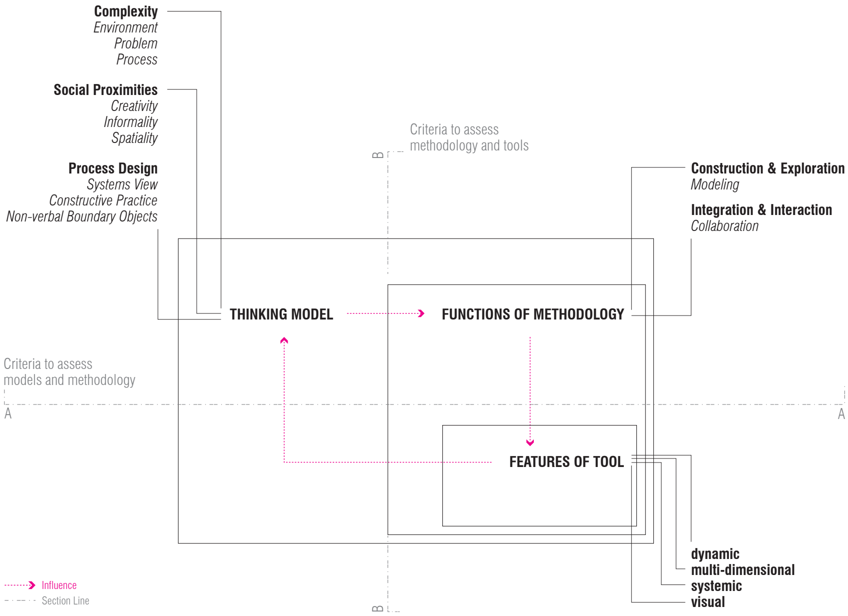

Figure 5: Criteria and Requirements for a New Model

The thinking about innovation processes, methodology and tool for their design are interdependent. Thinking model and methodology is assessed by criteria of complexity, social proximities and process design (section line AA). The according methodology and tool need to meet requirements of function (modeling and collaboration) and features of being dynamic, multi-dimensional, systemic, visual (section line BB).

A methodology for this new conceptualization, or thinking model, on how we conduct a design process, needs to promote collaboration and it needs to guide a process of exploration and creative construction (Birkinshaw et al., 2010. p. 45; Pisano, 2019, p. 9; Schubert, 2021, pp. 65–66; Szopinski et al., 2020, pp. 475–477). The function of the methodology is:[23]

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[23] Pisano (2019) introduces and uses the term „creative construction“ (ibid., p. 9) in a different way, which will be explained in detail in Chapter 3.3.4.

- **Interactive & Integrative.** For developing an innovation process as a multi-dimensional system, its representations needs to be interactive, i.e. intuitive to access, easy-to-use and integrative for different executives and stakeholders to engage in with their respective disciplinary background and expertise. It enables collaboration. The externalized representations of innovation process models are boundary objects, which are flexible and transformable.
- **Explorative & Constructive.** An innovation process design as a system for a company evolves through iterative phases of analysis and synthesis. The constant commute in a design process between problem and solution space is applied to the design of an innovation process. Thinking and making occur jointly, with the aid of visual tools. The expected innovation process is not projected at the beginning, but explored and constructed (i.e. modelled). The explorative and constructive nature generates new knowledge on the innovation process and new possibilities of configuration.

For the actual construction stage, tools support the transfer of the functions of the methodology stated above – integration & construction – into preliminary boundary objects. If a tool for this purpose is used (or developed), it needs to have following features:

- **Dynamic & adaptive.** The innovation process is a dynamic, responsive and adaptive process, in which formations of individuals and transformations, flow and emergence need to be observed. The interrelations of parts, their behavior and position are influenced and changed by their activities. A tool to model the innovation process needs to be dynamic and fluid, instead of static.
- **Multi-dimensional.** In an innovation process humans and technological elements are interrelated to each other and interact through different means over time. A modeling tool needs therefore to be multi-dimensional, displaying space and time. It shows relational proximities, who is interacting with whom, and spatial proximities, where the interactions take place and at what distance (spatially and conceptually). The type and frequency of interaction need to be considered according to whether it is personal, face-to-face or over a distance; whether it occurs randomly or regularly, and how often interaction occurs. This aspect of the model addresses the informal organization.
- **Non-linear & Systemic.** The innovation process is a socio-technical system of interrelated and interdependent parts, which interact in non-linear ways. The non-linearity, iterations and feedback-loops as well as randomness and openness need to be featured by the tool. The visualized process is an emergent and adaptive system open to new influences and events.
- **Visual.** To create a dynamic, multi-dimensional and systemic understanding, an innovation process requires an appropriate medium. Visualizations reframe the complex structure of an innovation process to an abstract yet workable degree. The innovation process is transferred to a non-verbal boundary

> objects. By being visual, awareness, understanding and interpretation of the company's innovation processes are facilitated, together with a simultaneous consideration of parallel and jointly occurring events, or their absence.

The formulated requirements for an alternative theoretical thinking model, methodology and tool require assessment. The field of management needs to investigate the extent to which existing conceptualizations and models of innovation processes provide an adequate theoretical basis. On the other hand, the field of architecture also needs to elaborate on how its thinking, methods and tools can support analysis, representation and design of innovation processes in an organization. The theoretical model presented here serves as a reference for assessing the approaches in the field of innovation management and the field of architecture. This thesis hypothesizes that architecture indirectly already provides the thinking and tools to address these requirements. To introduce an architectural approach in innovation management it is necessary to understand how innovation management is shaped, defined and performed.

3

3 – Management of Innovation Processes

The management of innovation and its processes is a leading management discipline and management function across industries (Dodgson et al., 2015b, pp. 11–13; Dodgson, 2018, p. 4; and Hauschildt et al., 2016, pp. 63 et sequ.). Innovation research takes an analytical perspective to explain how innovations occur over time. Innovation management is directed to the process itself, to manage innovation in time (ibid.; Vahs & Brem, 2015). Thereby companies seek to adjust their working processes to generate new forms of innovation (e.g., disruptive, radical and open). They apply innovation management to cope with complexities, reduce uncertainties and detach the occurrence of innovation from a dependency on fate or chance (Dodgson et al., 2011, p. 164; Dodgson, 2018; Trott, 2017; Vahs & Brem, 2015). Managing innovations is time-orientated and time-dependent; its goal is to generate and capture, in an appropriate time frame, the value from ideas and inventions for the benefit of the company (Tidd & Bessant, 2013; Vahs & Brem, 2015). Innovation management is a distinct kind of management discipline, which requires a different thinking. It is itself subject to change and has been evolving since the second half of the 20th century (Dodgson, 2018, pp. 14–15; Rothwell, 1994, pp. 5, 23–24; van der Duin & Ortt, 2020, pp. 1–4). In this chapter the nature of innovation management will be reflected, and how it provides advice to structure and guide innovative processes (Dodgson et al., 2015b; Tidd & Bessant, 2013). The literature on innovation management from the past two decades in academic discourse, and selectively from the decades before, has been researched on the basis of the keywords listed in Chapter 1, Table 1. It has been reviewed against the background of multi-level complexities, social proximities, and a process design approach.

First, the management of innovation will be explained in its particular thinking, scope and goals and in its use of models of innovation processes. Due to the diverse use of the term model at different levels of considerations, models in innovation research and management are categorized by level of abstraction. Innovation models as conceptualizations refer to thinking about innovation processes. Innovation process models as methodologies are located within the respective conceptualizations. They refer to the modeling and framing of innovation processes in organizations. At a level of operation innovation process management provides methods and tools for doing (see Figure 6; in reference to Dodgson et al., 2015b, pp. 10–13; Godin, 2015b, pp. 579–585, 2017; Tidd, 2006, pp. 3–4; Tidd & Bessant, 2013, pp. 75–78; Gassmann & Sutter, 2013, pp. 6–8).

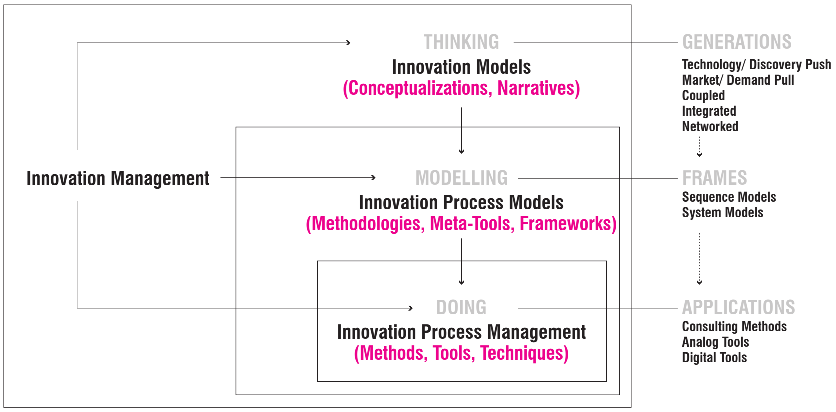

Figure 6: Categorization of Innovation Models

Models in innovation research and management are categorized as innovation models as conceptualizations and innovation process models as methodologies residing within the respective conceptualization. Methods and tools for doing and operation are placed in innovation process management. Author's own representation in reference to Dodgson et al. (2015b); Godin, (2015b, 2017); Tidd (2006); Tidd & Bessant (2013) and Gassmann & Sutter (2013).

For the work in this thesis, two groups of models are proposed: innovation models as conceptualizations and innovation processes models as methodologies. The latter group will be divided further into sequence models and system models, which will become the core objects of reference in this thesis. Second, selected sequence models will be analyzed in their response to an extended process view on innovation. As linear, non-linear and stage-phased models they address the innovation performance over time and project management aspects in the process (Cooper, 1990, p. 45). Third, selected examples of system models will be researched in their response to an extended process view on innovation. As non-linear, fluid and interactive models they focus on interactions between elements and their structural organization (Godin, 2015b, 2017, pp. 4–5; Tidd, 2006; Tidd & Bessant, 2013).[24] In the fourth part, the findings summarize aspects addressed by sequence and system models with a critical reflection.

3.1 Managing Innovation in Time

Innovation management supports the development and implementation of a potentially valuable innovation. It integrates perspectives, approaches and models from the fields of sociology, psychology, natural sciences, engineering and design (Fagerberg et al., 2005; Burr, 2014; Godin, 2017). With economic, technological, managerial and social developments, innovation management is continuously changing and adapting to new environments. While in German innovation management research on the business aspect of commercializing inventions prevails, the discourse in the English language literature from the United Kingdom, the United States and the Netherlands foregrounds an open, systemic and dynamic perspective on innovation processes (Trott, 2017, pp. 9–10 and as overview: Burr, 2014a; Gerybadze, 2014). Both research streams are examined in the following, with an emphasis on the latter body of knowledge. To structure the broad literature on innovation processes, innovation models will be distinguished from innovation process models (see Figure 7).

First, innovation models are explained as conceptualization and narratives. They influence the kind of innovation management a company follows. Second, definitions of innovation management are reviewed, which determine the characteristics of a design approach. Third, the scope and focus of innovation management and the skills needed for its performance are explained. This section summarizes the building blocks of innovation management and its implementation in practice. Fourth, the understanding, function and use of models in innovation management are analyzed. Their particular conception and use to guide innovation processes as sequences, or structure them as systems, is different to the conception and use of models in architecture. The analysis will provide the theoretical basis for reviewing the selected examples of sequence and system models in the following chapters.

3.1.1 Conceptualizations

Innovation processes are non-routines, or new routines, which have not been implemented in a company before (Hauschildt et al., 2016, p. 47; Tidd

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[24] Godin (2017) distinguishes between process models and system models. For reasons of clarity, the term process models is used in this thesis as overarching term comprising sequence models and system models. The process models Godin refers to are considered here as sequence models. The term technique, which is used in literature for the description of innovation process models e.g., in Hidalgo & Albors (2008) is avoided.

& Bessant, 2013, pp. 80, 624). The processes are uncertain in their outcome, deal with increasingly complex, open and networked problems, and have an impact on the future performance of a company according to their success or failure. Fostering and managing new routines require thinking, methodologies, methods and tools, different to existing problem solving approaches in management (ibid.; Hidalgo & Albors, 2008, p. 116). Innovation management focuses on these non-routines. It assists the company in developing new and "effective routines" (Tidd & Bessant, 2013, p. 624) for innovation processes. It manages activities, resources and decisions required during the phases of ideation, invention and implementation of a new product, service or process. Companies seek to balance through innovation management the risks and the chances of new developments; they seek to raise awareness of transformations in technology and markets; they nurture the generation and use of internal and external ideas. Innovation management is a bridge between a company's transformation for creating future value and the existing operations which secure the current business (Franken & Franken, 2011, p. 226). It structures an unplannable process (Tidd & Bessant, 2013, p. 642; Wecht, 2014, p. 256) by turning the dominant thinking about innovations and how they are developed into actionable process models and steps. The thinking has changed over the past century and has led to different generations of innovation models (Rothwell, 1994). They are still in consideration and in use in innovation management. They serve as conceptualizations and narratives to make the prevailing mental models in management explicit and align them with corresponding actions in company practices (Godin, 2017; Tidd & Bessant, 2013, pp. 75–78; Trott, 2017).

Rothwell (1994) distinguishes five generations of innovation models that have appeared since the 1950s: technology or discovery push; market or demand pull; coupled; integrated; networked model.[25] The first generation of technology push and the second generation of market pull are linear conceptualizations of the innovation processes, with distinct starting points in science, research and development or market and users (Godin, 2017, pp. 6–7). The third generation of innovation models couples technology-push concepts, from research to market, and market-pull approaches, from users to companies, as bi-directional and interdependent. In the fourth generation innovation processes are seen as an integrative value chain, in which suppliers participate as a source of ideas and new technological directions on one hand, and in which users are integrated by their insights and inputs on the other. A further breach in company boundaries is introduced with the fifth generation, which turns towards "a network of partners designing an integrated innovation system" (Van der Duin, Ortt, & Aarts, 2014, p. 489).[26] This networked model takes into account an open innovation approach in which inflows and outflows of ideas, developments and eventually innovations with external actors are possible, permitted and fostered (Chesbrough, 2003, pp. xi, 43). People, technologies and ideas are sourced and aligned in this paradigm across a company and outside the company's boundaries. According to Rothwell, the fifth generation represents the current and prevailing model of innovation in industries and companies.

In a categorization of six models, the generations of innovation and its processes are framed as black box, linear, interactive, systemic, evolutionary and innovative milieu (Marinova & Phillimore, 2006, p. 45). In this consideration,

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[25] For an overview on generations of innovation models see also Dodgson (2018, pp. 14–15), Rothwell (1994, pp. 5, 23–24), van der Duin & Ortt (2020, pp. 1–4).

[26] Van der Duin & Ortt (2008; 2020; 2014) reduce in their research on innovation management Rothwell's five models to four generations. They aggregate push and pull models to one linear type of model and define networked models as combination of the linear, coupled and integrated models. See e.g., Van der Duin and Ortt (2020, pp. 3–10).

the latter two prevail. The evolutionary model outlines variety caused by innovation as "equivalent to mutations": selection of innovations capable of surviving; reproduction of products and business; fitness and adaptation of the firm to a given or changing environment; changes in population; competing and collaborative interactions and external, socio-economic environments (ibid., pp. 49–50). The innovative milieu model sees relational and spatial proximities as vital for the creation of linkages and networks to drive innovation. "[D]ynamic collective learning processes" (ibid., p. 50) arise in an environment based upon a different mechanism of informality, ease of contact and trust between interacting parties.

The "greater acknowledgment of interaction loops" (Philipps, 2016, p. 16) is taken further in the development of circular or cyclic models (Trott, 2017, p. 32). In this view, innovative ideas evolve in any area of scientific exploration, technology research, product creation and market transition (Trott, 2017, p. 32). The interconnectedness and interrelation of the different areas promote fast innovation cycles which are enhanced when an entrepreneurial mind-set is placed at its core. Traditional management thinking would conduct a linear process from idea to development and implementation, with less openness to new conditions from outside (ibid., p. 33). An entrepreneurial mind-set instead can respond in agile ways to opportunities and integrate insights and learnings. Thus, cyclic, circular and wheel models of innovation have not yet become dominant in innovation management thinking or an innovation generation on the their own.

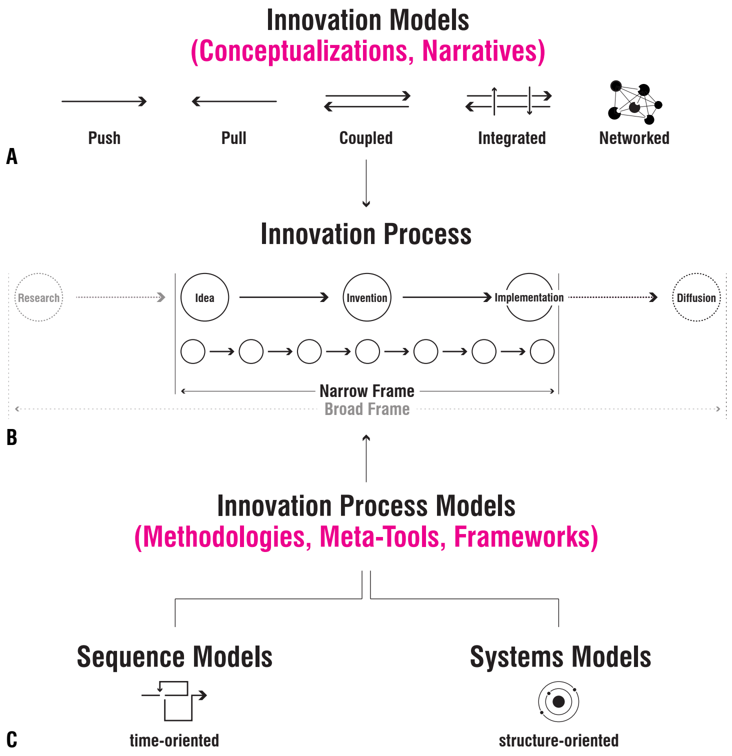

Figure 7: Categorization of Innovation Process Models

A Innovation models represent the thinking about innovation processes. They are conceptualizations and narratives expressed in different generations. **B** The innovation process is framed by narrow and broad understandings. In a narrow is frame it comprises idea, invention and implementation. In a broad frame it includes research and diffusion. **C** Innovation process models represent methodologies, meta-tools and frameworks to structure the frame of an innovation processes in organizations. The different kinds of methodologies, meta-tools and frameworks are grouped in sequence models and systems models. Author's own representation in reference to Godin (2015; 2017); Rothwell (1994); Verworn & Herstatt (2007a); Hofbauer & Wilhelm (2015).

As the models by Rothwell are still present and relevant, Dodgson et al. (2015b) describe them as non-temporal and time-independent. Innovation management needs to be aware of the different models and apply them according need (ibid., p. 18). The researchers add a sixth model of "future-ready" (ibid.;

p. 23): organizations need to build-up their "awareness of, and responsiveness to" (ibid.) changes, disruption and uncertainties in their environment. Key determinants of this future readiness are seen in the organizational culture and people's awareness and agility. A company should focus on these "less observable and measurable intangibles" and encourage "creativity and playfulness" (ibid., p. 24) in its employees. As a consequence, "judgement, expertise, experience and intuition" (ibid.) become a basis for decisions.

Innovation management is constantly reconfigured and evolving (Tidd & Bessant, 2013, pp. 274, 642). Trends in innovation management research from 1995 to 2015 show the increase of new research directions alongside the continued use of earlier approaches and models (Goffin & Mitchell, 2017, p. 22). The graphical representation visualizes the changes in the dominant thinking and school of thought in two directions: first, in terms of how innovation occurs and is understood; second, in terms of how it should be managed and fostered (Godin, 2017; Trott, 2017, p. 31; van der Duin & Ortt, 2020, p. 10).

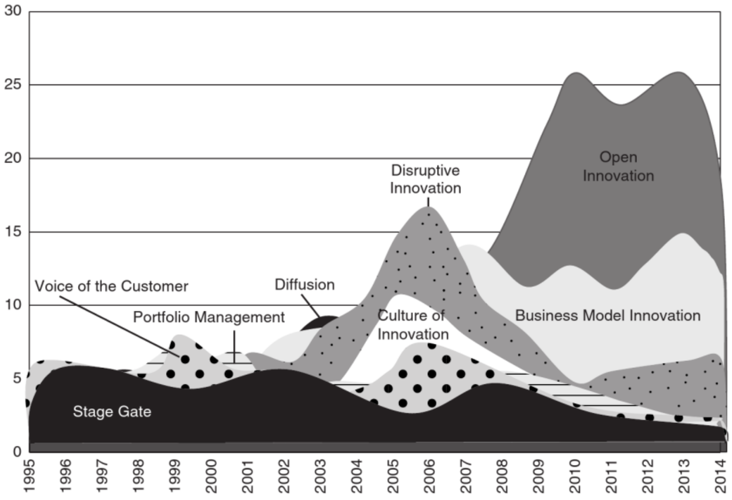

Figure 8: Research Focus in Innovation Management (Goffin & Mitchell, 2017)

Goffin & Mitchell (2017) visualized directions and focus in innovation management research by keyword search on eight dominating topics in abstracts. The abstracts were searched across six leading journals publishing on innovation from 1995-2015. Visualization by Goffin & Mitchell (2017, p. 22).

If new types of innovations constantly emerge (Salter & Alexy, 2015, p. 38), new models may be required to understand and design their processes, and shape a new kind of innovation management. Against this background, the conclusion in academic research "that the emergence of ever-newer generations of dominant innovation management approaches has come to an end" (Van der Duin & Ortt, 2020, p. 4) is open to question.

3.1.2 Innovation Management

Conceptions of innovation management differ across the academic literature according to their region of origin. In German academic literature, innovation management follows an engineering tradition that seeks to organize, structure and guide technological developments as projects over time. It relates to linear, coupled or integrated models of innovation, which will be explained in detail in Chapter 3.2. The literature emphasizes innovation and innovation processes in structured and phased ways; activities in an firm need to be assessed, selected and framed as innovative, in order to bring them within the scope of innovation management (Franken & Franken, 2011, p. 192; Hauschildt et al., 2016, p. 25; Schuh & Bender, 2012). Innovation management is applied at different levels in an organization: at a normative level innovation management incorporates visions, values and societal impact; at a strategic level it focuses on internal resource allocation and consideration of external environments; at an operational level it manages activities in order to establish, improve and foster the innovation capabilities of a company (Gassmann & Sutter, 2013, p. 6–8; Stern & Jaberg, 2010, p. 8). Innovation management comprises leadership, resource allocation and is orientated towards successful implementation. By reducing the complexity a company is surrounded by, innovation management is also understood as the management of cognitions and conflicts (Hauschildt et al., 2016, pp. 77; 188): people innovating need to be supported in their cognitive capabilities to become aware of opportunities, to interact, and to consider new configurations in relation to an innovation; conflicts caused by the changes innovative initiatives induce need to be addressed and balanced.[27]

The engineering tradition in innovation management is extended by arguments for developing a system and culture of innovation in an organization. The conscious design of an innovation system considers single processes as well as the institutions in which the innovation processes occur in order to foster innovative behaviors (Hauschildt et al., 2016, p. 67 and Chantzaras, 2019b, p. 541; Haller, 2003, p. 5). Soft factors such as leadership, culture and motivation are considered along with hard factors such as strategy, planning and control (Franken & Franken, 2011, pp. 226–227). The human factor and social elements are increasingly addressed as important resources and drivers for innovation processes (Hauschildt et al., 2016, p. V; Wördenweber, Eggert, & Schmitt, 2012, p. 3). Individuals and teams are encouraged to pursue new paths without having necessarily specified SMART goals or having achieved metric requirements (Hauschildt et al., 2016, pp. 24, 321): **S**pecific, **M**easurable, **A**chievable, **R**ealistic/Relevant, **T**angible/Time-bound goals and traditional performance indices tend to inhibit innovative initiatives, and especially hinder radical approaches (ibid. and Christensen, Kaufman, & Shih, 2008). In this regard, innovation management develops into a systemic discipline with an emphasis on consideration of people and their interactions.

Research literature published in English from North America, the United Kingdom and the Netherlands, considers innovation management in continuous transformation and evolutionary development. Among other views, it is seen as an enabling discipline, which encourages openness, agility, skill and capacity building in organizations (Goffin & Mitchell, 2017, p. 22). The ability to search for new ideas, select, manage, and "ensure good information flow and cooperation" (Dodgson, 2018, p. 31) within a larger innovation network is central. Innovation management organizes the innovation process through new "effective routines" (Tidd & Bessant, 2013, p. 624) which need to be learned by the employees in order to cope with transformations; thus, innovation processes also need to be managed as learning processes within an organization and among its employees. Innovation management is actively developed by organizations through experimentation, continuous improvement, constant review and reconfiguration (ibid., p. 642). As it becomes "engrained in practice" (Dodgson, 2018, p. 6) it changes with its environment. Consequently, innovation management considers different generations of innovation models and applies them in combination and according to requirements; it evaluates existing approaches to managing innovation and critically assesses new approaches

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[27] „Der Innovationsprozess ist als Führungsprozess stets darauf gerichtet, die kognitiven Leistungen der Innovatoren zu fördern und die von der Innovation ausgelösten Konflikte zu regulieren. […] Innovationsmanagement als bewusste Reduktion dieser Komplexität ist somit Kognitionsmanagement und Konfliktmanagement." (Hauschildt et al., 2016, p. 77).

in their potential for fostering innovative outcomes (Dodgson et al., 2015b; Dodgson, 2018; Tidd & Bessant, 2013). "The choice for a particular approach depends on the context of an organization" (Van der Duin et al., 2014, p. 10).

Ideally, innovation management deeply engages with the structures and processes of organizations; it acknowledges the uniqueness and uncertainty of processes and the possibility of "emergence, disruption, evolution and non-scalability" (Dodgson, 2018, p. 6). It fosters collaboration across different organizational levels and organizational boundaries; it is proactive, as well as responsive to its external environment (ibid., p. 7). It is contingent and contextual, meaning "that an organization increases its innovative performance if it matches the different ways of managing innovation processes and relevant contextual factors" (Tidd & Bessant, 2013, p. 95; van der Duin & Ortt, 2020, p. 59). The decline of predominant approaches, best practices, and the absence of "perfect organization for innovation management" (Tidd & Bessant, 2013, p. 642) requires innovation management – and the organization applying it – to be constantly aware of changes, transformations, and opportunities to act; it needs to improve the way new ideas are brought to successful implementation. The literature in English argues for a reduction of control mechanisms in management, such as those observable in the provision of checklists, quantifiable performance indices and the neglect of creative freedom (see: Hauschildt et al., 2016; Vahs & Brem, 2015, pp. 67, 139, 192). In innovation processes, dynamics with a system and social network perspective, flexibility and constant improvement of processes, creativity and play among the people involved, are recommended (Dodgson et al., 2011; Hidalgo & Albors, 2008, p. 115). Innovation management needs to address the complexity, uncertainty and unpredictability of innovation processes with a design attitude:

> *"Innovation management is not an exact or predictable science, but a craft, a reflective practice in which the key skill lies in reviewing and configuring to develop dynamic capabilities."*
>
> *(Tidd & Bessant, 2013, p. 642)*

The conception of innovation management as craft and reflective practice underlines on one hand the relevance of design as explained in Chapter 2.4. On the other hand, it offers a point of contact for the thinking and tools of architecture. Further points of contact for elaborating parallels, similarities and difference between innovation management and the architectural design processes may reside in innovation management's scope and practice.

3.1.3 Scope, Skills and Frames

The scope and practice of innovation management comprises different activities in the phases of idea generation, invention and implementation. It is seen as an institutionalized function, performed by distinct individuals, teams or departments, as well as a practice performed across an organization by its employees within a culture of innovation. Innovation management as a function has a particular scope, calls for particular skills and provides different frames to structure innovation processes.

Scope. Regarding its scope, innovation management searches, screens, evaluates and selects new ideas; it sources and integrates external innovations into the firm's structure and processes; it organizes and aligns needed resources; it manages and controls the innovative activities throughout an innovation process; it develops dynamic capabilities within the firm; it fosters a culture of innovation; it develops an innovation strategy and innovation program; it considers legal and intellectual property aspects, decides upon the implementation and diffusion strategy; and it ensures information flows and cooperation (Franken & Franken, 2011, pp. 225–228; Müller-Prothmann & Dörr, 2014, pp. 22–24; Schuh & Bender, 2012, pp. 5–14). Within this broad scope, the German discourse foregrounds the management of conflicts and the moderating role between competing interests to overcome resistances among people. Innovations management is expected to reduce innovation barriers, and actively promote the need for innovation in a company (Hauschildt et al., 2016, pp. 31–32, 61–62, 77; Stern & Jaberg, 2010, p. 71). In the North-American and British discourse human attention, process development, organizational structure and strategic leadership are emphasized (Dodgson, 2018, p. 18). The scope of innovation management addresses organization, people and processes with a systemic and forward-oriented approach (Brem & Viardot, 2013, pp. 348–349; Dodgson et al., 2015b, pp. 14–15; Dodgson, 2018, p. 18; Hidalgo & Albors, 2008, p. 116; Vahs & Brem, 2015, pp. 79–80):

- At an organizational level, innovation management contributes to the design of adaptive, flexible organizational structures and cultures. It nurtures the network of internal and external partners in formal and informal relationships. It balances exploration and exploitation, respectively the portfolio of different types of innovation in a firm. Innovation management supports an organization's response to challenges of disruption which arise from a multitude of directions.
- At the level of people, innovation management foregrounds the human element as the central driver for new initiatives. Suppliers and partners, clients and customers and – foremost – colleagues and areas within the organization are the main sources for innovation (Dodgson et al., 2008, p. 70; Tidd & Bessant, 2013, p. 270). Innovation management outlines human capabilities, encourages creativity and play, and incorporates learning strategies for individuals and teams.
- At a process level, it defines the processes and activities to be performed, aligned and supervised; it integrates innovation processes across organizational, technological and commercial functions, within an organization and outside an organization with external stakeholders.

Skills. Innovation management requires an "eclectic mix of skills" (Goffin & Mitchell, 2017, p. 27) from the people engaged in it. The skills range from hard skills as technical expertise, to the soft skills of communication and collaboration, and to finance and business administration knowledge (ibid., pp. 27–28). A social competence is needed, to seek and find innovative potential in people, to motivate, encourage, and assemble teams, to detect and resolve conflicts, and to communicate matters of innovation to inside and outside the organization; an innovation manager has competence in methods of structuring and fostering innovation processes, and disciplinary competence (Müller-Prothmann & Dörr, 2014, pp. 22–24; Vahs & Brem, 2015, pp. 190–192). But institutionalizing the role and function of an innovation manager with a diverse set of skills and a broad scope of work, is critical for feasibility. It is questioned, whether an individual, or a team or department are capable of meeting the diverse requirements and of performing the skills across an organization in an increasingly complex, dynamic, networked and open environment. If innovation is regarded as a question and a topic for all employees, based on a shared understanding and values, innovation management may need to be treated as a practice performed across an organization, independent of employees' assignment to particular innovation departments, innovation function and innovation roles (Bessant, 2003, pp. 766–767; Hauschildt et al., 2016; Vahs & Brem, 2015).

Frames. Lastly, innovation management provides frames to define, structure and foster innovation processes and the activities within (Fagerberg, 2005; Hauschildt et al., 2016). In a broad frame, activities are considered that extend from basic research in science to diffusion in markets (Gerpott, 2005, pp. 48–50; Hofbauer & Wilhelm, 2015, p. 9). In a narrow frame, which is the focus of this thesis, innovation management addresses three phases of innovation: idea generation, invention and implementation. The phases are subdivided into smaller stages and sections for reasons of operationalization and management depending on the respective thinking about innovations, the conceptualizations, approaches and process models managers pursue and apply (Vahs & Brem, 2015, p. 235).

Whereas the first generations of innovation models highlight specific phases assigned to particular departments, a systemic approach addresses the entire sequence from idea to implementation. New ideas evolve at every phase and at any time in this holistic process view and need to be considered in parallel (Godin, 2017, 10; 119; Hidalgo & Albors, 2008, pp. 116–117; Keeley et al., 2013, pp. 2–3). While in the past academia and practice have focused on the invention and implementation phases, practitioners are now paying increasing attention to the early stage of innovations (Herstatt & Verworn, 2007a, pp. 5–6; van der Duin et al., 2014, pp. 489–491). As phase zero or fuzzy front end it deals with a high degree of uncertainty regarding technology, market and organization; creativity and informal communication among acting people is high; information and knowledge are complex, often tacit and intangible; initiatives are driven by individuals, their awareness for impulses in interdisciplinary, cross-departmental settings with less involvement of upper management levels (Verworn & Herstatt, 2007a, p. 13). The phase is on the one hand highly influenced by its context and has on the other hand an important impact on the performance and success of the entire innovation processes (van der Duin & Ortt, 2020, pp. 105–106). The fuzzy front end period takes up about half of the total innovation time (van der Duin et al., 2014, p. 490). It influences the strategic direction a company intends to take at a relatively low cost level and provides the basis for idea selection and financial investments decisions as shown in Figure 9 (ibid.; Hofbauer & Wilhelm, 2015, p. 12; Verworn & Herstatt, 2007a, pp. 13–14).

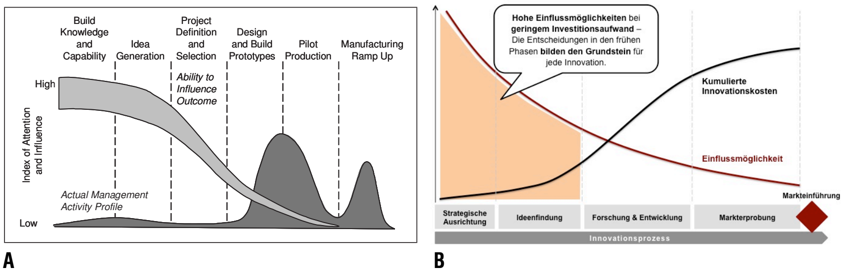

Figure 9: Development of Innovation Processes over Time

A Attention and involvement of management levels are low at beginning of innovation processes, while ability to influence direction is high. Visualization by Verworn & Herstatt (2007, p. 14). **B** Cost in an innovation processes increase along the phases, while the ability to influence direction decreases. Visualization by Hofbauer & Wilhelm (2015, p. 12). See also Tidd & Bessant (2013, p. 40).

Improving the management of the fuzzy front end fosters the generation of disruptive, radical and revolutionary innovations (Herstatt & Verworn, 2007b. pp. 5–7; Hofbauer & Wilhelm, 2015, pp. 12–14). These kinds of innovations account for a major source for long-term competitiveness (Verganti, 2009, p. 3).

Against this background, innovation management is a multifunctional discipline, which spans across different departmental structures and focuses both on processes and systems in a company (Schuh & Bender, 2012, p. 2; Wecht, 2014, p. 258). Innovation management seeks to understand and be aware of the different sources innovations can arise from, and the complex processes leading to their creation: "If managers know where to find innovations they can dramatically increase their innovation efforts" (Dodgson et al., 2008, p. 69) in the field they are concerned with and adjust their innovation management.

Thus, there are several reasons why companies fail to succeed in innovation despite their efforts in innovative initiatives and their management. Organizations and their employees are resistant to change in working processes, products and services (Hauschildt et al., 2016, pp. 31–33). They are unaware of transformations in technology and society. They perform a "good management" (Christensen, 2016, p. xvi) to listening to customers, investing in new technologies and surveilling market trends, which can be misleading. They lack "good tools" for financial analysis and decision making that "help [managers] understand markets, build brands, find customers, select employees, organize teams, and develop strategy" (Christensen, Kaufmann & Shih in Burgelman et al., 2009, p. 845; and Christensen et al., 2008). In the latter case, to create good tools, the thinking on innovation and its processes needs to be addressed, and "alternative methodologies" (ibid.) developed. Models in innovation research and management, as introduced in Chapter 3.1.1, represent and externalize prevailing conceptualizations of innovations and the processes they occur in. Models are also used as methodologies and guiding devices in innovation management. To compare the use and function of innovation process models with the use and function of models in architecture, a closer consideration of the term in innovation research and management is needed.

3.1.4 Models

Models serve in innovation research and management, as in other fields, as a "simplified representation" of a distinct part of reality (Godin, 2015b, p. 560); they are models of something, not identical with the thing they replicate, and they display or entail only the elements, which are relevant to its constructor (Godin, 2015b, p. 579; 2017, pp. 1–2; Saam, 2009, p. 517; Stachowiak, 1973, pp. 131–133).[28] Models of innovation and innovation processes serve as examples for guidance and as a concept to deal with contextual factors, formulate findings in research or illustrate a firm's innovation approach (Godin, 2017, pp. 213–215). They are analytical, not mathematical models which transfer "a conceptualization or theorization […] into a schema, graph or diagram" (Godin, 2017, p. 2). Models of innovation help to organize knowledge and to guide action, but are subject to change over the course of time. They depend on the context in which they evolve and the generation of innovation they relate to (ibid.; p. 2–4). Graphical elements and depictions have increased in relevance

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[28] Stachowiak (1973, pp. 131–133) defines three main characteristics or features of the term model: iillustration (Abbildungsmerkmal), abbreviation (Verkürzungsmerkmal), pragmatics (pragmatisches Merkmal). In the latter characteristic a model needs to be considered in its context: for whom it is a model, at what time or when and for what purpose (ibid.; Hof, 2018, p. 89). The translated terms illustration, abbreviation and pragmatics follow the terms used by Gänshirt (2012, p. 151) as no authorized translation of the publication exists.

in the past decades, leading to better understanding of complexities and their dynamics when dealing with innovation challenges. Seeing developments, interdependencies, effects and details simultaneously and in diagrammatic ways supports new approaches to complex problem solving (Eppler et al., 2016, pp. 10–14; Eppler & Kernbach, 2016, pp. 91–93; Russell et al., 2016, p. 51). In their "rhetorical function", models "give form to a theory" (Godin, 2017, pp. 213–215): they externalize, discuss, promote, and advertise a conception of innovation. The various terms used synonymously and interchangeably for models are scheme, diagram, perspective, view, paradigm, pattern, approach, concept and conceptualizations (Godin, 2015, p. 583; 2017, p. 210).

In this thesis, the term model is used in two separate but interrelated groups: innovation models and innovation process models. Innovation models are regarded as an externalized mental model and kind of thinking about the innovation process (ibid., p. 221; Tidd & Bessant, 2013, pp. 75–78). They are seen as conceptualizations of a simplified reality or a visual representation of a desired state. They are easy-to-understand, to apply and follow. As narrative, innovation models describe a sequence of events, theorized from research, experience or paradigmatic thinking (Cheng & Van de Ven, 1996, p. 593; Godin, 2015b, p. 581; Van de Ven et al., 1999, p. 181). Innovation process models are seen as methodologies, meta-tools and figures within or based upon prevailing mental model or conceptualization described in the first group (Tidd & Bessant, 2013, p. 75). As methodologies they guide action for the entire innovation process and create relational systems, in which independence and interaction are in focus (Godin, 2017, 140; 188; Vahs & Brem, 2015). As meta-tools they are structuring devices, operational, pragmatic, practical guides, to evaluate and decide, to teach, to direct, highlight certain areas of relevance in the innovation process, and to eventually foster and improve the innovativeness in firms (Godin, 2015b, p. 582; 2017, p. 208; Trott, 2017, p. 144). As figures, the models are visual, schematic objects (ibid.). Methods, tools and techniques – also called models in the literature – are considered as applications in innovation process management, and are not referred to as innovation process models here.[29]

The growing use of models in the academic and practical discourse on innovation and innovation management, is also the subject of critique. Models can evoke "scientificity" (Godin, 2017, p. 215) by synthesizing different parts in an abstract but attractive way. They can claim an inherent promise of success, can seek to create legitimacy, to draw support, to discipline teams or "provide an illusion of a sense of control" (Trott, 2017, p. 144; and Chantzaras, 2019b, p. 542; Godin, 2017, pp. 213–215). Unlike other disciplines such as architecture, models in innovation research and management are "not an instrument to explore, manipulate, and experiment with a theory, to stimulate the world and get better theories." (Godin, 2017, p. 208). They are normative and descriptive. As normative models they provide an orientation or a recommendation for action, often based on practice and experience. As descriptive models they externalize empirically sound processes or communicate and share specific innovation processes within a company (Verworn & Herstatt, 2000, p. 4). They represent, influence and shape the management of innovation processes (Trott, 2017, pp. 31–32, 144).

To elaborate, if innovation process models consider an extended process view of multi-level complexities, social proximities and process design – as

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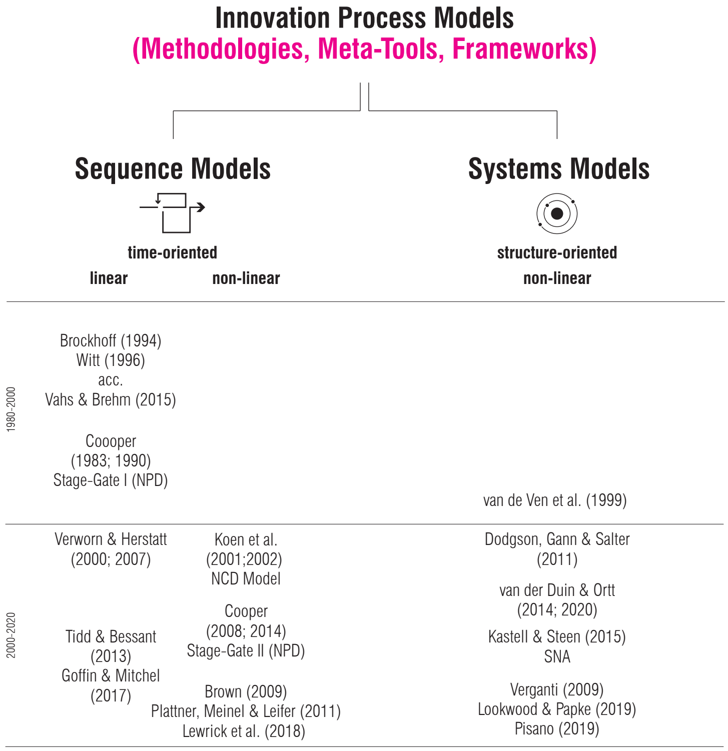
[29] Hidalgo & Albors (2008, p. 117) describe innovation management techniques (IMT) as umbrella term to subsume "a range of tools, techniques and methodologies that help companies to adapt to circumstances and meet market challenges in a systematic way." VanPatter & Pastor (2016) review innovation process design methods over the past century and describe them as innovation process design models. Both terminologies are not followed in this thesis.

developed in Chapter 2 – suitable examples need to be examined. The examples are selected on the basis of their perception in academia and practice, as well as in terms of their objective in providing responses to emerging challenges in managing innovations.

Summarizing, innovation management is a cross-functional discipline and reflective practice. It is contextual in terms of acting and reacting in a specific environment. Innovation management encompasses organizational culture and structure as well as individuals in their capabilities for innovation. It provides areas for exploration, creativity and learning on the one hand, and secures exploitation for successful innovations on the other. The fuzzy front end is valued equally as the inventive, development and implementation phases of an innovation process. Successful management of innovation depends on the organizational structure and culture it builds, the capabilities an organization develops, and the models, tools and techniques it uses (Lam, 2005, p. 117; Tidd & Bessant, 2013, pp. 85–88, 274 et seqq.; Vahs & Brem, 2015, pp. 79–80). Mental models shape the way individuals, teams and organizations think, and consequently shape their behavior and actions (Tidd, 2006, p. 4; Tidd & Bessant, 2013, pp. 74–78). Since the second half of the last century mental models of innovation have been turned into explicit knowledge with text-based descriptions and visual depictions (Godin, 2017, pp. 183 et seqq.). Sequential models have been developed with a focus on time and performance; systems models evolved subsequently with a focus on structure and interaction (Fichter, 2014, pp. 64 et seqq.; Godin, 2017, p. 5). The latter group addresses the systemic view on innovation processes. Though emphasized in recent research, the sequential perspectives are still in use and adjusted to new circumstances (Dodgson et al., 2015b, p. 18; van der Duin & Ortt, 2020, pp. 10–14, 30).

If the models in use change, the thinking about the process and the behavior adopted to innovate may change accordingly. In the following sequential and system models listed in Figure 10 are analyzed and reviewed



	linear	non-linear	non-linear
1980-2000	Brockhoff (1994) Witt (1996) acc. Vahs & Brehm (2015) Coooper (1983; 1990) Stage-Gate I (NPD)		van de Ven et al. (1999)
2000-2020	Verworn & Herstatt (2000; 2007) Tidd & Bessant (2013) Goffin & Mitchel (2017)	Koen et al. (2001;2002) NCD Model Cooper (2008; 2014) Stage-Gate II (NPD) Brown (2009) Plattner, Meinel & Leifer (2011) Lewrick et al. (2018)	Dodgson, Gann & Salter (2011) van der Duin & Ortt (2014; 2020) Kastell & Steen (2015) SNA Verganti (2009) Lookwood & Papke (2019) Pisano (2019)

Figure 10: Selected Examples of Innovation Process Models

Sequence and system models based on time of occurrence in leading publications.

in their response to an extended process view. Their offers and limitations for innovation management are summarized at the end of this chapter.

3.2 Sequence Models - Guiding Actions in Time

Innovation processes take place as interactions between different parties and actors. Innovation management structures and aligns these interactions as sequences of events and phases in order to improve, foster and lead them towards valuable outcomes in time. Sequence models are rooted in the thinking of the overarching innovation models and the prevailing generations of innovation (Godin, 2017, p. 5). They represent the primary operationalized models, or meta-tools, to manage innovation in push, demand, coupled-interactive or integrated views. In the sequences – synonymously termed steps, stages or phases – the models normatively provide recommendations, advice, guides, orientation and methods to executives and employees for performance measurement and decision making. These elements are conveyed in text-based form, with supporting visual and graphical depictions. As descriptive frames, sequence models are a valuable medium to communicate, develop and establish a common understanding within an organization (Trott, 2017, p. 144). They explain, communicate, disseminate or teach the innovation activities within a firm, the way it innovates, and where sources of innovation may reside (Verworn & Herstatt, 2000, p. 11).

The models are ideal step-by-step problem solving processes, which represent only parts of an innovation processes in reality. Their limited applicability needs to kept in mind, as they are not accurately followed in practice, and adjusted by organization individually (Corsten, 1989, p. 4; Trott, 2017, p. 144; Vahs & Brem, 2015, p. 240). They have been and are shaping thinking and doing of practitioners since their first formulation in the second half of the past century. Some examples of models are continuously further developed or newly created to address and foster an adaptive, dynamic, eclectic, contextual and design-oriented innovation management (Cooper, 2014; Hauschildt et al., 2016; Hofbauer & Wilhelm, 2015; van der Duin & Ortt, 2020). To investigate, if they also respond to an extended process view of innovation, well-known and advanced examples from English and German academic literature are selected. Sequence models are referred to as linear if they are one-directional along a time-dimension and if they do not explicitly depict or emphasize interaction loops or iterations. Non-linear sequence models follow the same time-orientation as linear sequence models, but outline iterations, feedback and interaction loops, or promote a cyclic arrangement of steps and phases.

3.2.1 Linear Sequence Models

Sequence models serve as guidelines or principles for how to start, conduct, continue and complete the innovation processes under constraints of time and resources (Hauschildt et al., 2016, pp. 164, 174; Vahs & Brem, 2015, p. 235; Verworn & Herstatt, 2000). Guidelines are “context-dependent directive[s]” (Fu, Yang, & Wood, 2016, p. 4) towards successful outcomes which have been deduced from empirical evidence in analyzing innovative companies, or are derived from experience in consulting or performing innovation processes. Principles are regarded as a “fundamental rule or law” (ibid., p. 3) for acting and behavior, which are followed and applied to constitute, support, conduct a method, or use and execute a technique or tool. The academic discourse has been shaped by stage-gate approaches since the 1980s (Hauschildt et al., 2016, p. 174; Verworn & Herstatt, 2000). In these kinds of approaches, phases or stages are precisely defined. They need to be completed at certain points of decision-making or gates and monitored (ibid.).

The Stage-Gate model, as introduced in the 1980s by Cooper (1983), has been an influential, normative approach for practice (Dodgson, 2018, pp. 31–32; Hauschildt et al., 2016, p. 174). It is based on empirical findings and insights from the structured process orientation "of successful "intrapreneurs" within major corporations" (Cooper, 1983, 2014, p. 20). "As both a conceptual and operational model" it optimizes new product innovation and new product development processes in organizations (Cooper, 1990, p. 44). The Stage-Gate model seeks to meet the requirements of being "sufficiently specific", "market-oriented", "multidisciplinary" and responsive to risks and failures and to function "as an action guide to managers" (Cooper, 1983, p. 6). It consists of stages and evaluation points (gates), in which a 'go-or-kill'-decision is demanded before proceeding with the next development stage (ibid., pp. 6–7; see Figure 11). As idea-to-launch process, the model helps to structure activities, reduce uncertainties and complexities in new product development, and by this accelerate and optimize the innovative outcome (Cooper, 1983). Market analysis and research is essential for success as they provide "a clear understanding of the customers' needs, wants, preferences, choice criteria, and use practices" (Cooper, 1983, p. 5). The model has been criticized as being too linear, rigid and structured, to respond to the changing contexts and requirements of innovation challenges (Cooper, 2014, p. 20; Vahs & Brem, 2015, pp. 242–243). Its misconceptions and misapplications, partially caused by its simple visual depiction, have led to further refinements and developments towards a non-linear sequence model (Cooper, 2008, 2014).

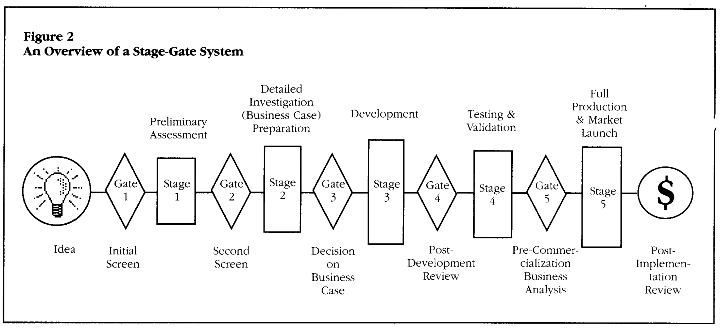


Figure 11: Stage-Gate Model (Cooper, 1990)

The Stage-Gate System acc. Cooper (1990, p. 46) represents an innovation process as sequences of stages of development and gates of assessment. The representation is a revised depiction from the first model sketch in Cooper (1983, p. 7). Visualization by Cooper (1990, p. 46).

In the German innovation literature, sequences models are structured similarly in three to seven or more phases depending on the author (Hofbauer & Wilhelm, 2015, p. 10; Verworn & Herstatt, 2000). They emphasize innovative product development, and provide for each phase, or step concrete advice for action and decision making. In general, the models begin with a phase of idea generation, problem formulation or strategic orientation (ibid.). Afterwards a screening, selection and acceptance phase of ideas follows. The favored ideas are turned into executable concepts, which are then tested for technical feasibility, evaluated with investment, business and marketing plans, tested, produced and implemented in the market (Vahs & Brem, 2015, pp. 230, 239–241). The linear sequence models function as project management tools for successful innovation processes, in the respective definition of success by the company (see Figure 12). The fuzzy front end, though influential for positive innovative outcomes is hardly addressed in these models (Tidd & Bessant, 2013, 418 et seqq.; Verworn & Herstatt, 2007a, pp. 5–7). This unstructured, complex, uncertain phase, which is driven by individuals in informal communications, is difficult to be framed with guided steps for executives and employees (Koen et al., 2001, p. 46; van der Duin et al., 2014, pp. 490, 479; Verworn & Herstatt, 2007a, p. 13).

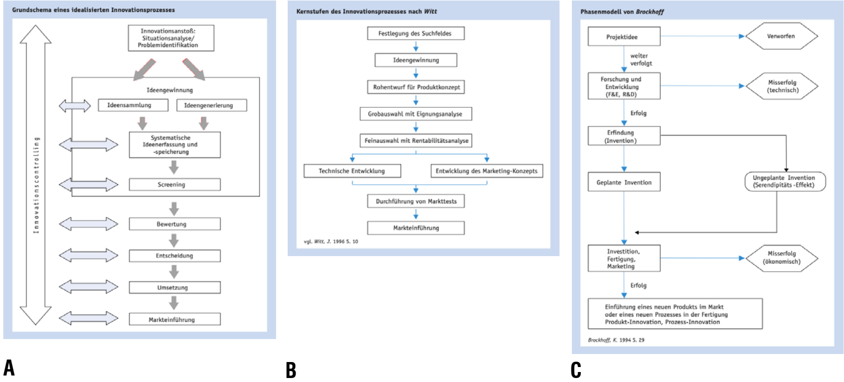


Figure 12: Examples of Linear Sequence Models (Vahs & Brehm, 2015)

Vahs & Brem, (2015) condense examples of innovation process models in a basic scheme of an idealized innovation processes **A**. The graphical depictions **A, C** are examples of linear sequence models in German innovation management literature in use and consideration acc. Vahs & Brem (2015). Visualizations by Vahs & Brem (2015, pp. 230, 239–241).

More generally, the sequence models described allow for an adjustment of the process depending on the particular context of a firm. In comparison to the detailed stages and gates in the examples mentioned above, these kinds of models function as a framework. "Innovation" is seen "as a core set of activities distributed over time" (Tidd & Bessant, 2013, p. 88). They define the different phases by scope, goals and required actions, and provide support with a broad range of methods, guidelines and tools to conduct and perform the work as required (Tidd & Bessant, 2013, pp. 59–61).[30] For instance, in the outline process model by Tidd & Bessant (2013) four phases of an innovation process – to search, select, implement, capture – are embedded in the existing innovation capabilities and innovation strategies of an organization. The capabilities as organizational pre-conditions and resources, as well as the strategic orientation towards future developments are continuously considered during each phase (ibid., pp. 46–48). The innovative organization provides the resource base for the activities to be pursued; the innovation strategy provides the direction and intent, and indicates which type of innovation should be selected. The model is treated as a framework that shows the different areas innovation management has to operate and succeed in (see Figure 13).

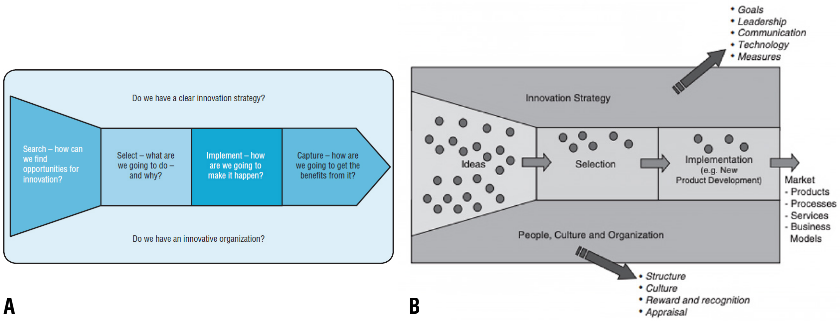


Figure 13: Simplified Model of an Innovation Process

Tidd & Bessant (2013) structure the innovation process with four phases to search, select, implement and capture, supported by an innovation strategy and innovative organization. Visualization **A** by Tidd & Bessant (2013, p. 47). Visualization **B** by Goffin & Mitchell (2017, p. 29) shows a similar model termed Innovation Penthatlon Framework.

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[30] Examples of methods to conduct: ethnography, user research, design sprints. Examples for guidelines to use: manuals, wikis. Examples for tools to apply: brainstorming, benchmarking, prototyping, checklists, stakeholder maps. See Tidd & Bessant (2013, pp. 289–290, 345–346, 353, 398); Hidalgo & Albors (2008, p. 118); Hanson (2018).

A similar example is the ‘Innovation Pentathlon Framework’ by Goffin & Mitchell (2017). The core phases of ideas, selection and implementation are surrounded by the foundational aspects of people, culture and organization, and the overarching directions of innovation strategy (Goffin & Mitchell, 2017, pp. 27–29). The metaphorical use of the term ‘pentathlon’ from sport indicates the multifaceted practice of innovation management, which requires outperforming skills and activities in different fields and occasions in time-dependent phases (ibid.; Tidd & Bessant, 2013, p. 86). Metaphors and analogies are in this case a means of communicating the innovation process differently and transforming existing mental models. Though both framework examples emphasize a systemic approach in their models, their use of metaphors (e.g., from sports) as well as their visual depictions, shows a linear and sequential conceptualization of the innovation process.

3.2.2 Non-Linear Sequence Models

Non-linear sequence models integrate interaction, iteration and feedback loops for revision, refinement or integration of new knowledge and requirements. The conceptual level of thinking about innovation as a non-linear sequence is rooted in coupled or interactive innovation models (Godin, 2017, pp. 116–120; Kline & Rosenberg, 1986, pp. 289–291).[31] In the Chain-Linked Model, as conceptualization, innovation occurs as integrative and interactive processes of multiple links between research areas, innovation and market, and of “feedback links” (Kline, 1985, p. 38) between phases pursued throughout the innovation process. Examples of innovation process models related to this conception of innovation, can be found in advanced generations of stage-gate models, the new concept development model (NCD-Model) and particular design thinking process models. They challenge the ideal representation of innovation processes in linear, sequential models. They outline the links between different sources of innovation and emphasize the relevance of iterative loops for successful innovations (Brenner & Uebernickel, 2016; Cooper, 2008; Kline, 1985, pp. 37–38; Koen et al., 2001).

Advanced generations of stage-gate models outline the interactive and integrative aspects in an innovation process (Cooper, 2008, 2014; Vahs & Brem, 2015, pp. 242–243). While earlier depictions show a strong linearity of the stages and a focus on financial aspects for a go-or-kill decision in the respective gates, the revised and adjusted models incorporate flexibility in their structure, the explicit consideration of contextual factors, and a more nuanced set of criteria for assessment, screening and decision making (ibid.). Described as a framework, system, guideline or playbook (Cooper, 1990, p. 44; 2008, pp. 213–218), it stresses the adaptive and context-dependent responses to varying innovation challenges and fast changing environments. The next generation stage-gate models as conceptualized by Cooper (2008) start with an idea stage termed “discovery” (ibid., pp. 214, 231), in which employees receive larger degrees of freedom to search and evaluate the kind of innovation processes to pursue (ibid.; and Verworn & Herstatt, 2007b, p. 118). For high-risk projects with high uncertainty and complexity the full stage-gate process is recommended. For projects to improve, modify, and extend a product or service the ‘Stage-Gate Xpress’ applies. It speeds up the stage business case formulation and merges the development and testing stage for faster product or service launches. ‘Stage-

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[31] Godin (2017, p. 118) describes the chain-linked model as "interactive model [...], a linear model with interaction and feedback loops among all the factors involved in the process of innovation [...]."

Gate Lite' is used for small and low-complexity projects with two stages and one decision gate in between: goal setting and implementation (Cooper, 2008, p. 228; Vahs & Brem, 2015, pp. 242–243).

Growing globalization, faster business cycles, increasing competition and decreasing predictability, have led to further development of the models (Cooper, 2014, p. 20), as the next-generation of idea-to-launch systems. Stages and gates become less relevant and less present. For a new innovation system, the features of being adaptive and flexible, agile and accelerated are foregrounded (ibid., p. 21). The systems need to adaptively respond to products, which are not clearly defined at the beginning; spiral and iterative developments support the formulation with the customer or user. In being flexible limits of standardization and application of experienced processes are overcome to meet evolutionary challenges. An agile innovation system fosters prototypical, forward moving developments with reduced bureaucratic activities in leaner structures. To accelerate the innovation processes, the system needs to allow stages to overlap and to be completed faster when needed or possible (Cooper, 2014).

In contrast to a prior well-defined sequence model for known surrounding with dominant design and experienced structures, measures and metrics, the new idea-to-launch process is different (Cooper, 2014, pp. 29–30): it incorporates risk-seeking, is iterative, experimental, and more open-ended in terms of defining goals and products; the gates are project-oriented, moving and flexible, with an emphasis more on effective results than the fulfillment of previously defined requirements and deliverables; the organization and its innovation management is shifting towards project-based cross-functional teams with greater autonomy (see Figure 14).

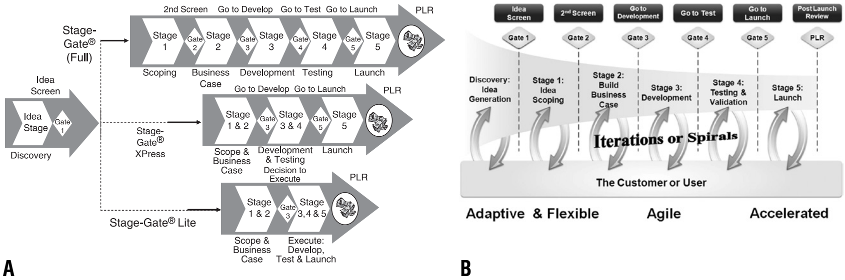

Figure 14: Modified Versions of Stage-Gate Models (Cooper, 2008)

Cooper (2008) modified the basic stage-gate model with different versions **A** to address different kinds of innovation processes. Visualization by Cooper (2008, p. 223). In a further development **B** Cooper (2014) framed the Next-Generation Idea-to-Launch System. Visualization by Cooper (2014, p. 21).

Stage-gate models are feasible for formal development of ideas and concepts – after these ideas and concepts are created and defined – but they are less applicable when novel ideas and concepts need to be generated in the first place (Koen et al., 2001, pp. 46–47). As an example, the New Concept Development Model (NCD) addresses this limitation and emphasizes the early phase of innovations, the fuzzy front end, which requires a different structure enabling a less rigid sequence of steps and interactions (Koen et al., 2001, pp. 48–49; Vahs & Brem, 2015, pp. 243–244). The broad innovation process consists of three differently structured phases. The NCD model represents a cyclic first phase, followed by a sequential New Product Development (NPD) Process and a linear commercialization phase (Koen et al., 2001, p. 51; Koen et al., 2002, pp. 5–6). The first phase is characterized by experimentation, discovery, unstructured work flows, high uncertainty and variability, individual and team initiatives (Koen et al., 2002, p. 6). Higher degrees of freedom allow employees multiple interactions and iterations for concept refinement and final decision making. The NCD model in this front end of innovation is therefore constructed in a radial or circular arrangement of three parts, the engine, the activities and the influencing factors (ibid., p. 8). The central engine represents leadership, organizational culture and business strategy; the five activities around the engine initiate a successful innovation process; they are intertwined with each other in a non-predefined way; engine and elements are embedded in an environment of influencing factors, the "organizational capabilities, the outside world (distribution channels, law, government policy, customers, competitors, and political and economic climate), and the enabling sciences (internal and external)" (Koen et al., 2002, p. 8).

Ideas flow and iterate across the five activities, until the concept is defined to start a phase of new product development. The authors of the NCD model outline "a random and non-sequential fashion" (Koen et al., 2001, p. 49) in the front end of innovation, by which the elements or activities relate and influence each other. They further describe the NCD model as a "non-sequential relationship model" (Koen et al., 2002, p. 7; see Figure 15).

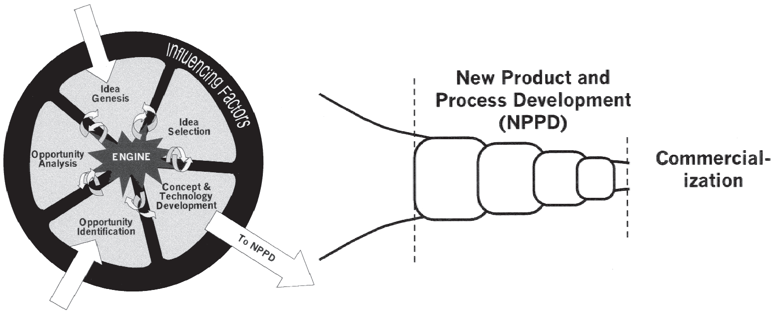

Figure 15: NCD Model (Koen et al., 2001, 2002)
The new concept development model (NCD) addresses the front end of innovation. It is the first and fuzzy phase of an entire innovation process that is structured in a cyclic model of front end innovation, new product and process development, and commercialization. Visualization by Koen et al. (2001, pp. 47, 51) and Koen et al. (2002, p. 8).

However, in this thesis it is viewed as a non-linear sequential model for two reasons. Firstly, the elements (or activities) are defined in similar terms and arranged in the same way as examples of sequence models presented earlier. Secondly, the entire innovation process is structured along a time dimension with stage-gate models being integrated as its second and third phases.

3.2.3 Design Thinking Process Model

At the end of the last century scholars and practitioners began to relate the challenges of innovation processes, of new product and service development to the way designers and engineers approach complex problems (Boland & Collopy, 2004b; Brenner, Uebernickel, & Abrell, 2016, pp. 6–7; Leifer & Steinert, 2011, pp. 151–154). Design attitudes and particular process models of design thinking have taken on a greater importance for management, especially in the context of innovation and transformational change (ibid.; Buchanan, 2015; Martin, 2009a). Chapter 2.4.2 introduced design and design processes as reflective and constructive practices that present design thinking as a mindset and structured way of dealing with wicked problems. In this section a further understanding of design thinking is explained, i.e. design thinking as a structured process suggesting sequences to follow in uncertain and ambiguous environments (Brenner et al., 2016; Leifer & Steinert, 2011, pp. 151–154). As a "human-centric" and "powerful methodology for innovation […] [i]t integrates human, business and technical factors in problem forming, solving and design"(Leifer & Steinert, 2011, p. 151). It is also regarded as a "tool to imagine future states" and as tool "to bring products, services and experiences to market" (Brenner et al., 2016; Buchanan, 2001; Lockwood, 2011, p. xi). For the purpose of consistency and in the context of this study, the conception of design thinking as a non-linear process will be not considered as a tool. The example of a design thinking process serves as a model or methodology or meta-tool in this study, to represent the general structure it conveys and the broad range of its different manifestations in practice (Brenner et al., 2016; Leifer & Steinert, 2011). The design thinking process model is based on several principles that differ from traditional linear process models in innovation management. It reframes the phases of an innovation processes with new terms and defines them as intertwined, changing areas, that mutually influence each other.

Firstly, the model is based on different thinking modes as constitutive for the process of design thinking: analytical thinking is combined with creative, intuitive thinking; divergent thinking to explore new opportunities continuously seamlessly alternates with convergent thinking to focus on the realization of a novel idea (Brenner et al., 2016; Liedtka, 2015); abductive reasoning as introduced in Chapter 2 is seen as a fundamental mode of formulating working hypothesis and testing them in unconventional and rapid ways. Secondly, the design thinking process model is based on foundational principles for how to act, interact and work collaboratively throughout the process: a deep understanding of needs, requirements and processes; a strong emphasis on collaboration and visual communication throughout all phases to apply "diverse points-of-view simultaneously" (Leifer & Steinert, 2011, p. 151); a commitment and dedication to learn in interaction with others and to learn through experimentation by the intense use of rapid concept prototyping and testing (ibid.). Thirdly, the model reframes the sequence of steps during an innovation process. The steps are overlapping phases, which are shaped and transformed through continuous loops of reflection, feedback and iteration across the entire innovation process. In practice and in academia a broad variety of design thinking process models has been developed and used in practice. They differ in the framing of the process, in terminology, number of phases and visual depictions.

In general, the various design thinking process models entail three to five stages or activities, that follow an idealized process, but relate in non-linear ways to each other and are fuzzy (Plattner, Meinel, & Leifer, 2011, p. xiv). In academic fields they are described as analysis, need finding, idea, prototype, test and re-definition phase. In the language of practice they are termed inspiration, ideation and implementation phase (Brown, 2009, pp. 15–16; Brown & Wyatt, 2010, pp. 33–35; Liedtka, 2015, pp. 927–928; see Figure 16).

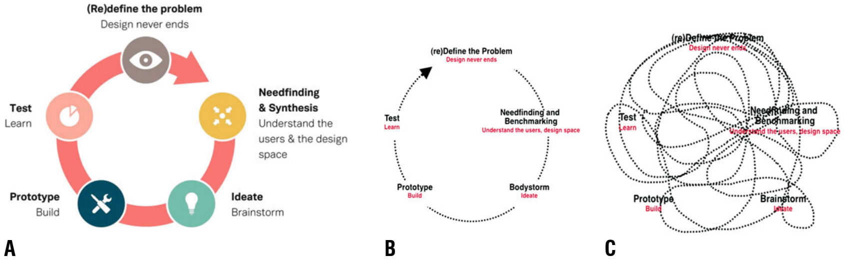

Figure 16: Design Thinking Stages (Plattner, Meinel & Leifer, 2011)

The idealized design thinking process adapted by **A** Brenner et. al (2016) and **B** Plattner, Meinel, & Leifer (2011) is structured in five major activities. In reality the process is non-linear and fuzzy **C**. Visualization **A** by Brenner et. al (2016, p. 11), visualization **B, C** by Plattner, Meinel, & Leifer (2011, p. xiv).

An example, frequently referred to by academics and practitioners, is the five-stage process from the d.school of the Hasso Plattner Institute of Design at Stanford University (McDonnell, 2015, p. 114). In this model the analysis stage consists of a discovery and interpretation phase, a phase to empathize with the problem case and define a problem statement; the idea stage is framed as an ideation phase; the test stage is divided into an experimentation and evaluation phase, or into a prototyping and testing phase (Brown & Wyatt, 2010, pp. 33–35; Liedtka, 2015, pp. 927–928; see Figure 17).

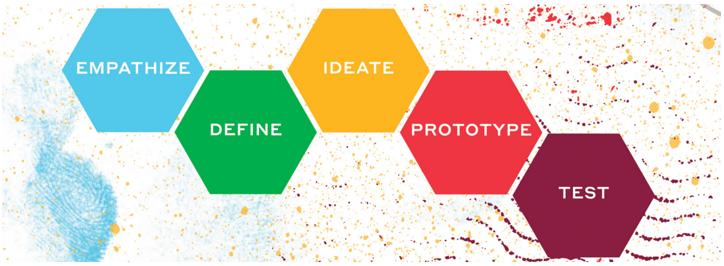

Figure 17: Design Thinking Process (HPI of Design, 2010; 2018)

Five different work modes define the main activities to be performed and conducted in a design thinking process. Visualization by HPI of Design (2018, p. 2).

The phases are interrelated one to another and considered as spaces the design thinking process flows through in a circuitous and consciously or unconsciously intended manner (van Prud'homme Reine, 2017, p. 67). The process is designed to achieve a viable, economically feasible and human-centered outcome at a faster pace than traditional innovation approaches (Brown, 2008, p. 86; Vogel, 2011, pp. 11–14, Lockwood, 2011, pp. xi–xiv; Uebernickel, Brenner, Pukall, Naef, & Schindlholzer, 2015, pp. 6–7).

Depending on the author and the model proposed, the design thinking process is also seen as "a form of open innovation" (Van Prud'homme Reine, 2017, p. 65), suitable for different types of innovation extending from incremental to radical innovations, and applicable to different contexts within an organization, from product to strategy innovation (Vogel, 2011; Auernhammer & Roth, 2021, p. 2). It supports innovation management in applying new modes of creative working and fosters faster cycles of development through constant iteration and prototyping. Its sequential approach of consecutive steps is dedicated primarily to innovation projects themselves and to the delivery of a new product, service, and process in a defined time frame.

System models on the other hand refrain from time-oriented guidance for innovation. They focus on the structure of interactions in a complex and emergent process. As sequential models only partially address the new requirements of an extended process view, system models are reviewed next in selected examples.

3.3 System Models - Structuring Interactions

The first, second and third generation of innovation models influenced the development of sequential innovation process models. The fourth and fifth generation of innovation models, took into account the changing context a company is embedded in and transformed the way companies understand and structure their innovation processes. In the fourth generation, an integrative view depicts the larger integration and interaction with suppliers, partners, customers and users. The fifth generation outlines a systems respectively network perspective. The interconnectedness of innovation processes across a firm's institutions and increasingly outside its organizational boundaries are relevant (Chesbrough, 2003; Marinova & Phillimore, 2006, p. 47). While sequence models describe the process as a function or task to be fulfilled and "single factor oriented" (Godin, 2017, p. 119) in the dimensions of time and performance, system models consider an innovation process as structure of interacting parts – people and things – of environments and of functions in multi-dimensional ways (ibid., p. 188).[32] They offer an approximation of how innovation processes are fuzzy and uncertain in reality and how they evolve over time. Human agency, multi-level spaces, dynamics of interaction and emergence of ideas are becoming “key concepts in the study of change and innovation” (Poole, 2004, p. 16).

System models are used at different scales in innovation research and management. Innovation systems can be applied at national, regional or sectoral levels and at the level of a company. At the national level they represent the interaction and relations of institutions, public organizations, and companies and are concerned with governmental and geographical aspects (Edquist, 2005, pp. 181–184; Marinova & Phillimore, 2006, pp. 47–48). At a company level, they comprise on one hand the institutions in a firm, in which sequential innovation processes are embedded and applied in (Hauschildt et al., 2016, p. 67; Pisano, 2019; van der Duin & Ortt, 2020). On the other hand, an innovation system comprises the frameworks and schemes a company defines and applies together with its particular language and phasing of the innovation processes (Dodgson et al., 2011; Trott, 2017). System models see the innovation processes as a system and intend to “move[s] discussion away from traditional terms – ‘research’, ‘development, ‘engineering’ that bind the study of innovation to functional terms.” (Dodgson et al., 2011, p. 189). They originate from academic research, are based on empirical findings at innovating firms or result from consulting practice; they consider emerging challenges in innovation management as well as the changing context of an organization, the activities and actors in an innovation process, the people and purpose of their initiatives, the time and performance of an innovation process.[33] System models are defined in this thesis as non-linear models, methodologies or meta-tools, to understand and design innovation processes and their environment by displaying activities and locations of people and institutions, their multi-dimensional relations and interactions in a dynamic and emergent way (Hauschildt et al., 2016; Völker, Thome, & Schaaf, 2012). The examples of system models that are reviewed in the following, are selected by their presence in academic discourse, their practical orientation and their intent to provide an approach to innovation management that entails elements of an extended process view. They are systemic, dynamic, multi-dimensional, open, networked, or design-based approaches. The models reviewed are grouped by their core focus. Contextual system models comprise different existing innovation process models and apply them based on an assessment of the context; dynamic and fluid models outline flexibility and agility, adaptation and learning; network models depict innovation processes as a structure of agents, relations and interactions; design-based and auto-constructive frameworks foreground design attitudes, design expertise and the build-up of innovation cultures. The overview shows models that address aspects of context, dynamics, networks and design in innovation management. The models are seen as responses to a changing context and new requirements in managing innovation processes. Architectural thinking and tools will be related to these aspects in the upcoming chapters.

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[32] Godin (2017, p. 119) analyzes the discourse on generations of innovation models: “In sum, the narrative goes from linear models to models of a holistic type. Demand has shifted back to what it was in the 1960s: a single factor (among many) under many guises: interactions between suppliers and users, for example, and user innovation. The field began constructing new kinds of “mental models,” as John Ziman (1991) called them: multidimensional rather than single-factor oriented. The terms used to describe such models are many: iterative, interactive, recursive, systemic.”

[33] In an alternative categorization, system models of innovation processes are described as interactive models. Interplay, relations and dynamics of agents and context, the surrounding environment a company is facing, are emphasized with a holistic-systemic perspective. These interactive models are more related to conceptualizations than to methodologies and meta-tools as they are investigated here. See Fichter (2014, pp. 70–77).

3.3.1 Contextual Frameworks

Contextual models describe a company's need to constantly observe and respond to its environment and the particular context it is embedded in (van der Duin et al., 2014, p. 491; van der Duin & Ortt, 2020, pp. 16, 45). In the example of contextual innovation management, organizations are context-dependent in their actions and "cannot influence their environment" (Van der Duin & Ortt, 2020, p. 48). They need to adapt and choose their field of competition; they need to offer and provide freedom in their internal structures, to organize, develop and apply innovation processes context-specific (van der Duin & Ortt, 2020, pp. 62–63). The term context is used, to include aspects which are not "directly (…) related to the organization's environment or industry", but require consideration (ibid., p. 51). Three main contextual factors – industry, organization and technology – are specify the nature of the innovation management to apply and its performance as push-, pull-, coupled, or network approaches (van der Duin & Ortt, 2020, pp. 59–62). The contextual factor of industry comprises the market a company acts in or intends to enter, with "users (…), suppliers, competitors, industry-specific regulations or institutions, business models, and customs." (ibid., p. 51). The contextual factor of organization refers to the structure an organization is shaped by and the culture it has. It asks whether a company operates in a more "formal", "mechanistic" way, rather than being "loose" and "flexible", or if it operates in a more "informal", "organic" way, as opposed to "strict" and "constrained" (Van der Duin & Ortt, 2020, p. 54). The contextual factor of technology considers the maturity level of a technology. Existing technologies can be stable and require an organization to exploit them; moderately changing technologies may require adaptation in the processes of an organization; disruptive technologies may induce new approaches in the innovation process (ibid., pp. 55–56; see Figure 18).

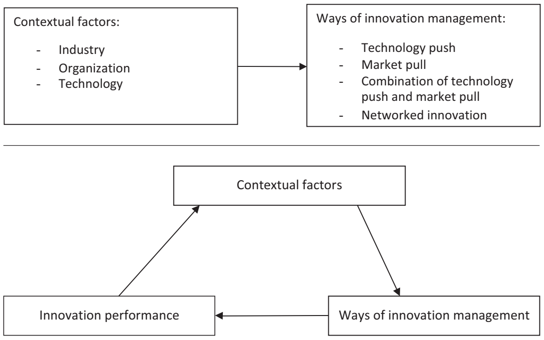

Figure 18: Contextual Innovation Management (van der Duin & Ortt, 2020)

Contextual factors of industry, organization and technology determine the four ways of innovation management and eventually the innovation performance. Visualization by van der Duin & Ortt (2020, pp. 60, 62).

Contextual factors determine the innovation management a company applies and eventually their performance. The interplay between these three components in the model of contextual innovation management are "not static" (Van der Duin & Ortt, 2020, pp. 60–61). The innovativeness of a firm is seen in an organization with the "best structural fit to an ever-changing environment" (Lam, 2005, p. 117). Consequently an adaptive system is proposed in contextual innovation management: it builds up the capabilities of a firm to consider, decide and combine different existing process models in parallel and according to the situation (Dodgson et al., 2015b; van der Duin & Ortt, 2020, p. 10). Organizations need to become flexible, dynamic, adaptive, and connected with other organizations (van der Duin & Ortt, 2020, pp. 13–14).

To implement a contextual innovation management four conditions need to be fulfilled. Firstly, an organization needs to possess the knowledge, expertise and skills regarding the different ways to innovate; secondly, it needs to offer an organizational structure of freedom, in which innovation managers can reflect and decide upon the approach to pursue; thirdly, it needs to constantly assess and systematically adjust the applied innovation processes; lastly, the organization needs to follow formal protocols by consciously deciding, implementing and controlling the applied innovation processes (van der Duin & Ortt, 2020, pp. 109–111). Specific success factors of the innovation process need to be built context-specific as well. Success factors are not stable, but temporary and locally determined (van der Duin & Ortt, 2020, p. 27). Following the success factors of a "one-size-fits-all approach" (ibid.) or applying the performance indices of normative and descriptive models is questionable. It may lead away from the distinguishable advantage of one organization towards a resemblance of another organization and result in the similarity of both. A neo- or isomorphism among organizations and their innovation processes would be the outcome (Hargadon, 2015, p. 168; van der Duin & Ortt, 2020, p. 27).

Contextual innovation management is a "kind of postmodern approach" (Van der Duin & Ortt, 2020, p. 10), in which dominant models for innovation management do not prevail, but an adaptive structure is developed to select and apply existing process models of managing innovations (ibid., pp. 10, 127). It is a meta-model with a systemic view on the organizational structure of a company and its surrounding context. The dynamics of the model reside in the constant and contingent adaptation and re-combination existing innovation processes models.

3.3.2 Dynamic & Fluid Models

Dynamic and fluid models emphasize the non-linearity, complexity and unpredictability of innovation processes. In contrast to sequential models and their traditional termed phases, they propose alternative frames of activities and interrelations in the process (Dodgson et al., 2011; Dodgson, 2018; Van de Ven et al., 1999). Agility, adaptation and contextual aspects are central. Notions of travel and play, of discovery and design are foregrounded as responses to dynamic and changing environments. As examples, the Innovation Journey (Van de Ven et al., 1999) and the "Think, Play, Do schema" (Dodgson et al., 2011, p. 3) will be explained. They combine empirical analysis of practice with research on innovation. The two examples belong to process models of the fourth and fifth generation of innovation models.

The Innovation Journey is defined as "a non-linear cycle of divergent and convergent activities that may repeat over time at different organizational levels if resources are obtained to renew the cycle." (Van de Ven et al., 1999, p. 184). The research findings from longitudinal studies relativize prevailing assumptions in the concepts on innovation and the linear sequence of activities during the process. They outline the relevance of learning, leadership roles, external relationships and institutional infrastructures. Staged or phased approaches are not feasible for capturing the messy and complex progression in developing an innovation, which is predominately "the result of a non-linear dynamic system" (Van de Ven et al., 1999, p. 5). The innovation journey as model is based on a non-linear map of observed process characteristics with divergent and convergent modes of behaviors. Idea generation, people, transactions, context, outcomes and the innovation process itself are not determined, fixed and stable. Ideas evolve over a longer period of time, called gestation, in which chance and the advent of shocks as triggers to initiate the process, play an important role. Ideas are constantly reinvented, proliferated, discarded or terminated; a diverse group of people from different levels fluidly engages and disengages in the process at varying degrees; transactions occur across a network and web with other stakeholders and in relation with external institutions; the context in which the company acts constrains the activities on one hand, but can be influenced by the company on the other; the innovative outcomes are indeterminate and may lead to unknown, not foreseen directions (Van de Ven et al., 1999, pp. 7–17). During the journey, different paths to proceed with and follow are possible. Situations of ambiguity occur and the absence of control needs to be acknowledged. Managing innovation is less a matter of control as approached in the "control philosophy of conventional management practice" (ibid., p. 65), but a question of "orchestrating a highly complex, uncertain and probabilistic process" (ibid., p. 59).

These different concepts are reflected in a map of characteristic activity patterns during an innovation process. These activities span in the authors terms from: gestation, shock, planning, to proliferation, setbacks, criteria shifts and fluid participation, to management integration, relationship development and infrastructure building, to adoption and termination (ibid., pp. 23–25). Though the patterns are related to the familiar periods of initiation, development and implementation, they do not follow a linear path or an iterative sequential route. They occur simultaneously or in parallel at different organizational levels. The visual depiction of these different activities serves as empirically supported road map in order to outline the non-linear, complex and unpredictable sequence of events and reframe the activities as they occur in reality. As a " "fireworks" model" (Van de Ven et al., 1999, pp. 34, 37) the map provides a generic orientation through a "rugged landscape" towards innovation which cannot be accurately planned or controlled (Van de Ven et al., 1999, p. 65; see Figure 19).

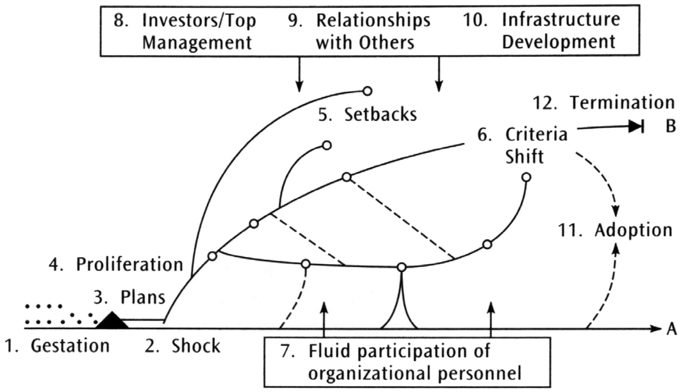

Figure 19: Fireworks Model of the Innovation Journey (van de Ven et al., 1999)

The fireworks model depicts the key components of the innovation journey, which follow a non-linear path. Visualization by Van de Ven et al. (1999, p. 25).

A company needs therefore to consider the journey as a cycle of divergent and convergent behaviors in order to adapt, react and act to changing events and environments. Several elements for this organization are important. A culture of innovation explores, motivates and stimulates. An adaptive and dynamic cycle of learning especially through discovery reveals tacit understanding about innovation initiatives and generates information about relationships and dependencies of the involved parties, resources and environments (Van de Ven et al., 1999, pp. 84–85). A "pluralistic leadership" (ibid.; p. 116) blends into the process and guides by acting in different roles: the leader is a "corporate sponsor, mentor, critic and institutional leader" (ibid.; p. 124). An "inter-organizational [relationship] web" (ibid., p. 127) is flexible and temporary, alternates between intense exchange to lose connection, provides opportunities for collaboration and cooperation. "The construction of an industrial infrastructure" (ibid., p. 149) supports the innovation process in a broader industry context.

The model introduces a new mental frame for the innovation process by using the metaphors of journey, landscape, river and skiing. It emphasizes trial and error approaches, adaptive and dynamic learning processes, practice-based experience, competence and relevance of luck, chance, triggers and shocks. It recommends to foster the probability for people to interact and initiate new directions, and to encourage "direct personal confrontations" for start innovative activities (Van de Ven et al., 1999, p. 30). Innovation management shall "go with the flow" (ibid., p. 213) and maneuver the journey instead of seeking to control it. This implies to be aware of the patterns of a firm's journey, its phases and activities of divergence and convergence. "[A]mbidextrous management skills" (ibid., p. 214) are required for the phases and the transitions from diverging to converging activities (see Figure 20).

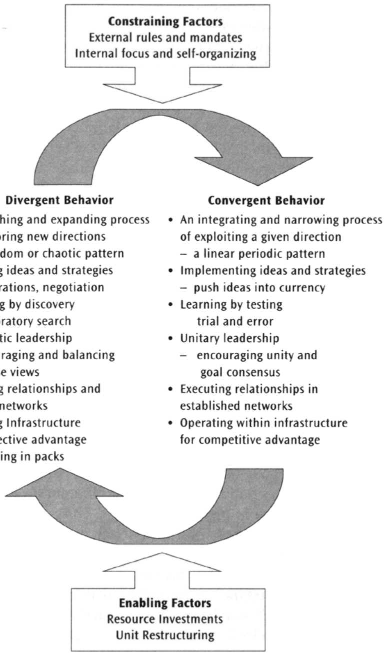

Figure 20: Cyclical Model in the Innovation Journey (Van de Ven et al., 1999)

The cyclic model recommends alternating behaviors of divergence and convergence needed to maneuver through the innovation journey. Visualization by Van de Ven et al. (1999, p. 185).

Flow, dynamics and adaptation to changes in innovation processes and environments are similarly considered in the example of the "Think,Play,Do" model (Dodgson et al., 2008, p. 64). Based on empirical evidence, on innovation and economic research the model supports the development of distributed and open innovation processes, which are strategically and technologically integrated with internal and external stakeholders, communities and networks (ibid., p. 63 Dodgson et al., 2011, pp. xii-xiii). A company's organizational flexibility and responsiveness is crucial for its future success in unpredictable and fast changing environments (Dodgson et al., 2008, p. 64). The model termed 'schema' focuses on the "flow of connected and iterative activities" (Dodgson et al., 2011, p. 2) during an innovation process and "breaks away from traditional categories" (ibid., p. xi) and functions of research, development and engineering. It replaces the prevailing sequential and segmented approach by a concurrent and integrated approach which prioritizes the activities of "thinking, playing, and doing" (ibid, p. 1; and pp. 105–106, 108–111, 161–163): thinking as "option-creating activities" arises from science and education; playing as "selection activities" refers to the practice of design; doing as realizing activities is "putting chosen ideas into practice" at an accelerated speed through the use of new technologies, e.g., in rapid prototyping (Dodgson et al., 2011, p. 140).

Play is stressed as the "primary activity for unlocking value in the fifth generation innovation process" (Dodgson et al., 2011, p. 138), in which multiple players interact and experiment in an open, distributed, integrated and networked view on innovation. The activity of play links the thinking space with the doing space, "gives shape to ideas" (ibid.), enables people to explore, learn, manipulate through models and simulations; it integrates different views and engages with decision makers, stakeholders and users through boundary objects or technology. Play applies valid aspects of design practice and design principles in the process of innovation, as imagination and intuitive guesses, physical craft expertise and digital code knowledge, experience and judgement (ibid., pp. 110, 114, 129–137, 194). With the "Think, Pay, Do schema" (ibid., p. 3) the growing role of design and prototyping in innovation is given appreciation. It offers "a more useful and contemporary idiom of an innovation process" (ibid., p. 3; and p. 189), to describe and prescribe ways in which firms and practices of different scale and industries can meet the present challenges of innovation. Central to the model is a new kind of technology, innovation technologies (IvT), which complements the craft, ingenuity and skills residing in a company to innovate, but requires new organizational structures and skills to intensify innovation initiatives (ibid.). Based on technological advancements in information and communication technology, these innovation technologies provide new ways to create innovations at a faster pace and an economically more feasible rate while reducing risk and uncertainty at the same time. Their effectiveness depend on the people, their expertise, and the intuition and skills to use, apply and implement it (ibid., p. 5; see Figure 21).

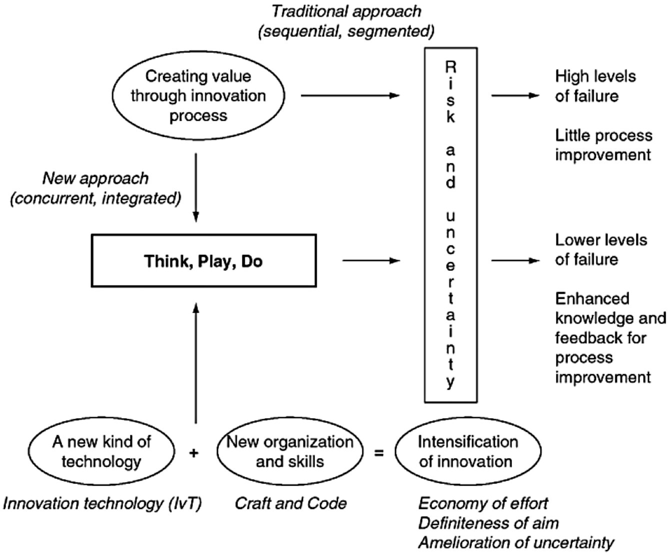

Figure 21: Think, Play, Do-Schema (Dodgson et al., 2011)
Visualization by Dodgson et al. (2011, p. 4).

Innovation technologies make it possible to think, play and do things differently and support the creation of a collaborative environment (ibid., p. 8–12): They liberate, enable, empower and assist people in searching for and creating options, selecting and testing directions and putting ideas rapidly into practice. At the level of thinking innovation technologies extend the innovative activities by data creation, searching and mining tools; by new infrastructures for collaboration in the service of gaining, building and exchanging knowledge; by visualizing complexities. At the level of playing, simulation and modeling, tools support the generative and explorative search for alternatives. At the level of doing, tools for rapid prototyping and advanced manufacturing enable testing directions for implementation and exploitation.

To succeed with the approach of 'Think,Play,Do' companies need to develop special forms of external relationships, transform their internal structure and processes and manage learning, knowledge and creativity in new ways (ibid., pp. 164–165). In the first case, an integration across organizational and technological boundaries needs to be developed with customers, suppliers, research institutions, competitors and systems of existing products, services and processes. In the second case, the organizational structures need to become project-based, team-oriented and media-enriched by digital and analog tools. New skills and leadership approaches need to be adjusted accordingly. In the third case, learning needs to be fostered, knowledge bases need to be bridged and creativity supported (Dodgson et al., 2011, pp. 168–186). The growing importance of play and flow in the workplace for creative processes and innovation is further supported by empirical and conceptual studies in organizational research (Mainemelis & Dionysiou, 2015, p. 137).

3.3.3 Network Models

Open and distributed innovation processes with social interactions at multiple levels require an appropriate analysis and description of the interdependencies and dynamic interrelations between the acting entities (Ahrens & Molzberger, 2018, p. 301; Kastelle & Steen, 2015, p. 101). Network models serve in the context of this thesis as methodologies and meta-tools to understand the innovation process differently. They consider innovation processes as changing network of configurations between different actors; they represent and model visually the complexity of interactions and relations; and thereby they analyze, interpret and design measures for developing innovation processes (Drexler & Janse, 2013, pp. 118–119; Kastelle & Steen, 2015, pp. 103–104). The metaphorical use of the term 'network' in innovation research and management has contributed in social network analysis to an appropriate and "rigorous analytical approach" to study and manage innovation (Kastelle & Steen, 2015, p. 102; Sørensen & Mattsson, 2016, p. 1650024–3). Network models comprise a particular understanding of the function of social networks in economic environments; they use special tools for its analysis and visual depiction; and they convey different implications for innovation management to those of sequential models (Kastelle & Steen, 2015, p. 116).[34]

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[34] The Actor-Network Theory (ANT) needs to be distinguished from the Social Network Analysis. Network and actor are defined differently. In the ANT, human and non-human entities construct their network through interactions with other human or non-human entities, and become through this construction the actor. Actor and network form a unity acc. Peuker (2010, p. 326). The network is a "recorded movement of a thing" and not a representation of a social network, as Latour (1996, p. 378) clarifies. He notes that "(…) the actor-network theory (hence ANT) has very little to do with the study of social networks. These studies, no matter how interesting, concern themselves with the social relations of individual human actors – their frequency, distribution, homogeneity, proximity. It was devised as a reaction to the often too global concepts like those of institutions, organizations, states and nations, adding to them a more realistic and smaller set of associations. Although ANT shares this distrust for such vague all-encompassing sociological terms, it also aims at describing the very nature of societies. But to do so it does not limit itself to human individual actors, but extends the word actor – or actant – to non-human, non-individual entities. Whereas social network adds information on the relations of humans in a social and natural world which is left untouched by the analysis, ANT aims at accounting for the very essence of societies and natures. It does not wish to add social networks to social theory, but to rebuild social theory out of networks." (ibid., p. 369). For a comparison between ANT and SNA see also Vicsek, Király & Kónya (2016).

Networks are sets of actors called nodes and their links termed ties (Drexler & Janse, 2013, pp. 118–119; Kastelle & Steen, 2015, p. 103). Actors can be individuals, teams, an organization, an inter-organizational group, an industry, region or a global community; actors can also represent a problem, challenge, concept and project, people are attached to (ibid; Ahrens, 2011, p. 301; Powell & Grodal, 2005, pp. 63–64). Networks can be established intentionally by organizations, e.g., as strategic alliance, or they emerge from "primordial" or informal relations (Powell & Grodal, 2005, pp. 63–64). Networks become advantageous in economic environments when they develop a social capital that represents "resources embedded in a social structure" (Lin, 2001, p. 12). Actors in the network can access and mobilize this capital, to enhance, support or nurture behavior and actions, and eventually increase their performance and the performance of the network (Burt, 2001, p. 32; Dodgson et al., 2008, p. 136).

On the other hand, though networks connect communities, disciplines, organizations or industries, they can also entail structural holes. Structural holes describe potential connections to create value in a relevant field, which have not been established through a network or which are only bridged by a single node or actor. The single actor gains an advantage through his or her position, develops social capital through the structural hole and can turn it into an advantage (Burt, 2001, pp. 34–35; Kastelle & Steen, 2015, p. 109). In this regard, the centrality of actors or nodes, i.e. their position relative to the network, influences the network and the actor's performance (Perry-Smith & Mannucci, 2015, pp. 216–217). As ego-centric networks they display an individual's environments and ties, as global or whole networks they capture the totality of entities with their relational structure and provide a systems view (Ahrens, 2011, p. 301; Kastelle & Steen, 2015, p. 103; Perry-Smith & Mannucci, 2015, p. 214).

From the perspective of collaboration between organizations, networks can be categorized by degree of formality and temporal stability (Powell & Grodal, 2005, pp. 59–60). Formal or contractual networks can be agile for strategic purposes, or turn into stable operational networks (e.g., as project groups). Informal networks can be invisible and fluid, or "primordial" (Powell & Grodal, 2005, pp. 63–64), anchored in the culture, practice or discipline of individuals and organizations (e.g., as business networks). Accordingly, the ties between the actors differ in networks. They can be directed or undirected, present or absent, weighted or unweighted (Ahrens, 2011, p. 301; Drexler & Janse, 2013, pp. 118–119). The mode of interaction represented through the ties can be distinguished, for example, as formal or informal, strong or weak, explorative or exploitative (Drexler & Janse, 2013, p. 119). The quality of relations in a network, i.e. characteristics and types of ties, as well as the structure of the network, i.e. the patterns and positions of nodes and ties, influence the innovation outcomes of a network (Kastelle & Steen, 2015; Perry-Smith & Mannucci, 2015).

The diversity of the connections fosters innovative initiatives; actors who bridge structural holes and exploit the "opportunity for arbitrage" improve their innovative performance (Kastelle & Steen, 2015, p. 109; Powell & Grodal, 2005, p. 62); weak ties matter for exposure to non-redundant and new information, to different people, to diverse and contrarian views, and lower reciprocity, meaning that ties are less bi-directional and less limited to a specific group of agents (Perry-Smith & Mannucci, 2015, pp. 209–210). These aspects stimulate and foster creativity, judgement, interpretation, non-conformity and eventually innovation (ibid. Kastelle & Steen, 2015). Strong ties matter for reasons of stability in changing environments, motivation, trust, engagement, sharing, and for "knowing where knowledge resides" in a network (Kastelle & Steen, 2015, p. 108; Perry-Smith & Mannucci, 2015). In knowledge intense industries with new forms of innovation, networks are important, to learn and discover ideas, extend knowledge and resource base, and collaborate in dynamic and changing environments respectively contexts (Dodgson et al., 2008, 2008, pp. 133–135; Powell & Grodal, 2005, pp. 59–60; van der Duin & Ortt, 2020).

The social network analysis (SNA) addresses the significant role networks play in the innovation process. It emphasizes and researches the way the quality and structure of relations and networks influence creativity and innovation (Dodgson et al., 2008, p. 137; Perry-Smith & Mannucci, 2015; van der Valk & Gijsbers, 2010, p. 6). It is not one unified approach, but more a set of techniques applied in a basis procedure (Ahrens, 2011, p. 303; Holzer, 2013, 254; Kastelle & Steen, 2015, pp. 102–103).

> *"Social network analysis may be defined as the disciplined inquiry into the patterning of relations among social actors, as well as the patterning of relationships among actors at different levels of analysis (such as persons or groups)."*
>
> *(Breiger, 2004, p. 505)*

The SNA relates innovation management to evolutionary economics and evolutionary models of innovations as explained in Chapter 3.1.1 (Kastelle & Steen, 2015, p. 104; Marinova & Phillimore, 2006, pp. 49–50). The aspects of variation induced by innovations and "network connections" as "the key drivers for selection and retention processes" (Kastelle & Steen, 2015, p. 104) within and between organizations are especially emphasized. The SNA provides a systems view of complex adaptive systems as a whole (e.g., organizations, inter-organizational groups and industries) while simultaneously keeping individual parts in sight; it supports deciphering patterns of relations; it offers a direct lever to effective change through the management and reconfiguration of the formal and informal networks in an organization (Kastelle & Steen, 2015, pp. 104–105; Perry-Smith & Mannucci, 2015, pp. 214–215). Network models by a social network analysis provide a visual x-ray of informal structures in an organization (translation by author, Zenk & Behrend, 2014, p. 214), which are normally hidden or invisible to management, but influence the performance of the employees.[35] Through advancements in information and communication technologies and by a growing body of cross-disciplinary research, social network analysis has become an "important tool for innovation management" (Drexler & Janse, 2013, p. 115; and Borgatti & Halgin, 2011, pp. 1168–1169; Dodgson et al., 2008, pp. 134, 138). On the one hand innovation management intends to "shape the networks to create […] optimal configurations" (Kastelle & Steen, 2015, p. 108) for innovation, while on the other hand these configurations are not stable, but need to change with the project or task. The structural and dynamic nature of the SNA supports both sides (see Figure 22).

Basic to conducting a social network analysis is the sourcing and collection of data, its organization and structure, and the visualization of relations and

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[35] Zenk & Behrend (2014, p. 214) point out: „Soziale Netzwerke beeinflussen unter anderem die Leistung, Innovation und Zufriedenheit von Mitarbeitern und Organisationen (Brass 2012). Jedoch sind diese informellen Netzwerke versteckt und Manager können sie nicht in ihre Entscheidungen miteinbeziehen. Im Hinblick auf die soziale Struktur müssen Maßnahmen blind entwickelt werden, die vielleicht nur die Symptome und nicht die Ursachen von kooperativen Abläufen bekämpfen. Mittels der sozialen Netzwerkanalyse kann eine Art „Röntgenbild" von informellen Strukturen und Ressourcen erstellt werden. Diese Methode hilft Entscheidern und Managern, die passenden Maßnahmen zu initiieren und deren Wirkung sowohl visuell zu dokumentieren, als auch anhand von Kenngrößen zu bewerten."

interactions in a graph or model (Kastelle & Steen, 2015, p. 106; van der Valk & Gijsbers, 2010, p. 6). The data for the analysis can be qualitative for depicting ego-networks through interviews, surveys, ethnography and text analysis (Ahrens, 2011; Kastelle & Steen, 2015; Zenk & Behrend, 2014). To analyze whole networks, quantitative data is sourced through available large data sets from databases and pools, e.g., e-mail traffic, movements, registries, and data mining. (Kastelle & Steen, 2015; Zenk & Behrend, 2014, p. 224).

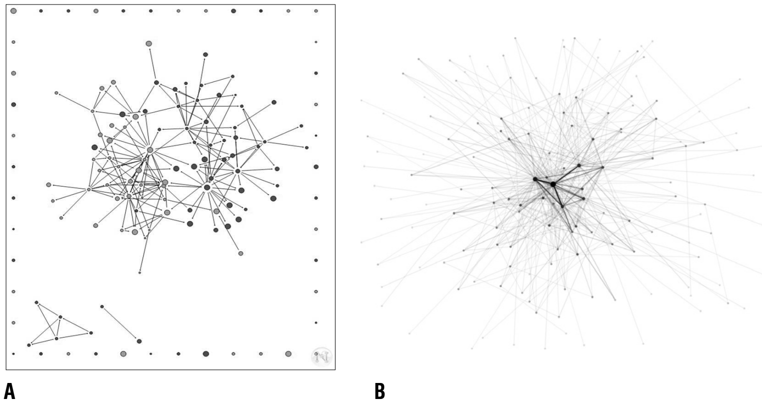

Figure 22: Examples of Social Network Analysis
A Example of a problem-solving network analysis in an engineering company. Visualization by Kastelle & Steen (2015, p. 114 ; 2010, p. 84). **B** Example of an innovation network analysis of parallel innovation initiatives. Visualization by Sørensen & Mattsson (2016, p. 1650024-13)

The models generated through a social network analysis are unique and company-specific. They differ between firms and vary in their feasibility for innovation process design by the way they are set up, by the type and quality of data used, and the techniques applied. Advanced analysis approaches as exponential random graph models allow the comparison of the actual observable network structures with statistically possible networks, to deduce the critical active elements that drive processes; longitudinal analysis makes it possible to consider the time dimension for the evolution of network structures and actor behavior; multilevel approaches allow the analysis to relate the individuals to groups, organizations and industries; weighted network analysis enables integration of the value of relationships in the models in term of the ways in which interactions take place; their frequency and the content they transmit; whether the ties are weak or strong, formally or informally developed (Kastelle & Steen, 2015, pp. 111–113). Research has established that physical proximity and location influence the probability of tie formation and the build-up of creative and innovative teams. The communication flows of knowledge workers (e.g., engineers), exploration by and engagement of teams as explained in Chapter 2.3.2 and the formation of an innovative milieu, depend on face-to-face interaction and physical localization (Allen, 1995; Longhi & Keeble, 2000, 27–29; Marinova & Phillimore, 2006, p. 50; Pentland, 2015, pp. 105–119). In the SNA, central actors, teams, organizations or hubs can be localized and displayed in their physical proximities to each other to provide a more accurate depiction of the social network of an organization.

The visualizations of data based on the analysis conducted enable innovation management to capture the complexity of interacting parts in an innovation process, to view the whole structure of an organization and its parts. They allow the visual analysis of the depicted network by searching and identifying patterns of relationships and interactions, and support adjustment of the structure in order to develop or transform the innovation process (Drexler & Janse, 2013, pp. 123–128; Kastelle & Steen, 2015, pp. 116–117). They help with identifying silos, detecting hubs and knowledge loads, and discovering key actors, who function as bridges to connect individuals, teams, departments or communities. The models visually reveal isolated nodes and bottlenecks by which processes can be inhibited or slowed down (Kastelle & Steen, 2015, p. 115). The measures innovation management takes to transform the innovation process can by visually modelled and followed in their effects and impact on other entities and the network structure. In visualizing the informal networks organigrams sketched in hierarchical diagrams can be transformed into a realistic display of the organizational structure as shown in Figure 23 (Kastelle & Steen, 2015, p. 116; Zenk & Behrend, 2014, p. 219).

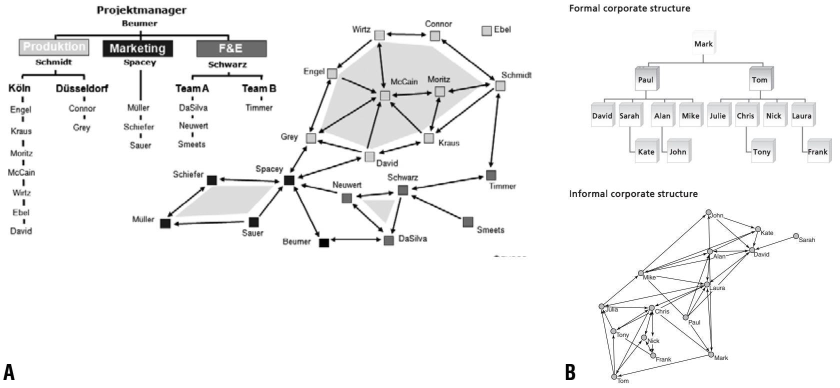

Figure 23: Organizational Charts and Informal Networks

Comparison of organizational charts that represent a hierarchical corporate structures with a representation of the same orgsanizational structures as communication networks. Visualization pair **A** by Zenk & Behrend (2014, p. 219), visualization pair **B** by Dodgson et al. (2008, p. 139).

Network models in innovation processes foreground human entities with their formal and informal ways of connecting and interacting in the generation of novel ideas and initiatives. Flow and dynamics, as mentioned in the fluid models, are depicted visually as an emergent network of relationships and interactions.

3.3.4 Design- & People-based Frameworks

The design thinking process models described in Chapter 3.2.2 are stage- and project-oriented sequence models to generate an intended outcome (McDonnell, 2015, p. 114; Verganti, 2017b, pp. 73–76). Design-based models and people-based frameworks focus on people as central agents for innovation. They provide approaches to support the organization as whole in the development of their innovation system. Design is applied as a strategic activity, alongside its technical and coupling function between departments, (Hobday et al., 2011, pp. 9–10). The innovation process and its management is described as act of design and construction (Dodgson, 2018, p. 51; Martin, 2013; McDonnell, 2015). The heterogeneous models in consideration here, design the innovation management in a firm holistically. They focus on shaping interactions, networks and organizational change to foster innovations. The example frameworks of design-driven innovation (Verganti, 2009), innovation by design (Lockwood & Papke, 2018) and creative construction (Pisano, 2019) are considered as models in this thesis, as they introduce alternative mental models of innovation processes and propose new methodologies to manage innovation.

The meta-model of design-driven innovations shifts the challenges for innovation management from traditional technology development to technology interpretation (Verganti & Dell'Era, 2015, p. 154). Against the background of distributed, open and collaborative approaches to innovation and an increasing accessibility to technologies and creative ideas, a company excels in the market by interpreting technology differently and by creating a new meaning: it addresses latent needs and "radically redefines the meaning of things" to the customer and user (Verganti, 2009, p. 116; Verganti & Dell'Era, 2015, pp. 145–147). Radical innovations are considered as a major source of competitive advantage (Verganti, 2009, p. 3). With a technology focus, and "culturally neutral methods" (ibid., pp. ix; p. 228) only incremental innovations can be achieved (see also Chapter 2.4.2). A company needs therefore to combine creativity with "forward-looking research" (ibid., p. xi) and initiate a design discourse with experts from diverse fields, i.e. interpreters inside and outside the organization, on a local and global scale (ibid., pp. 11–13, 119–120). The process of a design-driven innovation is an uncodified process of interpretation "interwoven into relational assets with a network of key interpreters" (Verganti, 2009, p. 14). Once these key interpreters are discovered, found and selected internally and externally, a close collaboration begins in which the relationships and discourses are placed above solution finding (ibid.). The challenge for management is accordingly to identify, nurture and convert the existing personal relationships into discourses for radical innovation of meaning. "Judgement and the ability to build social capital" (ibid.) are the key capabilities for executives when implementing design-driven innovations (see Figure 24).

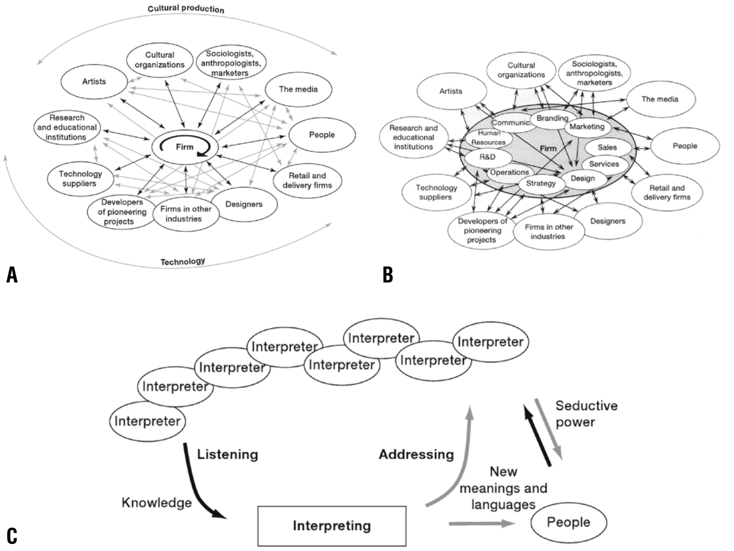

Figure 24: Process of Design-Driven Innovation (Verganti, 2009)

Design discourses and relational assets are essential elements in the process of design-driven innovation. **A** Design discourses occur throughout an organization among different actors and stakeholders. **B** They represent and provide relational assets, on which an organization can build upon. **C** The process of design-driven innovation consists of the performance of listening, interpreting and addressing. Visualizations by Verganti (2009, pp. 120, 134, 207).

Listening, interpreting, addressing are the main activities in the design-driven innovation process (ibid.; pp. 13, 134). In listening the information and knowledge of valuable interpreters is accessed, which broadens, challenges and questions the beliefs and structure of the company and its market in a context of changing environments; in interpreting, the company combines the knowledge it has gained from interpretation with its broader internal knowledge, technology and assets, and develops a unique proposal; the addressing stage initiates the preparation for the introduction of a new meaning in the market (Verganti & Dell'Era, 2015, pp. 152–153). External interpreters and executives play a key role in the model or framework: the interpreters have a bridging function as language brokers and mediators (Verganti, 2009, pp. 154–155); the executives give direction and develop the vision in a culturally subjective way (ibid., p. 227). The personal culture of executives together with the personal cultures of interpreters and people inside the organization constitute valuable relational assets of a company (ibid., p. 228–229). In this framework, design is understood as making sense of things and creating a new meaning (Verganti, 2009, pp. 22; 25–27; Verganti & Dell'Era, 2015, pp. 141–143), design practice becomes manifested in the art of discourse, of interpretation and critique, to form new thoughts and ideas (Verganti, 2009, pp. 119–120; Verganti & Norman, 2019).

In the example of "Innovation by design" (Lockwood & Papke, 2018) the framework is based on findings that innovation culture and design thinking tend to converge and increase economic performance. Companies are increasingly incorporating design as strategy and building up competencies in design thinking (ibid., pp. 17–19). Design thinking in this framework is understood as a particular way of working with a set of principles. It comprises: right problem identification, empathy and collaboration, learning through experiments and prototypes, integration of business aspects in the creative process (Lockwood & Papke, 2018, pp. 23–32). To build a successful design thinking organization, this particular way of working needs to be embedded in an organizational culture that is designed for awareness and constant adaptation. People in this culture are aware of their environment, of other people, their relations and interactions, they are also aware of the obstacles, options, knowledge and learning capacities of a firm (ibid., pp. 40–42). They question "how and why we interact with one another in our organization in the way we do" (ibid., p. 40) and decide, why, how and with whom to participate for innovation inside and outside an organization. In this way, design thinking organizations apply design thinking across all levels to meet emerging challenges and adapt to changing environments. They become successful "learning organizations" (ibid., p. 42). The framework does not propose a "process-oriented model of stages" (ibid., p. 27) to describe the needed steps towards a design thinking organization. Instead, it formulates attributes that describe successful organizations from practice. Based on empirical studies, ten attributes are specified (ibid., pp. 27–32):

- a design thinking methodology is implemented across the entire organization;
- a "pull factor" (ibid., p. 28) is nurtured to address emotion and increase human creativity;
- the focus of the organization is directed to finding "the right problems" (ibid., p. 28), to cope with their wicked nature and reframe them;
- a "cultural awareness" (ibid., p. 29) exists to notice and understand the way an organization and its people work and innovate;
- "curious confrontation" (ibid., p. 30) is practiced to embrace ambiguity and uncertainty in the problems to solve and to manage diverse thinking constructively;
- co-creation is conducted inclusively;
- "open spaces" (ibid., p. 31) are designed to support new work modes and play;
- a "whole communication" (ibid., p. 31) is conducted, to experience innovation as contextual inquiry, to use visualization for conveying information and storytelling for problems and solutions;
- the leadership is aligned;
- a purpose is given in adding value to the world.

The attributes can be flexibly approached by an organization. As a first step, they support the creation of a design thinking culture; secondly, they promote the implementation of a design thinking practice and eventually evolve into a design thinking organization. In this process of building "a culture of innovation" further "potential organization models of the future" (ibid., p. 208) can be explored and can evolve. 'Innovation by design' does not offer a model with graphical depictions, but provides a guide in written form, innovation managers can apply.

The continuous adaptation of an organization, its rejuvenation, is considered in a further example of models as "creative construction" (Pisano, 2019, p. 9). With reference to the expression by Schumpeter of "creative destruction" (Pisano, 2019, p. 2; Schumpeter, 2003, p. 83) a company needs to rebuild its innovation capabilities from within in order to respond to architectural, radical and disruptive innovations. Three fields are essential: an organization has to create an innovation strategy, has to design an innovation system, where the capabilities reside, and has to build an innovative culture, which permanently transforms and shapes the capabilities (Pisano, 2019, pp. 4, 15–17). In the innovation strategy the company formulates where and why it aims to compete and innovate, maps out opportunities, defines the direction of value creation and decides on the detailed innovation process to follow, depending on the context (ibid., p. 19). The innovation system is the organizational fit to the strategy, "a coherent set of interdependent processes and structures" (ibid., p. 27). It comprises the search for novel ideas, the synthesis of the elements explored into business concepts, and the selection of an opportunity to harness (Pisano, 2019, pp. 109–110, 176–177). People are a fundamental part in this system as innovation is seen at its core as "a human activity" (ibid., p. 179). They connect and bridge diverse fields, they explore, experiment and learn in appropriately designed processes (ibid., p. 151). The structures of an innovation system should support the "cross-flow of ideas, talent, expertise and experience" (ibid., p. 151). With its innovation system an organization needs to provide tools to deal with uncertainty and ambiguity, by applying advanced analytical tools, by working with hypothesis and developing critical discourse or "vigorous debate" (ibid., p. 172; and pp. 141–142, 158–174). The innovation process fluidly evolves during "highly interactive activities" (ibid., p. 177) of search, synthesis and selection; they are explorative, experimenting and learning activities (ibid., p. 142). Accordingly, the innovation system is a learning system (ibid., pp. 176–177). Building it, is a "systems design problem" (ibid., p. 110):

> *As a leader, you are taking on the role of an organizational engineer. Good systems engineers make their business to understand the components of the system, the way they interact, and the desired performance trade-offs. The same principles apply to designing innovation systems."*
>
> *(Pisano, 2019, p. 110)*

Structured models of phases and stages do not consider the dynamics of a learning system and their demands for reconstruction. They draw "their inspiration from manufacturing processes" (ibid., p. 142) in which predictability, optimization and control are assumed. Building an innovative culture is the third field leaders have to perform and maintain. As "cultural architects" (ibid., p. 197) they engineer a culture of positive and demanding tensions between failure and competence, experimentation and discipline, psychological safety and critical debate, collaboration and individual accountability, flat hierarchies and strong leadership (ibid., pp. 197–216). These measures are interrelated to the organizational systems a company has developed or intends to design (ibid., p. 216).

The framework of creative construction offers guidance for a constant transformation of the way a company innovates and the way it is structured. "The design of a product mirrors the design of the organization that created it." (ibid., p. 144). Hence, the structure and culture of an organization shape thinking and behavior, and also limit its possibilities (ibid., p. 150). In conclusion, an organization needs to be shaped by "creative constructive leaders" (ibid., p. 218). They continuously and simultaneously design and re-design the innovation strategy, innovation system and innovation culture. Similar to 'Innovation by Design' the model of 'Creative Construction' is communicated through verbal means. It makes use of diverse metaphors representing creative construction as journey, as the creation of an organizational DNA, engineering a machine, architecting a house or bespoke tailoring, but the model is not represented graphically.

3.4 Findings – Innovation Management in Transformation

Innovation management seeks to structure the unplannable process of innovation over time. By fostering non-routines and developing new routines in an organization innovation management helps to build up dynamic capabilities for complex and changing challenges. Innovation management is influenced by overarching conceptualizations (referred to as innovation models), concerned with how innovations occurs and how organization will guide and structure their processes. The innovation models in academia and practice change over time, as indicated with the terminology of 'generations' of innovation models. At a process level, innovation process models are developed as methodologies, meta-tools and frameworks. They evolve from sequential linear prescriptions for project management and control to systemic and adaptive frameworks for manoeuvring and design in changing environments. Though new sequence models, as shown in Chapter 3.2.2, have been developed to fit requirements of flexibility, adaptation, agility, they still focus on the innovation objective, its single process and outcome. Design thinking process models, as referenced in Chapter 3.2.3, are seen as sequential, non-linear models. They integrate iterations in the process, apply thinking and tools from design disciplines, outline collaboration and experimentation, reframe and rename the particular activities for innovation in their scope and duration. Their phased structure is targeted at accelerating the innovation process with a human-centered approach. But design thinking with this ambition is contested in being "a workable innovation model in firms" (Hobday, Boddington, & Grantham, 2012, p. 22). It is questioned if it aids a systemic management of innovation processes with the goal of creating open, radical and disruptive innovations (Blakely, personal communication, February 2020; McDonnell, 2015; Verganti, 2009).[36] In his critique on prominent process models of design thinking Verganti (2017a) states:

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[36] In a personal communication on February 11, 2020, Dave Blakely, Senior Vice President of Education and Masterclasses at business incubator MACH49 in the San Francisco bay area, remarks, that design thinking is only one ingredient to sophisticated innovation. Agile or lean, open and disruptive aspects need to be integrated as well.

> *"To make design thinking palatable to citizens of the business world, most advocates of what is labeled "design thinking" have articulated design as a set of clearly articulated processes and methods, packing it into 5-step processes, double diamonds, brainstorming, quick ethnography, empathy maps, customer journeys, blueprints, and the like.*
>
> *This enables them to bring design closer to the language of business schools and the managerial palate. But by doing this, most promoters of design thinking eradicate the cognitive core of how designers think. Missionaries of design thinking for business have done everything they could to tell managers what managers wanted to hear: that design is not a matter of guts, intuition, or felt-sense, but a matter of process."*
>
> *(Verganti, 2017a, p. 101)*

Reviewing the selected sequence models, the following observation can be made. Sequential approaches and "variations on linear thinking continue to dominate models of innovation" (Trott, 2017, p. 31). The models support clarity and decision making. They are normative, prescriptive and descriptive; they formulate "actionable steps and processes rather than explaining the inner workings of an organization as a whole" (Chantzaras, 2019b, p. 541). Social interactions are not integrated and depicted in the models, though the respective authors mention their value. Due to the normative nature and the proposition of defined steps, the design of a deviant process is limited. Aspects of analysis and decision making are foregrounded, while aspects of synthesis and design remain vague. Required design skills and design expertise in this regard are rarely mentioned. The models address a generic single innovation process, rather than a very own system and culture that an organization develops for innovation. In this perspective, the application and use of existing sequence models across organizations and industries may be questionable. If organizations develop their innovation processes based on conceptualizations and methodologies of this kind, they may not achieve a competitive advantage. Organizations would resemble one another in their processes and structure, and show an organizational isomorphism (Hargadon, 2015, p. 168; Hasse & Krücken, 2013, p. 240; van der Duin & Ortt, 2020, p. 27). If "good management" as Christensen (2016, p. xvi) found in his research on disrupting innovation, "was the most powerful reason they [well-managed firms] failed to stay atop their industries" (ibid.), companies may lose their innovative capabilities not despite their innovation management, but because of it. Table 3 summarizes the extent to which the selected examples consider the conceptualization of an extended process view of innovation, as suggested in this thesis.

System models address the deficiencies of sequential models, especially against the background of disrupting, radical or "transformative innovation" (Pisano, 2019, p. 142; and Dodgson et al., 2011, pp. 188–189; Dodgson et al., 2015b, pp. 13–14; Verganti, 2009, pp. ix-x, 14). They focus on the structure of innovation processes in an organization and consider emerging challenges as well as new demands on innovation management. Context, dynamics, fluidity, networks, people and design are emphasized in the transition from a directed sequence view into a system view. The context of an organization is not stable, but changing and to some degree transformable by the organization. The contextual framework (Chapter 3.3.1) as well as the dynamic and fluid models (Chapter 3.3.2) outline this. Complexity is embraced and integrated, instead of reduced and controlled. This can be observed in the build-up of learning capabilities, the conduct and experience of learning cycles, continuous exploration and curious confrontation of the dynamic models (3.3.2) and the design-based frameworks (3.3.4). Network models (3.3.3) provide new depictions of the complex structure of relationships, ties and interactions in an organization. The idea of man and the human image is shifted from a negative connotation. Organizations need to speak less of resistances among employees, colleagues and other stakeholders, but outline a positive attitude and culture, where the organization and its innovation management empower and support its people. The examples of dynamic models (3.3.2), design-based and people-based frameworks (3.3.4) illustrate this shift. People are seen as designers and creators of the innovation processes, instead of as users applying a pre-defined sequence and executing management decisions. The key role of the human factor and the social interactions are represented in the dynamic and network models (3.3.2 and 3.3.3) and the design-based frameworks (3.3.4) for example through the concepts of interpreters, design discourse, vigorous debate, social network, social capital, structural holes, play and learning.

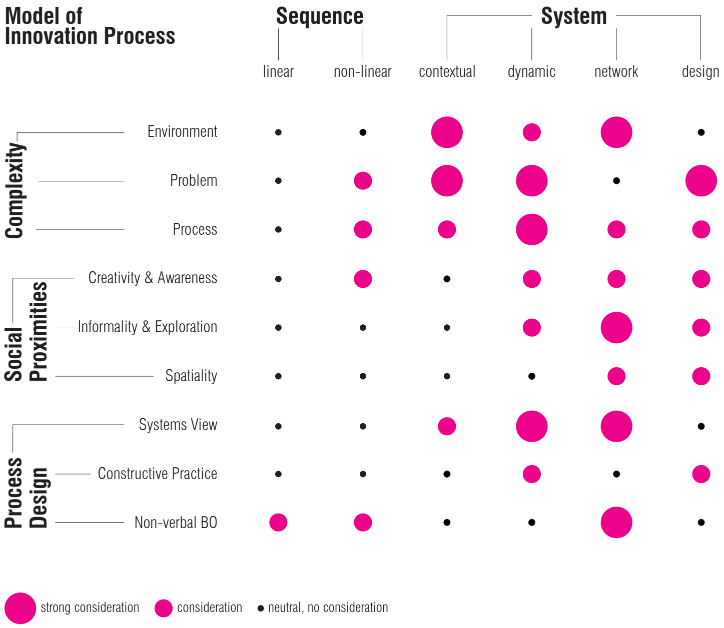
Network models (3.3.3) in this regard, excel by displaying the relationships, strengths of ties and proximities visually. They offer new perspectives for the analysis and understanding of emergent behaviors. Objective and neutral methods and tools in innovation management, as stage-gate models, are questioned. Contextual models (3.3.1) integrate them as elements in a tool-box of context-specific innovation management. Dynamic models (3.3.2) and design-based frameworks (3.3.4) replace them with design-driven or constructive approaches. Unlike design thinking process models, design in the dynamic models and design-based frameworks is understood as activity for developing and carrying through the innovation process in relation and response to the context and the challenges to be met. Design does not follow a sequence of steps. On the one hand, it is reflective and explorative, open to discussion and to giving new meaning to things. On the other hand, it synthesizes, experiments, plays and prototypes. The notion of play in particular is emphasized in the 'Think, Play, Do' model (3.3.2):

> *"Although all the areas of the innovation process we have analysed are important, perhaps the one that is most deserving of attention is that of play. Play is the lubricant in the innovation engine, it is what keeps the parts working together to create movement. The roles of play, design, and prototyping are ripe for future research."*
>
> *(Dodgson et al., 2011, p. 202)*

The aspects system models consider are related to the conceptualization of an extended process view. In Table 2 the referenced system models are compared to the extent they consider aspects of complexity, social interaction and process design. With their focus on context, system models address the conceptualization of complexity and process design. By integrating dynamics, networks and people they take into consideration social interactions and process design. In dynamics, fluidity and design, complexity and process design aspects are addressed.The reviewed system models also have limitations in reflecting the extended process view as proposed in this thesis.

Table 2: Comparison of Innovation Process Models

The sequence and system models examined are compared with each other. They are evaluted in terms of the extent to which they take into account the extended process view with regard to complexity, social interaction and process design.



Model of Innovation Process		Sequence		System			
		linear	non-linear	contextual	dynamic	network	design
Complexity	Environment	•	•	⬤	●	⬤	•
	Problem	•	●	⬤	⬤	•	⬤
	Process	•	●	●	⬤	●	●
Social Proximities	Creativity & Awareness	•	●	•	●	●	●
	Informality & Exploration	•	•	•	●	⬤	●
	Spatiality	•	•	•	•	●	●
Process Design	Systems View	•	•	●	⬤	⬤	•
	Constructive Practice	•	•	•	●	•	●
	Non-verbal BO	●	●	•	•	⬤	•

⬤ strong consideration ● consideration • neutral, no consideration

While the examples consider some aspects of the conceptualization well, the aspects together are not reflected. The models integrate the complexity of environment, problem and process, but differ in their integration of social interactions and process design. While informality and exploration are emphasized extensively in the dynamic and network models (3.3.2 and 3.3.3), the spatial dimension and use of visual analysis is only seen in the network models. In regard to process design the models provide systemic and holistic views, but use design as constructive practice in broad and generic ways. The visual construction of thought and use of non-verbal boundary objects as discussed in Chapter 2.4.2 and 2.4.3 are not emphasized. The innovation process models are used less as "an instrument to explore, manipulate, and experiment with a theory" and develop better approximations to reality (Godin, 2017, p. 208). With the exception of the 'Innovation Journey' the system models analyzed are instead normative and prescriptive, based on empirical findings and research in practice.

The use of metaphors in innovation literature – such as DNA, organism, house, building, architecture, construction, machine, tailor, ship, journey, skiing – seeks to describe the uniqueness of the innovation process and its management. But it does not sufficiently convey and transfer the potentials and capabilities from the discipline or field the metaphor originates from.[37] This is of importance for this thesis when the metaphor relates to building architecture. As will be shown in Chapter 5, architecture is not simply making "choices […] about where to put up "walls" " (Pisano, 2019, p. 146) and laying the foundations for a building (ibid., p. 150), a misconception Pisano discusses in 'Creative Construction'. In the context of this thesis, the thinking and tools of architecture in separation from their relation to buildings is central. Architecture as a discipline, reflects, designs and engineers interactions with the use of models as non-verbal boundary objects. It synthesizes a new whole from existing parts

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[37] The use of metaphors in the context of organizational design and organizational structure has been elaborated by Morgan (1997). He analyzes different metaphors for organizations, researches their implication for thinking and outlines their shortcomings.

and organizes the in-between and informal relations. For management "the social life of firms" (Hobday et al., 2011, p. 14) and the informal organization in "the "white spaces" (ibid.) between the boxes on the organization chart" are becoming increasingly important. Innovation management, for which the same is valid, may benefit from a new methodology to design innovation process from the field of architecture (Boland & Collopy, 2004b; Brown, 2009; Dodgson et al., 2011; Hobday et al., 2011, p. 14; Luebkeman, 2015b). Before the architecture of innovation processes is explained in detail, a selection of applied methods and tools for innovation processes design in practice will complete the managerial perspective.

4

4 – Related Applications: Methods & Tools in Management Practice

Innovation process models are considered as methodologies and meta-tools. They provide a frame for organizations to deduce concrete activities following a particular conceptualization and guidance. At an operational level, organizations use applications. In the view of this thesis, applications are methods and tools that support the transfer of the methodologies and frameworks to concrete action in practice. The applications meet specific requirements deduced from the innovation process model a company follows in its innovation management. For example, when an innovation process model is based on collaboration and social interactions, an appropriate tool supports knowledge exchange and project work between different stakeholders. It offers features to manage idea generation and record the different proposals. When an innovation process model emphasizes sequences and performance, an appropriate tool assists in structuring and tracking the innovation stages and decisions gates across an organization and between organizations. It provides recommendations for concrete actions and dashboards for assessing innovation initiatives. Applications shape the behavior of the people on a daily basis and how they conduct and implement innovation processes in practice. If a methodology respectively an innovation process model reflects an extended process view of innovation, the corresponding application needs to transfer the way of thinking and acting with its features. Innovation process models and applications are interrelated. Therefore applications from practice need to be reviewed to determine the extent to which they transfer requirements arising from an extended process view. The number and variety of offerings has increased in the past two decades with the development of new digital technologies (Endres, Huesig, & Pesch, 2021, p. 4; Huesig & Endres, 2019, p. 304).

For this thesis, examples are reviewed from computer-aided innovation management tools, digital software and web applications, digital and analog working methods, and tools to analyze, organize, improve and re-define phases of innovation processes. The selection has been made on the basis of their market position and the features they offer against the background of an extended process view. Regarding the market position, leading market applications are reviewed as well as new entrants in innovation management that suggest novel tools and methods. Regarding the features, the selection concentrates on applications that address aspects of complexity, social interaction and process design.[38] The applications are clustered by the breadth of their scope: company tools like enterprise architecture tools and business model generation address the whole company and its processes; innovation management software provides digital tools for configuration, structure and management of innovation processes; innovation process consulting focuses on developing innovation capabilities in organizations. The different applications are assessed by the extent to which they support a methodology of extended process view and offer corresponding features. As elaborated in Chapter 2.5 a methodology for an extended process view functions integratively and interactively as well as being explorative and constructive. A tool for this sort of methodology should support collaboration

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[38] Project management and consulting tools like system analysis, organizational analysis, situation and context analysis will be not explicitly described. For an overview and description of these and other tools see Andler (2013, pp. 321–365).

and modeling. To transfer and implement the methodology, a tool should provide features for dynamics, multi-dimensionality, systemic perspectives and visual thinking. Differently stated, this chapter assesses which applications support the practice of an innovation process design, as proposed in this thesis.

4.1 Company Tools

Enterprise architecture tools support decision making processes regarding strategy, resources, people, business, manufacturing and finance. Their integrative approach, which relates organizational structures, processes and information technology, addresses the company as a whole, in which innovation processes are one component. Leading market examples are Avolution, BIZZdesign and ardoq according to industry reports for 2019 (McGovern & Resnick, 2019).[39] They analyze enterprise data, work with dynamic visualizations that change in response to changes in parameters and input data, graph charts and dashboards, and social interaction technologies (ibid.).

Business model tools, in the second group of examples, deal with processes of value generation for enterprises or their parts, e.g., business units (Szopinski, Schoormann, John, Knackstedt, & Kundisch, 2020, p. 470). The tools developed since the turn of the millennium to generate and innovate business models outline visualizations with different levels of detail and chart the relevance of relationships and interdependencies. Business modeling tools deal with more qualitative aspects than enterprise architecture tools; they use visualization techniques to develop, discuss and apply a new strategy (Casadesus-Masanell & Ricart, 2010, p. 205; Täuscher & Abdelkafi, 2017, pp. 162–163). They are of interest as they promote an integrative view of business processes like innovation with an emphasis on collaboration and visualization.

4.1.1 Enterprise Architecture Tools

In enterprise architecture tools, the innovation process is seen as one business process among others, which can be assessed, structured and managed based on enterprise data and its analytics. The focus is on efficient operations and quantifiable performance indices in innovation processes. In general, the tools are designed to be easy-to-use and intuitive according the vendors. They provide graphical charts, analytics based on graphs, dashboards and dynamic visualizations that change in response to changed parameters or inputs. The use of visual elements makes it possible to explore and understand complex challenges in an organization, as well as patterns of performance and development. Enterprise architecture tools increasingly integrate digital social interaction technologies, such as chat, comment or streaming functions, to enable and foster communication and collaboration among the users. Tools in the marketplace differ in their features and degrees they allow the user to adjust, transform and model the processes, and to interact and collaborate with each other.

In the example of ardoq, a dynamic and data-driven platform, data, information, and knowledge are entered, retrieved from other applications or

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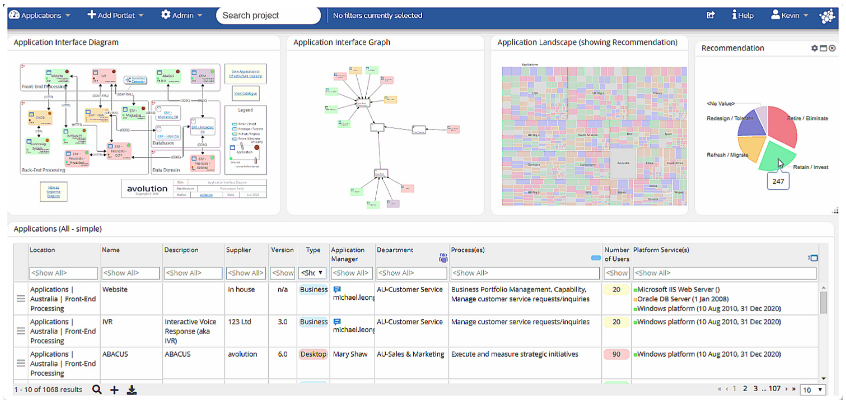
[39] In a report of the research company Gartner on enterprise architecture tools, the vendors Avolution, ardoq and BIZZdesign were rated as leaders in the industry (van der Heiden, Jhawar & Hart, 2021). For further information regarding the vendors see for example Avolution Abacus: https://www.avolutionsoftware.com/abacus/; BIZZdesign: https://bizzdesign.com/solution/enterprise-architecture/; ardoq: https://www.ardoq.com/use-cases/business-process-modeling.

sources and stored as components and references in a repository (ardoq, 2019). With default rules of component types and references between the type, termed “out-of-the-box meta models” (ardoq, 2019, min: 1:24) the user generates dynamic visual depictions, dashboards and presentation, which automatically adjust to changes. In contrast to mind-mapping or graphical tools, in which the user partially creates the visual depiction, “you don’t draw in ardoq, you add and connect data to create information that can be analyzed and consumed” (ardoq, 2019, min: 2:01). Information from the organization at large, from stakeholders and experts can be sourced and integrated by surveys (McGovern & Resnick, 2019).

In the examples of the vendor Avolution and its derivate Abacus graph chart views allow the user to explore the relationships of different components, for example between people, between trends, which have been sourced by trend radars or research, or between the costs of different fields. The users can interact with this graphical depiction of organizational processes. For innovation purposes an interactive digital portal is offered, to enable communication, collaboration and integration of different active parties and stakeholders. In different areas, which are simultaneously displayed or available in the software, ideas can be shared and circulated, assessed, elaborated and approved as innovation project. Its impact and outcome as innovation project can be visualized and further analyzed. The software gives support to “streamline innovation management” (McGovern & Resnick, 2019).

As a collaborative business design platform, the example of BIZZdesign/HoriZZon, provides an intuitive modeling software for dynamic visualizations and dashboards. The user can set different views or areas with e.g., graphs, dashboards, process models to see information at once and tap into these areas (BiZZdesign, 2022a). Depending on the user’s role, e.g., as executive, strategy, change or project manager according areas can be defined: A ‘strategy and motivation area’ offers insight into possible ideas and context; an ‘understand area’ summarizes the analysis and intelligence conducted or in progress regarding a project; a change area lists existing and needed capabilities as well as the current and target operating model; an investment and execution area is dedicated to the setup of the project management for the innovation initiative. In another view, the “Strategy on a Page view” (BiZZdesign, 2022b) displays the possible stages of an innovation project with different kinds of information regarding strategy, operation or risks. The tool supports an interdependent way of thinking, in which value streams and business capabilities are aligned (McGovern & Resnick, 2019).



Applications (All - simple)

Location	Name	Description	Supplier	Version	Type	Application Manager	Department	Process(es)	Number of Users	Platform Service(s)
<Show All>	<Show All>	<Show All>	<Show All>	<Show	<Shc	<Show All>	<Show All>	<Show All>	<Show	<Show All>
Applications | Australia | Front-End Processing	Website		in house	n/a	Business	michael.leon	AU-Customer Service	Business Portfolio Management, Capability, Manage customer service requests/inquiries	20	Microsoft IIS Web Server () Oracle DB Server (1 Jan 2008) Windows platform (10 Aug 2010, 31 Dec 2020)
Applications | Australia | Front-End Processing	IVR	Interactive Voice Response (aka IVR)	123 Ltd	3.0	Business	michael.leon	AU-Customer Service	Manage customer service requests/inquiries	20	Windows platform (10 Aug 2010, 31 Dec 2020)
Applications | Australia | Front-End Processing	ABACUS	ABACUS	avolution	6.0	Desktop	Mary Shaw	AU-Sales & Marketing	Execute and measure strategic initiatives	90	Windows platform (10 Aug 2010, 31 Dec 2020)

1 - 10 of 1068 results

« ‹ 1 2 3 ... 107 › » 10

Figure 25: Example of Visual Interfaces for Innovation Process Modeling

Visual interface for innovation process modeling and management on the example of Abacus by Avolution (2022).

4.1.2 Business Model Design

In the context of business model design existing tools support analysis, creation and development of new processes that a company can apply to generate value for customers and itself (Osterwalder, 2004, pp. 14–16; Szopinski et al., 2020, pp. 469–473). Though the innovation process independent from new business creation is not directly addressed, the tools can be used to analyze and represent innovation processes, especially because of their emphasis on non-verbal means (Eppler & Hoffmann, 2013, pp. 9–10; Täuscher & Abdelkafi, 2017, pp. 160–161). Aside from being integrated in larger software platforms as enterprise architecture tools, approaches and tools for business model design and generation have been developed independently and are available as stand-alone applications. The business model "is a reflection of a firm's realized strategy" (Casadesus-Masanell & Ricart, 2010, p. 205), which represents the logic of the way the firm is structured, the way the firm operates and conducts tasks, and the way the firm creates value in the market with its distinct model and its intended processes. As "conceptual blueprint of the company money earning logic" (Osterwalder, 2004, p. 17), the business model is an intermediate level between the planning level of strategy and implementation level of process (ibid., p. 14). It is interrelated with the strategy of a firm, takes into account its vision, values and culture, and provides the frame and orientation for actions (Casadesus-Masanell & Ricart, 2010, pp. 204–205; Eppler & Hoffmann, 2013, pp. 7–8).

For business model design, creativity, collaboration and the visual abstraction of complexity is essential (Eppler & Hoffmann, 2013, p. 9; Simonse, 2014, p. 67; Täuscher & Abdelkafi, 2017, p. 161). People from different working fields and disciplines interact, to create and develop new structures and processes for a competitive advantage. The multitude of choices and consequences in a firm need to be reduced to a cognitively manageable degree, which allows for experimentation with new relationships, interactions and processes (Casadesus-Masanell & Ricart, 2010, pp. 197–198; Eppler & Hoffmann, 2013, pp. 10–11; Täuscher & Abdelkafi, 2017, pp. 160–162). Finding the appropriate level of abstraction respectively scale for analyzing and reviewing a business model depends on the point of interest and the particular expertise of the parties involved:

> *"An analyst studying a particular organization's business model will often be unable to process the complete model because it is too complex (there are too many choices and consequences). But, by zooming out, although details blur, larger 'chunks' - aggregations of those details - become clearer. Finding the 'right distance' from which to assess a given business model is more an art than a science. Looking from too close at every choice and consequence, the analyst will miss the larger picture of how the business model works in overall terms e but looking from too far away will mean all interesting details are lost."*
>
> *(Casadesus-Masanell & Ricart, 2010, p. 200).*

The use of visualizations and "visual artifacts" (Täuscher & Abdelkafi, 2017, p. 161) as "boundary objects" (Eppler & Hoffmann, 2011, p. 31; 2013, p. 9) plays a an important role in the business design and business innovation process to (ibid.; Szopinski et al., 2020, pp. 475–476): they support creativity, communication, collaboration, decrease the cognitive load, serve as external storage for information, make knowledge explicit and accessible, structure and group elements which belong together, show existing relationships and reveal opportunities for new connections or interactions in the business model. Besides giving support to dealing with complexity and knowledge sharing, appropriate visualizations provide assistance to "overcome the dominant logic of a firm" (Eppler & Hoffmann, 2013, p. 10), which represents the conceptualizations the organization and its management levels have regarding the business processes and the related resources. The dominant logic, similar to the models of innovation, are implicitly communicated or explicitly codified and shared in "schemas, cognitive maps, mind-sets as well as belief structures and frames of reference" (ibid., p. 6). By visualizing existing business models and dominant logics, the parties involved can discuss the prevailing conceptions, reframe business complexities and explore other logics (ibid., p. 10).

Visual business model representations are for example grouped in terms of the elements they display, by transactions they suggest or by causes they explain (Täuscher & Abdelkafi, 2017, pp. 164–167). In the elements views, visual depictions of business models display information on pre-defined topics or elements, as key partners, value propositions, customer segments, or developed themes. Transactional perspectives show streams of tangible or intangible objects, actions and interactions between elements. Causal views convey dependencies and relationships between elements (ibid.). Advanced models integrate two different views, elements and transactions, or elements and causes, but are limited in integrating all three perspectives of transaction, elements and causes. Analog tools to visualize and design business models are also available. Working face-to-face and "draw by hand in pencil" (Rother & Shook, 1999, p. 14) as proposed by the technique of value stream mapping with senses additional to the visual (haptic, sensoric, smell, gesture) are now being replaced by virtual platforms, offering, for example, simulations and modeling tools from Insight Maker (Szopinski et al., 2020, pp. 469–470) or collaborative online whiteboards from MIRO.[40]

Despite the empirically stated benefits for innovative projects to interact physically in-person, digital tools ease and enhance the processes in other important aspects. They integrate an extended network of participants and foster participation, they externalize information and knowledge in a graphical and comprehensible way visible for everyone, and they back up or assess ideas and concepts with data and analytics (ibid.). The software tools in use for business model innovation differ in their technical architecture, and provide to a greater or lesser extent possibilities for modeling and collaboration. Regarding modeling functions, elements in the business model are customized, developed, commented, assessed, navigated and filtered during the design process. In terms of collaboration, the software offers options for how to communicate between users, how to synchronize the work, to manage users, their rights and activities, and the use of repositories to centrally access information (Szopinski et al., 2020, pp. 475–476). Business model design tools provide degrees of freedom for the user to develop the model and interact. They also offer possibilities to combine qualitative aspects such as vision, strategy and culture with quantitative aspects of operation time, cost and outcomes.

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[40] Insight Maker is a free, web-browser based simulation and modeling platform https://insightmaker.com. MIRO is an online collaborative whiteboard platform https://miro.com/index/

4.2 Innovation Management Software

Digitization of data, information and knowledge, advancements in computing power and software intelligence offer new possibilities for designing and managing innovation processes (Huesig & Endres, 2019, pp. 302, 304). Innovation management software addresses the particular complexities in innovating, the growing importance of social interaction, and the management of agile work processes as introduced in Chapter 2 (see also Chantzaras, 2019b; Lundberg et al., 2014). Its origins are rooted in computer-aided innovation (CAI) which initially approached the early stages of innovation processes and new product development with the use of information technology and computer-aided tools (Huesig & Endres, 2019, p. 303; Hüsig & Waldmannstetter, 2013). In innovation management software different system developments are covered, which have been developed before. Hüsig & Waldmannstetter (2013) outline:

> *“ [...] we want to address a stream of research regarding CAI, which is rooted in Ideas Management Systems, ESS (Employee Suggestion Systems), Management and Marketing Information Systems (MIS/MAIS), Decision Support Systems (DSS), PLM and Group Decision Support Systems (GDSS), that have been developed specifically to support innovation activities. We call specific software tools for innovation management ‘Innovation Management Software’ (IMS).“*
>
> *(Hüsig & Waldmannstetter, 2013, p. 135–136).*

Innovation management software represents in this perspective “a subcategory of CAI that addresses especially the innovation management activities and methods” (Huesig & Endres, 2019, p. 305). It provides an integrated set of methods and tools, which are built upon a specific theory, approach or methodology, for analyzing how innovations occur at present and in future, how their generation needs to be structured and designed, and what elements matter for creating an innovative organization (Hidalgo & Albors, 2008, p. 117). They differ in terms of functionality, scope and features for idea management, for management of product development or innovation strategy (Huesig & Endres, 2019, p. 305). Innovation management software addressing all three of these aspects or “functional groups” (ibid., p. 305) is considered as multifunctional. If it additionally integrates supporting features to the different functional groups it is described as “total solutions” (Huesig & Endres, 2019, p. 306; Hüsig & Waldmannstetter, 2013).[41] Multifunctional and total solution software are considered in the following as innovation management platforms with a modular and platforms with a holistic approach (Huesig & Endres, 2019, p. 304). The first group provides a platform with independent applications for specific demands, the second group serves holistically an innovation system “in which integrated internal and external communities are fully incorporated” (ibid., p. 304). The distinction is gradual and temporary as the market in that field changes dynamically by scope of offerings and services.

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[41] Though the software is regarded as tool, the term tool is not consistently used in academic literature and management practice. The terms ‘technologies’, ‘techniques’, ‘methodologies’ and ‘methods’ are occasionally used to describe tools, e.g., in Hidalgo & Albors (2008, p. 117).

4.2.1 Module-structured Innovation Management Platforms

Module-structured innovation management software provide a central platform, where idea management, new product or service development and development of innovation strategies can be run separately or integrated and interdependent (Endres et al., 2021, p. 5). They can be extended by further applications, e.g., the integration of external parties, trend radars or market intelligence and consulting services. The platforms promote communication and collaboration between employees of a firm and between external parties. They emphasize an organization's culture and the collective intelligence or the intelligence of a crowd as essential drivers for innovation (Huesig & Endres, 2019, p. 303). Creativity and the ideas of individuals are sourced and discovered with information technology at scale, meaning that people across an entire organization, from different departments, functions and location are enabled to participate in an innovation process. To address and foster open, networked and distributed innovations, large and diverse groups of people within and outside the organization are activated, engaged and guided in the process from idea generation to implementation.

The platforms provide structures to participate, socialize, create communities, propose ideas or accept a given challenge. Common to market leading platforms are the use of social media features, two-dimensional graph visualizations, dashboards and online collaboration tools, to create ideas and develop projects. If innovative ideas are pursued further, the platforms offer supporting features for individual employees and teams such as project management tools, practical guides or consultancies. In top-down approaches in the practice of innovation management structures a distinct group or department develops the innovation strategy, initiates, manages and controls the innovation processes. In contrast, the examples of innovation management platforms in consideration here transfer a bottom-up methodology. Innovation is regarded as a matter the entire organization and its employees need to take care of; it is open to all, independent from hierarchies and departments; it is dependent on the creativity, motivation and interaction of people from a diverse field of knowledge and expertise, which can be sourced and fostered company-wide and externally, e.g., with partners, industry networks or other academic communities (Chesbrough, 2003, pp. 19, 51–52; Leitner, Warnke, & Rhomberg, 2016, p. 232).

The platforms function for example as market-places for ideas and tournaments (Garud et al., 2013, p. 783; Terwiesch & Ulrich, 2009). Through a transparent voting, contest or selection system, the favored contributions are progressed in several gates towards their implementation, depending on the characteristics of the particular organization using them. Enterprises like InnoCentive, Brightidea, exago, Ideadrop or itonics offer collaborative platforms to crowd-source ideas within and outside an organization (Staten & Hopkins, 2020).[42] In general, the innovation management software in use is customized to the needs and requirements of an organization and expandable with modules as specified venture labs, trend radars and consulting services for e.g., setting

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[42] InnoCentive is a web-based open innovation market-place proposing innovation challenges to a global community https://www.innocentive.com. Brightidea is an idea management software for employees in an organization https://www.brightidea.com. Exago is an innovation management platform for idea management, collaboration and performance assessment https://www.exago.com. Idea Drop is an innovation management platform supporting the innovation funnel from early stage of crowdsourcing and idea development and selection to implementation and performance analytics https://ideadrop.co. Itonics is a web-based innovation management platform offering integrating modules from trend management to idea management and strategic resource management https://www.itonics-innovation.de.

up innovation programs or run particular innovation initiative (Endres et al., 2021, pp. 6–8; Staten & Hopkins, 2020). According to the vendors, particular algorithms analyze existing enterprise data (e.g., on resources, cost, production processes, business performances, patents) and the data or information contributed by theemployees regarding innovation (e.g., ideas, inventions, best practices), to ensure the detection of new opportunities and the efficient management of multiple innovation process. The different processes are managed simultaneously and independently from locations across the organization.[43] The features the platforms offer mirror and follow a particular methodology, how the innovation processes shall be conceptualized for a company. Idea generation, innovative solutions and innovation project management are centered, whereas the organizational structure and visualization of a company with its interdependent and interrelated elements is not addressed. Adjustments of the software to fit a company's demands for a different innovation process model are limited. Reviewing the examples, innovation management software digitizes a linear innovation processes model and the associated activities that prevail in the particular industries. Especially for large-sized and global enterprises they serve as a tool to scale and "streamline" (Exago, 2021) proposed innovation methods and processes and manage them efficiently. Though the company can customize the software it also adapts itself to the platform and the features it offers, and through this to its implicitly assumed or explicitly stated methodology. In one example, the platform offered by IdeaDrop reduces complex interactions between different parties with a streamlined process for idea management and the integrated use of different means of communication and collaboration across devices and operating systems (see Figure 26).

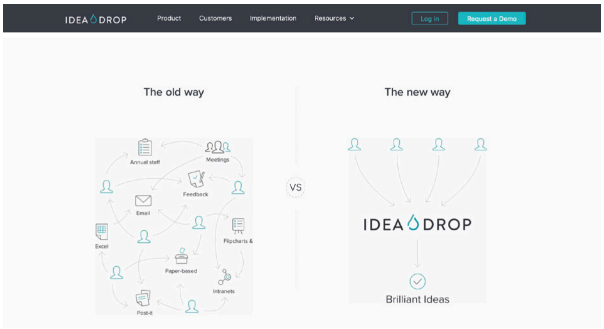

Figure 26: Example of Optimized Idea Management Processes

Centralized flows of idea management in the example of Idea Drop (2021).

The broad range and variety of modules and tools offered may run counter to the clarity and guidance companies seek in applying innovation management software (Huesig & Endres, 2019, p. 311; Staten & Hopkins, 2020).

4.2.2 Holistic Innovation Management Platforms

Holistic innovation management platforms provide a "one-stop-shop" (Duran, 2020) or "all-in-one (…) platform" (Planbox, 2022a), to integrate all innovation related activities from idea to implementation. Contributions of ideas, innovative initiatives and projects can be run as organization-internal or in collaboration with external partners, communities, networks and new parties, who participate

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[43] See for example BrightIdea https://www.brightidea.com and Exago https://www.exago.com.

in a challenge or contribute to the solution for a proposed project. The software also offers modules to be used independently, but to begin with the creation of a proprietary innovation eco-system for the company is targeted. Crowd-based processes, data-driven analytics and search technologies supported by artificial intelligence to discover problems trends and opportunities foster initiatives and support innovation processes. The platforms construct their digital space following the vendor's proposed principles and methodology. In the example of Planbox, a leading market platform, the ISO 56000 Standard of innovation management is transferred to a digital application (Planbox, 2022b).[44] In the case of innosabi, a platform with growing market acceptance, a methodology of agile crowdsource innovation developed by the company is transferred to a digital infrastructure (innosabi, 2022a; van Delden, 2016, pp. 18–26; van Delden & Chia, 2020, pp. 49–60).

Planbox provides a modular platform for "the full innovation portfolio management lifecycle" (Planbox 2022c) and offers in parallel programs for the build-up of employee cababilities (Planbox, 2022d). The solutions proposed are structured according four stages of "Discover, Innovate, Develop, Realize" (Planbox, 2022c) in innovation funnel. Its interactive structure allows to collaborate across the teams, departments and locations, and eases communication with a dynamic language translation. The activities proposed when using the platform employ elements of gamification, through which participants and users are engaged in innovation initiatives, measured in their performances and are given recognition or rewards. The parallel tracking and analysis of activities and results are visualized in dashboards configured for relevant company metrics and trends. For example, successful individuals, teams or departments can be identified, the absence of activities observed, or the disconnection of areas in the organization localized. The innovation management software is supported by client consulting and client guidance with feedback loops based on insights gained from the use of the platform and the implemented innovation programs (Staten & Hopkins, 2020). It offers further integration through "AI-powered self-driving innovation" (Planbox, 2021): accessible internal and external data sources such as social media feeds and databases of patents are processed, to discover and identify opportunities, enable building up teams and automating routine tasks in the idea generation phase. Innosabi integrates enterprise data, people and ideas in an innovation ecosystem based on a methodology of a crowd-sourced innovation approach with principles of agile software development (innosabi, 2022a; van Delden & Chia, 2020, pp. 51–53).[45] The principles of agile innovation comprise openness through communication and dialogue; collaboration for a shared goal; prototyping for constant improvement and learning; adaptability when facing change and transformation (van Delden & Chia, 2020, p. 53). The innovation tools and methods provided are continuously improved and integrated in the platform to connect the users to new insights, developments and useful methods regarding digitization and innovation. "The innosabi Software Suite offers all the necessary tools to cover innovation end-to-end" (innosabi, 2022b) which consists in digital tools to generate, develop and manage insights, ideas, community, partner, start-ups and "technological knowledge and expertise" (ibid.) residing in an organization.

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[44] The information regarding the ISO 56000 Standard was shared during an online interview with a company representative, conducted by the author on July 30, 2020.

[45] The 'Manifesto for Agile Software Development' builds the basis for the agile innovation approach of innosabi acc. van Delden & Chia (2020, pp. 34–44). The manifesto states core values as: "Individuals and interactions over processes and tools. Working software over comprehensive documentation. Customer collaboration over contract negotiation. Responding to change over following a plan." For information on the manifesto see Beck et al. (2001).

In summary, innovation management software seek to address almost every aspect of innovation activities in an organization. However, the increased functionality of the platforms and the integration of further aspects "could lead into an "over digitalization" and over shooting of the demands of the actual potential users, the innovation managers" (Huesig & Endres, 2019, p. 311). Though the platforms can be tailored as white-label products according to the needs of an organization regarding innovation methods and community approach, the principle of a bottom-up approach in innovation needs to be reviewed critically as well. If the structure of innovation processes and the usage options of the platform are pre-designed, and if decision gates are integrated for innovation in particular areas, an organization may be limited in exploring new fields and allow unexpected ideas to occur and become supported.

4.3 Innovation Process Consulting

A third group to make use of innovation process models are consulting services. Company tools and innovation management software encourage the use of information technology. Innovation process consultancies work on a case-specific basis with the organization and its employees. Accordingly, they apply approaches to analyze and design innovation processes that are developed by their experiences in practice and conceptual thinking about innovation.[46] Digital methods and tools or software systems are integrated as elements to support and implement the consulting approach. The examples selected showcase approaches with a focus on social interactions and process design. They prioritize integration, skill building, serving and visual mapping. The first example recommends in-person direct consulting with software support for engagement in the initial phase; in the second example skill-building of employees by digital means for teaching and training is central; the third example illustrate a practice-proven innovation strategy consulting. The fourth example applies visual techniques for innovation process mapping in order to analyze "the black box of service innovation processes" (Olesen, 2017, p. 95).

In the example of Nosco, a consulting firm based in Denmark, the innovation ecosystem and infrastructure for the company is developed using three elements: direct consulting with on-site explanation and training of methodologies and tools; a digital space as a platform for engagement through innovation challenges and initiatives; a physical space, where the innovation projects and teams are set up and supported (Heckmann, 2020; NOSCO, 2021). In large and heterogeneous enterprises idea management software is used to raise awareness for innovative initiatives, engage the people with new subjects and source promising ideas, which are pre-selected for further development. The software has an easy-to-use interface, enabling users to communicate, share, collect and vote for ideas at the beginning of an innovation project with a minimal requirement on knowledge and training (NOSCO, 2020). After a digital evaluation and final selection, the team-formation phase is conducted physically in settings as workshops and boot-camps, where face-to-face interactions innovation methods and tools are explained and taught. The innovation process is started digitally through the platform and then transferred to physical space for its development and implementation (Heckmann, 2020). Companies as Nosco concentrate on the application of innovation methodologies, on how to connect company-wide and with external communities, and how to run efficient

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[46] For an overview of different innovation methods developed and conducted by consulting firms and design agencies see VanPatter & Pastor (2016, pp. 20–21).

innovation programs. Assisting the client throughout the innovation process is equally important as the support provided by an easy-to-use software platform to source, collect, manage and select ideas.

In the second example, e.g., at the LUMA Inistitute, innovation processes are supported and shaped by capability building in individuals. They are taught, trained and guided in how to innovate in general or how to innovate faster with design-enabled approaches (LUMA Institute, 2022; VanPatter & Pastor, 2016, pp. 22–23). Central to skill building for innovation is the explicit communication and training of practical frameworks, methods and tools with a broad audience through digital and analog means. Occasionally offerings in this field are described and provided by playbooks or manuals.[47] Innovation culture and innovative capabilities in a company depend on the individual employee, his or her motivation, skills and empowerment to understand, participate, contribute and lead novel initiatives. This kind of consultancy relates closely to design-based frameworks as explained in Chapter 3.3.4. A defined set of methods, tools and principles, which the employees at all organizational levels can apply as needed is essential. The innovation process unfolds with the conduct of the methods, following usually a double-diamond methodology of diverging and converging phases. As a result, the knowledge, skills and expertise gained regarding the methods and tools and their application constitute a common language for innovation to communicate and develop across functions, departments, organizational levels and organizational boundaries (Lockwood & Papke, 2018, pp. 27–28). “The LUMA System” (LUMA Institute, 2022) for example is a framework of methods and tools, which are easy-to-learn and applicable to a broad and diverse range of challenges within a company. Methods and tools are organized as three main phases of an innovation project: looking, understanding, making. In each phase, particular methods and tools are proposed, explained and trained. Methods and tools can be used afterwards individually, combined in any order or adapted to specific situations.

Leading strategy consulting firms like Boston Consulting Group conduct a practice-proven method of their own. In this case, the service starts with the clarification of vision and strategic intent and continues with the creation and development of an innovation system in which different innovation processes are enabled, supported and accelerated. The focus is to “collaborate closely with the client to strengthen its innovation system“ (BCG, 2022) using a holistic approach. It addresses the entire cycle for creating an innovation system by integrating innovation strategy, courses of action, transition to operation and enablement through establishing innovation platforms (BCG, 2022). In the case of “BCG’s Innovation Journey” (BCG, 2022) each phase is supported by additional digital analytical services as well as digital and analog methods. According to this approach, building up and maintain “critical capabilities” (ibid.) in an organization ensures the continuing existence of the innovation strategy developed, and consequently the evolving innovation processes.

Mapping innovation processes represents an alternative approach to understanding and visualizing complex processes in qualitative ways “without reducing their complexity” (Olesen, 2017, p. 95). It develops a process theory to explain “dynamic phenomena (…) as innovation and change” (Langley, 1999, p. 691) which have a “fluid character that spreads out both over space and time” and are difficult to capture by sequential process ordering (Langley, 1999, p. 692; and Olesen, 2017, pp. 98–99). Though the approach has not been developed

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[47] For example, van der Pijl, Lokitz & Solomon (2016) provide the guidebook ‘Design a better business: New tools, skills, and mindset for strategy and innovation.’ The innovation consultancy Dark Horse Innovation (2017) presents its approach in the ‘Digital Innovation Playbook. The essential exercise book for founders, doers and managers.’

into a consulting service, it argues for visual techniques to represent informal aspects of interactions and uncover patterns of interactions and relationships. The simultaneous consideration of "data and conclusions visually in one place" supports the observer in dealing with complex situations and different amounts of information (Olesen, 2017, p. 109). The visual mapping allows the user to analyze, explore and represent the complexity of an innovation process at an abstract, interpretive, flexible and manageable level while maintaining an appropriate level of accuracy (Langley, 1999, p. 702; Olesen, 2017, pp. 95; 109). Different mapping techniques are used to analyze a situation at several moments in time, the acting agents and their discourses and positions (Clarke, 2003; Olesen, 2017). For a comprehensible map of an innovation process that also includes qualitative aspects such as emotions, cognitions and "underlying forces" (Langley, 1999, p. 703) that have a causal effect on activities, different graphical representation are developed and superimposed (Olesen, 2017). As pure "analysis does not produce synthesis, the process of theory development contains always an uncodifiable step that relies on the insight and imagination of the researcher" (Langley, 1999, p. 707). In this passage the design aspect of creating a new meaning with abductive thinking becomes apparent, and relevant for the development of a unique innovation system.

4.4 Findings – Digitization of Prevailing Models

The methods and tools reviewed are examples of transferring innovation process models into practice. Sequence process models are implicitly assumed or referenced in general introductions as shown in enterprise architecture tools (4.1.1) or module-structure innovation management software (4.2.1). System oriented process models are explicitly described in applications coming from business model design (4.1.2), partly from holistic innovation management software (4.2.2) and partly from innovation process consulting (4.3). In enterprise architecture tools innovation management is seen as an operational process among other business processes. It can be managed accordingly, with the support of information technology and the optimization of communication and knowledge-exchange processes. Business model designs consider contextual aspects for the design of processes. They integrate visual thinking and apply visual tools to generate alternative perspectives on the organization and reach a higher level of abstraction in relation to its processes. Innovation management software structures, organizes and accelerates the process phases with aid of information technology and computing capacities. On the one hand, examples digitize and optimize sequential structured innovation processes or apply a standard procedure of innovation management. On the other hand, examples seek to re-organize innovation processes of a firm according to their thinking. Innovation process consulting addresses case-specific the needs of an organization. The examples emphasize hybrid support (analog and digital), skill-building training and phase-structured consulting. Summarizing, the different kind of applications seek to improve innovation projects. They extend and accelerate innovation processes in complex environments through digital technologies. They enable initiatives and self-organization, foster awareness and communication, analyze performance metrics, trends and behavioral patterns based on collected and generated data from an organization, its processes and its employees.

Despite the advantages of implementing the applications for successful innovation management, critical aspects can be observed. Digitization, and continuing offerings of digital tools to improve and extend the innovation process across and outside an organization, to integrate knowledge and trend-platforms, may lead to an "over digitalization" (Huesig & Endres, 2019, p. 311). The features offered may exceed the needs of an innovation manager. Crowd-sourced and crowd-selected ideas do not guarantee a successful innovation, as the quantity of submitted ideas is not aligned with the quality of proposals (Acar, 2019; Rehn, 2019, pp. 43–49). In innovation management software, algorithms and data analytics are provided but with limited explanations regarding their development and structure. The software analyzes retrieved, available generated data in specific ways developed by the vendor. The programming of the processes could be biased or have built-in preferences that influence the kind of discovery of emerging ideas, trends, people and resources for innovative initiatives. Developing communities through social media promotes exchange, collaboration and culture building on one hand; on the other hand it could lead to siloed structures or echo chambers in an organization neglecting diverse ideas or contrarian alternative solutions (Pentland, 2013; 2015, pp. 29–33). The displacement of physical interactions through the application of digital tools reduces other non-verbal means of communication and perception. These are important elements for constructive discourses, for interpretations and the building of shared understandings. With the use of digital applications the probability of random, chance and conflicting encounters in-person decreases. The place where novel ideas for innovation emerge is mostly presented relationally, showing individuals, teams, departments and their interconnections. Lastly, the increase in the possibilities provided by analog and digital methods and tools as sources for ideas, together with calls for tournaments, competitions, workshop and innovation programs, may have the effect of constraining creative alternatives and cause an "innovation fatigue" (Rehn, 2019, p. 3) among employees and teams and thus across the organization.

Against the background of an extended process view developed in Chapter 2.5 (and similarly conceptualized in Szopinski et al., 2020, pp. 475–477), it is questionable to what extent the software applications reviewed are capable of putting a new methodology into practice that:

- support collaboration and modeling,
- offer features for dynamics, multi-dimensionality, systemic perspectives and visual thinking.

The applications are rated on the basis of reviews in the academic and grey literature, online search and personal interviews with representatives of the software companies. While collaboration is encouraged and fostered in the methods and tools, the modeling function for exploring and constructing an innovation process does not appear to have been addressed. Users can explore single innovation processes, but can only adjust them – if possible at all – in predefined ways. The whole organization with its innovation system is not subject to these changes. The majority of the applications considered rely on a defined path from idea to launch.

They are limited to investigating or transforming the organization of innovation processes in a firm by relocating people, teams, departments or organizational units, and by altering their interactions in relational and spatial terms. Though gamification elements are considered, the possibility of playing with alternative configurations of innovation processes and discussing different innovation systems is not addressed.

Table 3: Comparison of Applications by Support of Functions

Company tools, innovation management software and innovation process consulting support differently the functions collaboration and modeling, which a methodology for an extended process view of innovation needs to provide.

Application	Company		IM Software		Consult
	EA	BMD	module structured	holistic	process focused
Interactive & Integrative Collaboration	⬤	●	●	⬤	⬤
Explorative & Constructive Modeling	•	●	●	●	●

⬤ strong consideration ● consideration • neutral

The applications considered promote efficient and agile innovation processes that are mostly related to sequential process models. Though visualizations have increased in relevance, flow charts, tables and 2-D diagrams reflect this sequential understanding. For an extended process view, for the analysis and design of an innovation process as a reflective and constructive practice, methods and tools need to be able to handle dynamics, integrate multiple dimensions, provide a systemic view and visualize this with particular types of boundary objects. Three of the reviewed examples emphasize three categories (multi-dimensional, systemic, dynamic or visual), two support two categories (multi-dimensional, systemic or dynamic). Dynamic and visual features are not well supported.

Table 4: Comparison of Applications by Features for Extended Proccess View

Company tools, innovation management software and innovation process consulting offer a broad variety of features to analyze and design innovation processes. Regarding features to model and design innovation processes holistically as conceptualized in this thesis, the application are well suited to consider multiple dimensions and systemic perspectives. Dynamic and visual features are limited.

Application	Company		IM Software		Consult
	EA	BMD	module structured	holistic	process focused
Dynamic	●	•	•	•	●
Multi-dimensional	●	⬤	●	●	●
Non-linear/ Systemic	⬤	●	•	●	•
Visual	•	●	•	•	•

⬤ strong consideration ● consideration • neutral

Innovation process models and applications are interrelated. To support a new innovation process model and put it into practice, the functions and features required need to be made available. As the examples reviewed are limited in this respect, other methods and tools need to be considered, which may exist in other fields and disciplines. If and to what extent the thinking and tools of architecture can address these limitations, will be investigated next.

5

5 – Architecture of Spatial Innovation Processes

Building architecture and the practice of architecture have been used as metaphors and analogies in innovation management. They draw on common conceptions at the surface of architectural thinking, work and the use of architectural tools (Tzonis, 2004, pp. 68–69). The discipline of architecture has not made its inner workings explicit as an approach to innovation management and process design. It has not developed a theory of innovation and has scarcely investigated its relationship to innovation management for the purpose of engaging with this field (Aksamija, 2016, p. 15; Speaks, 2002, p. 212). Architects and in general

> *"[...], designers themselves are often not very good at explaining how they design. When designers – especially skilled, successful designers – talk spontaneously about what they do, they talk almost exclusively about the outcomes, not the activities. They talk about the products of their designing, rather than the process."*
>
> *(Cross, 2013, p. 6)*

This chapter provides the theoretical basis to understand the process of architectural design, its thinking and tools as a particular kind of innovation management. It firstly outlines the relation of architectural practice to innovation, explains the architectural design process and provides an overview of tools in architecture for seeing, thinking and acting (Gänshirt, 2012, p. 52). Secondly, it investigates how architects understand organizations. Under the term 'architectural programming' the early phases of architectural design processes are reviewed as the design of innovation capabilities for clients and users to meet the challenges of transformation, systems design and creating new meanings. Spatial intelligence, architectural engagement and the use of boundary objects are fundamental capacities of architects, used to develop a deep understanding for organizational processes. In the third section, the design of models of organizations is explained as a powerful approach for synthesis.[48] The distinct nature of the way architects work with complexity, their approach to framing social interactions and influencing behaviors through design, and their process design for organizations will be explained. With regard to the hypothesis of this thesis, architectural thinking, practice and the use of its respective tools offer aid to challenges in innovation management. They support a methodology of an extended process view, as described in Chapter 2.5. The extent to which the attitudes, principles and tools of an architectural approach is applicable to innovation management will be summarized in the findings.

5.1 Architecting Processes

Architecture as a discipline and profession is related to the design, planning and construction of buildings (Pallasmaa, 2016, p. 36). As a noun, it is mostly

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[48] Lawson (1997, p. 258) regards drawings as "one of the most powerful tools of thought and communication." Tzonis (2004, p. 69) uses the same phrase of 'power' for sketches.

perceived as a physical manifestation, an artifact, created with a theoretical, systematic and purposeful intent; as an activity, it is the generation and development of these intents, performed by architects, and also the process of giving form to an idea (Hillier, 2007, pp. 32–33). A building has a value, serves a purpose and use, functions "as the transmission of culture through artefacts" (Hillier, 2007, p. 30) and is – special productions or infrastructure facilities aside – designed for humans (Pallasmaa, 2016, p. 36).

The origin of the word architect derives from the Greek terms of 'ἀρχή' (arché) and 'τέχνη/ τέκτων' (téchne, tekton) (Fischer, 2014, pp. 23–24). Arché as a noun is understood as beginning, origin, start; as a verb is means to be the first, to take the lead, to begin or to rule. The term 'tekton', is rooted in the notion of an executing carpentry, which directs craftsmen in ship building or stone work (ibid.). The ἀρχιτέκτων, a homo faber, is perceived as a "master builder" (Gänshirt, 2012, p. 19) leading, managing and controlling the craftsmen in the construction work for the built environment (ibid., pp. 18–19). The original meanings have remained valid in architectural thinking and practice over the course of time. As an engineering practice, architecture deals with materials, science, and technology; as a managerial practice, it deals with organization, structure and leadership; as a design practice, it deals with intentions and meaning, the imagination and creation of something not-yet-existing, and at the same time purposeful and useful for people (Cutler, 2013, pp. 124, 127; Gänshirt, 2012, pp. 19, 207; Pallasmaa, 2016, pp. 37–39). The ability to synthesize, to unify demands from engineering, management and design perspectives is the essential capability of architects.

> *"Naturally we can find an ability to mediate or synthesize in many other areas of artistic activity. But architecture serves so many needs and functions at once that its answers appear to be more developed and richer than those of other arts. In particular, architecture must always provide a (practical) answer of how to integrate functional and other claims."*
>
> *(Illies & Nicholas, 2009, p. 1238)*

Regarding conflicting requirements and demands by different stakeholders, architecture can also be considered as an applied science for managing conflict ("angewandte Konfliktwisssenschaft" acc. Düchs, 2012, p. 422), a practice that can "overcome philosophical tensions by suggesting practical possibilities, namely designs" (Illies & Nicholas, 2009, p. 1252). In their relations to physical buildings, "architects handle drawings and models, not bricks and boards" (Leatherbarrow 2001, p. 87).[49] Depending on the scope of assignments, the project's scale, requirements, goals and purpose, architects encounter different forms of complexity, conflicts and contradictions (Bachman, 2012, pp. 61–76; Gleiniger & Vrachliotis, 2008). They deal with wicked problems in their planning processes (as explained in Chapter 2.2.2), and seek to synthesize an inclusive, "difficult whole" (Gleiniger, 2008, p. 57) and furthermore an "unfinished whole" that adapts to changing needs and offers future possibilities for action and application. The outcome should be authentic, vivid and cultural diverse in meanings (Gleiniger, 2008, 42–45; Venturi, 1992, p. 16).

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[49] Acc. Carpo (2013a, p. 128) the separation of construction and design began in the 15th century. From then on, drawings and models became the main medium for architects to communicate ideas, concepts and design and manage construction works. See also Amt (2009).

Architects address “the unique essence of the design situation, a generative teleological seed principle” (Bachman, 2012, p. 69) with a strategic and fitting design solution. In this encounter with complex situations, architecture deals with innovation in several directions. On the one hand architecture innovates through its design process by creating novel outcomes for its clients and users. On the other hand – which will be the focus of this thesis – architecture creates the (spatial) frame for innovation processes to occur. It constructs the spaces for people to innovate in the physical realm through building designs (Allen & Henn, 2007, pp. 2–3; Gómez, 2013, pp. 75–77) and in the virtual realm through the organization of relationships and knowledge (Budds, 2016; Samuel, 2018, pp. 114–115, 154–162). The architectural design process and its use of non-verbal tools to see, think and do are essential for this (Gänshirt, 2012, pp. 52, 78). In the following, architecture for innovation and the characteristics of the architectural design process and its non-verbal tools will be investigated further. These areas consider multi-level complexities, social interactions and a systemic, constructive design process in a way that supports an extended process view of innovation and innovation management.

5.1.1 Architecture for Innovation

Architecture and architectural work have been related to innovation throughout its history with new building designs, technological advancements in planning and construction, building materials and technical equipment, computer aided architectural design and building information modeling (Aksamija, 2016, pp. 13–19). The academic discourse and emphasis in practice on innovation and architecture is new to the discipline, having started around the turn of the millennium (ibid.; Shelden, 2020b, p. 10). For this thesis a distinction is made between innovation in architecture, architecture as innovation and architecture for innovation.

From a management perspective, innovation in architecture takes place in architectural products, services and processes, and occurs in incremental, radical or transformative degrees (Aksamija, 2016, pp. 12–19).[50] Innovation is perceived, e.g., in new typologies of buildings, new technological constructions, in the development and use of new materials, experiments with new shapes, layouts, and the integration of new digital technologies in design processes or new business models (ibid.; Brookes & Poole, 2005; Ratti, 2017, p. 5; Shelden, 2020a). From an architectural theory point of view, architecture is seen as an innovative discipline in itself or “ars inveniendi” (Nönnig, 2007, p. 256), concerned with the continuous generation of something not yet existing (Daniell, 2013, pp. 114–117). This broad understanding of the architectural outcome as innovation, as created and implemented newness, resides in the characteristics of architectural work and its “innovative imperative” (Hillier, 2007, p. 33). Design assignments are often unique and project-based; the outcomes are usually non-scalable or prototypical; the novice thinking of architects in alignment with their design expertise seeks for novel solutions; the problem seeking attitude reformulates challenges and the scope of work (Vassal & Oswalt, 2016, p. 141; Peña & Parshall, 2012, p. 5). The architectural design process can be viewed as an innovation process with phases differently termed than in innovation management. The phases of ideating, inventing and implementing in innovation processes are comprised in the architectural design

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[50] For instances, in product innovation building design, building construction or parts thereof are focal; in service innovation offerings and ways of interactions with client and user are addressed; in process innovation generation, development and production of design outcomes in collaboration with others are subject (Aksamija, 2016, pp. 12–19).

processes by designing, planning and building a new whole. The inherent degree of newness in architectural projects places them on a continuum between standard outcomes and innovative results. Projects in general are characterized to be unique, and to differ in their degree of creative and innovative intent (Paletz, 2012, p. 429). For distinguished architects like Le Corbusier or Frank Gehry architecture is an approach to innovation.[51] Architects like these pursue new projects "with a desire to do something differently and better than he has done before and to experiment with materials, technologies, and methods in his quest" (Boland & Collopy, 2004a, p. 3). The inventive abilities and innovation capacities of architects and architectural practices to think beyond existing situations manifests itself in being "unconventional" and evoke change through a "novel response to existing circumstances" (Nelson, 1974, p. 105; and Lawson, 2005, pp. 146–147).[52] The challenge for architects is to seek and invent the task (Vassal & Oswalt, 2016, pp. 140–141). Their novice thinking, i.e. thinking anew without fixation, opens an unrestricted number of directions to solve a given problem, but is at the same time coupled with a design expertise to eventually deliver a result (Lawson & Dorst, 2009, pp. 38, 98–103). Architects innovate for clients strategies, organizations and buildings, which incorporate their company culture, business model and way of working (Knittel-Ammerschuber, 2006, pp. 15–17, 158; Sancho Pou, 2013, pp. 21).

Architecture for innovation shifts the focus and scope of work to fields beyond building design. By giving "up its obsession with space, genius and the utopian search for the new" (Speaks, 2002, p. 202) architecture is used to develop, for example, new social systems and sustainable environments, and to design organizational structures and strategies (Henn, 1998, p. 429; Pallasmaa, 2016; Sancho Pou, 2015).[53] The "other architect" (Borasi, 2015b) interprets and performs architecture differently:

> *"For as long as architecture has been reduced to a service to society or an „industry" whose ultimate goal is only to build, there have been others who imagine it instead as a field of intellectual research: energetic, critical and radical. […]*
>
> *Here architecture is no longer understood as a practice that inevitably brings about the construction of an artifact, but as a way of thinking, observing, and analyzing the present and the society in which we operate; of identifying and asking questions while marking a new territory on which to act; of looking for or inventing suitable tools; and, finally, of responding generously and concisely.*
>
> *(Borasi, 2015a, p. 362)*

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[51] The exemplary named architects were influential with their design of buildings and influential, e.g., for introducing new housing typologies, new construction processes and the use of new materials. Le Corbusier (officially Charles-Édouard Jeanneret, 1887-1965), French-Swiss architect and painter, proposed concepts for mass construction of dwellings, large glass façade elements, load bearing skeleton structures, and concrete as sculptural building material. His introductions were regarded as novelties at their time and disruptions in the architectural scene; see Pevsner, Honour & Fleming (1992, pp. 373–374) and Nelson (1974, pp. 105–109). Frank Gehry (1929), Canadian/US-American architect, transfered software technologies from aerospace engineering into architecture. His building designs of complex shaped forms required new technological approaches. As spin-off to his architectural studio he founded Gehry Technologies to consult other practices and companies in complex design issues with digital design software and 3D technologies; see Pevsner et al. (1992, p. 228) and Gehry, Lloyd & Shelden (2020).

[52] Nelson (1974, p. 105) describes Le Corbusier's design of Villa Savoye as novel response, which changed after its completion 1931 in radical ways design and construction of living houses.

[53] The focus of architects on building designs and constructions needs to be put into relation to the total amount of new buildings. Thoughtfully designed building project by architects account "only for 5–10% of new buildings in the United States and for approximately 2% globally" (Chantzaras, 2019a, p. 2; and Ross, 2010, p. 9; Czaja, 2017).

In continuation of this description, architects extend their fields of practice "on the ever-shifting edge of architecture" (Hyde, 2013, p. 20). They experiment and develop new, "non-traditional models of practice" (ibid.), act as consultants, change agent, designers of systems, design strategists with leadership skills, as innovation designers, disruptors and entrepreneurs (Castle, 2018; Fisher, 2015b, p. 45; Hyde, 2013, pp. 20–24; Shelden, 2020a). They apply – for example, and in context of this thesis – their architectural thinking, skills, expertise and tools to develop new working systems for clients, users and communities; to transform and change behaviors in organizations; to build up the innovation capabilities of enterprises. Architectural work, the architectural design process and its outcomes become a medium for innovation through which the innovation system of an organization takes shape (in reference to Gómez, 2013, pp. 76–77; Henn, G., 2016, pp. 6–7).[54] In the following chapters, the theme of architecture as an innovating discipline and architecture for innovation is central. Its relevance for innovation management will be researched in the architectural design process and the use of non-verbal boundary objects.

5.1.2 Architectural Design Process

The architectural design process can be viewed in terms of codified descriptions of the scopes of work. The following descriptions outline in detail the sequential working phases commonly agreed upon by professional corps, architectural chambers and legal authorities have (Fischer, 2018, pp. 116–117; Schramm, 2017, pp. 6–12). Integrated in honorary fee systems by a plan of work, they ensure the practicability of architectural work and regulate its operations throughout the building design process from the first sketches to completion (Gänshirt, 2012, pp. 68–70; RIBA, 2020, pp. 8–9). Depending on the national area in which architectural services are offered, architectural activities are organized "as a logical course of action" (Lawson, 2005, p. 35) which consists of the initial brief, sketch plans, working drawings and site operations (Dubberly, 2004, p. 35; Samuel, 2018, p. 107; RIBA, 2020, pp. 9, 39). Throughout the design, planning and construction process, an architectural practice balances "trade-offs" (Styhre & Gluch, 2009, p. 228) between the time, cost and scope of design works. The detailed description of work scopes and fee recommendations support architects and clients in decision making and the submission of deliverables, required for a successful building project. It has shaped the common understanding and conceptions of architectural work and represents the design of building as a linear sequence of steps. Against the background of architecture for innovation it ignores several essential aspects.

Creativity and innovation in an architectural design process result from its non-linear, iterative and abductive nature (Fischer, 2014, pp. 116–117). The architectural design process is a simultaneous reflection and construction of something that does not yet exist, which is not adequately valued be being bound to material building cost (Gänshirt, 2012, p. 70).[55] Value creation resides in the development of new organizational configurations, processes and cultures. Experiences occurring in the interaction of architects with clients, users and

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[54] The architect Gunter Henn (2016, p. 7) describes building architecture as a medium of innovation: "Innovation ist ein sozialer Vorgang, der auf Austausch und Offenheit basiert. Die Architektur [des Gebäudes; Anm. d. Verf.] wird dabei zum Medium der Innovation."

[55] According to German honorary fee regulations the fee for architectural work depends on the building construction cost. Additional works or works beyond the defined scope for a building design need to be negotiated separately. For further information and a critical view on fee regulations see Fischer (2018, pp. 99–100, 116–117); Schramm (2017, pp. 262–264).

stakeholders have a transformational impact in changing conceptions, behaviors and systems (Gänshirt, 2012, pp. 68–70; Samuel, 2018, p. 108).

The architectural design process is a conceptual and generative process of interrelated activities and thinking modes (Lawson, 2005, pp. 48–49; Pallasmaa, 2016, p. 35). Attempts to structure, describe and model the process in a linear sequence started with the design methods movement in the 1960s, but remained limited in their ability to capture the individual uniqueness and the essence of the design process as it actually occurs and to provide advice or guidelines for practice (Cross, 2001, p. 50; Gänshirt, 2012, p. 70). Coping with ill-defined or wicked problems requires an iterative, non-linear and simultaneous consideration of a project's requirements, needs, goals and changes (Gänshirt, 2012, p. 50; Lawson, 2005, p. 151). The uncodified architectural design process is characterized by the architect's dynamic movement between the problem and solution space, by special ways of thinking and particular design activities, by the application of distinct principles, methods and tools (Lawson, 2005, pp. 290–301; Lawson & Dorst, 2009, pp. 48–60). Its final goal is to achieve a meaningful synthesis of multiple, often conflicting and contradictory demands, requirements, needs, goals and visions; this synthesis frames complexities to a workable degree without reducing them (Chantzaras, 2019b, p. 542; Tzonis, 2004, p. 68; Venturi, 1992, p. 16). Architects diverge in exploring ideas and generating alternatives; they converge by focusing on a direction for further development, detailing of construction and implementation (Cross, 2008, pp. 54–55). The simplicity achieved in works of art and architecture is basically the essence of a complex problem solving process (Pallasmaa, 2014, p. 40). Architects therefore work in a "liquid state" (Boland & Collopy, 2004a, pp. 10, 17–18; Gehry, 2004, p. 20) and constant commute between the problem formulation and its resolution; they think in architectural ways and perform activities with architectural tools.

Liquid State. The context in which architectural practices are working in and working with entails complex and contradictory demands (Venturi, 1992, p. 16). The context causes uncertainty – in a way similar to that caused by the context in which innovation processes are embedded – regarding the design direction to choose and ambiguity about the kind of approach to apply. To cope with uncertainty and ambiguity the design process is kept in a "liquid state" (Boland & Collopy, 2004b, p. 273): it is kept vivid for iterations, adaptable to the integration of new requirements, open to direction shifts and changes brought about by sudden moments of insight during the finalization of the design process (Gehry, 2004, p. 20; Lawson, 2005; Pallasmaa, 2016). While a decision attitude practiced in management favors the reduction of uncertainties, a design attitude values uncertainty as a necessary condition to accept and work with:

> *"[…] good designers tend to be at ease with the lack of resolution of their ideas for most of the design process. Things often only come together late on towards the end of the process. Those who prefer a more ordered and certain world may find themselves uncomfortable in the creative three-dimensional design fields."*
>
> *(Lawson, 2005, p. 154).*

Architects, ideally, challenge the brief provided by clients, and work to uncover the nature of the problem beyond the explicitly formulated requirements and goals (Cross, 2013, p. 70; Vassal & Oswalt, 2016, p. 141). The design brief usually given by clients in the beginning is not seen "as a specification for a solution but as a starting point of a journey of exploration" (Cross, 2013, p. 8). The outcomes of an architectural design process may impact longer time frames, and life cycles, and go beyond the initial requirements of clients and users. Spatial, technical and relational requirements may change, as well as perceptions and values in relation to the environment, society and culture. Architects relate their problem and solution formulations to a next larger context in space and time. They "imagine, foresee and think of the implications and consequences when a design is going to be built" (Chantzaras, 2019b, p. 544; and indirectly Robinson, 2001, pp. 71–73). Brief and briefing is a "continuous process" (Lawson, 2005, p. 297). The problem formulation emerges "or co-evolves" (Cross, 2008, p. 42) with the development of possible solutions (Dorst & Cross, 2001, p. 434; Lawson, 2005, p. 48). Architects constantly analyze, synthesize and evaluate their approach to the problem and solution. They constantly commute with "negotiation between the problem and solution" (Lawson, 2005, p. 49) spaces until a resolution takes shape (see Figure 27).

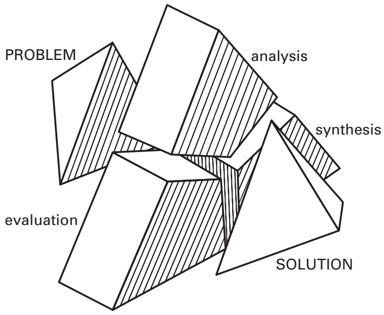

Figure 27: Design Process (Lawson, 2005)

Lawson (2005) describes the design process as „negotiation between problem and solution" that is performed in a continuous circle of analysis, synthesis and evaluation. Visualization by Lawson (2005, p. 49).

Architectural Thinking. Architects start their work on the basis of insufficient information and apply different modes of reasoning and thinking. They are abductive, lateral and visual thinkers; they balance descriptive modes with an reflective, constructive and imaginative capacity; they are inherently optimistic (or "futurists" acc. Dator, 2016, p. 549) about achieving an improvement for a situation in a long term perspective; they immerse empathically in a situation; combine novice thinking with design expertise; perform an art of criticism; apply their spatial intelligence and use non-verbal tools for their thinking (Beucker, 2016, p. 35; Gänshirt, 2012, p. 22; Lawson, 2005; Pallasmaa, 2016, pp. 38–43).

Their abductive thinking is an intuitive thought, or informed guessing, based on research, knowledge or expertise (Clarke, 2016, p. 91). Architects explore possible directions in this way and iterate back, if the conducted approach provides insights and learnings that requires revision of their initial guess or working hypothesis. With their lateral thinking architects relate observed problems to distant fields, foster the creation of alternative mental models and build up new frames to overcome design fixation (Lawson, 2005, pp. 200–201; Lawson & Dorst, 2009, pp. 38, 153). With their visual thinking they graphically develop and externalize their thoughts, ideas, and knowledge (Lawson & Dorst, 2009, p. 104; Schubert, 2021, pp. 29–30). They enter a dialogue between themselves and the visuals created, and pursue the "formation of an idea using a tangible medium" (Chantzaras, 2019b, p. 542; and Lawson, 2005, pp. 278–281; Schubert, 2021, p. 19). Sketches and drawings are "the demonstration of an idea as well as its advent" (Leatherbarrow, 2001, p. 91). Architects visually represent their own ideas, thoughts, information and knowledge in relation to understanding the problem; but they also represent the idea, thought, and knowledge of others as planning partners, clients or users (Gänshirt, 2012, p. 81; Lawson, 2005, pp. 293–295). The reflection-in-action throughout the architectural design process is essential for the co-evolution of problem definition and design solution. It fosters a constructive dialogue (with oneself and with others), and spurs iteration and movement towards novel solutions. Depending on their individual preferences, expertise, skills and judgement, architects generate design alternatives for reflection, evaluation and the discourse with others (Lawson, 2005, pp. 209–212).

They weigh up different pathways of design alternatives in mind, externalize them in their very own practice of making representations and keep decisions for a design direction open and fluid or 'liquid'. They start and maintain "parallel lines of thought" (Lawson, 2005, pp. 212–219) to focus simultaneously on different aspects or parts of a problem at varying scales. Architects actively foster critique and criticism and apply constraints (Gänshirt, 2012, pp. 79, 200; Pendleton-Jullian & Brown, 2018, p. 112).[56] Criticism and "repeated critical discussions" (Nilsson, 2013, p. 5) based on created non-verbal artifacts "as bearers of knowledge and as results of making processes" (ibid., p. 2) are constitutive for the development of the design solution and its quality (Gänshirt, 2012, pp. 196–200). In this, similar design dialogues or discourses become present, as elaborated in design thinking practice (Chapter 2.4.2) as well as in innovation management practice (Chapter 3.2.3. and 3.3.4).

The consideration of details and the whole of a project as a whole occur in parallel, while the absence of a necessary fit between the parts of the project's resolution is tolerated. It allows the architect to remain agile, capable of adapting to unknown developments, changes and insights. Architects iterate from different points of view, giving order on one site, but allowing disorder on another. In the course of the design process a deep understanding of the problem and empathy for the situation evolves (Chantzaras & Rung, 2017, p. 35; Nelson & Stolterman, 2012, pp. 4–5, 43–47, 54). Architects immerse themselves in the client and user perspective while retaining a long-term perspective that goes beyond current needs (Pallasmaa, 2016, p. 42). At the start of the process, they envision a design on behalf of and together with the client. They lead the process with a particular understanding of their job, that architect Denys Ladsun described in an an interview in 1965:

> *"Our job is to give the client … not what he wants, but what he never dreamed he wanted; and when he gets it he recognizes it as something he wanted all the time"*
>
> *(Architect Denys Lasdun quoted in: Cross, 2007, p. 52; Lawson, 2005, p. 168).*

The activities architects, and designers in general, perform have been summarized by Lawson (2005, pp. 290–301) and Lawson & Dorst (2009, pp. 48–60) as formulating, moving, representing, reflecting, evaluating, managing,

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[56] Critique is regarded here as a constructive discourse, while criticism is seen more as the direct address of elements of concern or question (Pendleton-Jullian & Brown, 2018, pp. 111–113): "Critique, as practiced in the design studio, is different from criticism or evaluation in that it is a *working on, together*, not a disinterested evaluation of one person by another. And while involving assessment, it goes beyond *assessment of* into the realm of *how to think about*. Therefore, it moves the process forward through speculation as well as analysis." (ibid., p. 112). Critique and criticism are essential formats in architectural eduction, referred to also as 'crit' or design review. Flynn, Dunn, Price, & O'Conner (2020, pp. 178–180) derive the crit from criticism and note that in higher education sometimes the direct address prevails instead of a dialogue.

integrating and synthesizing. In the context of this thesis the capabilities in focus are those that enable a deeper understanding of alternative representations of innovation processes. The capabilities make it possible to work with these representations in an integrative and constructive way with others and to synthesize a new whole. Throughout their different activities in the design process architects develop and use non-verbal tools. These are essential means for representation and reflection, for integration and synthesis. They further enable interaction and collaboration between designers and non-designers, between architects and non-architects in the development of new systems.

5.1.3 Non-verbal Tools

The tools architects use are tools to see, think and make (Gänshirt, 2012, p. 52; Nilsson, 2013, p. 1). They are "intellectual abilities" (Gänshirt, 2012, p. 98) that shape the way architects think and thereby influence the design direction they pursue (ibid., 99). The tools allow architects to reflect-in-action: they help externalize, represent, uncover, structure, generate information and knowledge, and give form to thoughts, ideas, concepts and design solutions (ibid.; Lawson, 2005, pp. 48–49). They are core elements in the design process for the generation of ideas, the communication and development of concepts, and for synthesizing intermediate states and final results.

Architects, trained in a craft-, practice- and material-based discipline, think with their hands, produce sketches, diagrams, drawings and spatial, 3-dimensional models (Boland & Collopy, 2004b, p. 273; Cross, 2013, pp. 12–13; Gänshirt, 2012, p. 149; Leatherbarrow, 2001, p. 91; Pallasmaa, 2009, pp. 89–120). Meaning, function and use of these non-verbal tools are different from their understanding and usage in management disciplines. Non-verbal means are used in architectural work – and in a "culture of design" (Cross, 1982, p. 226) in general – to overcome limitations of "verbal, numerical and literary modes of thinking" (ibid.) and access a problem in a cognitive field where visual, haptic and emotional senses are addressed and aid the analysis and construction of thoughts and imageries.[57] The non-verbal means are the principal means of abduction. Architects use them to frame the complexities of environment and context they are dealing with, to represent and understand social interaction and behaviours, to visualize requirements and needs, in order to design a coherent new whole (Chantzaras, 2019b, pp. 537, 542; Cross, 1982, p. 226; Lawson & Dorst, 2009, p. 42; Nelson & Stolterman, 2012, pp. 93–102). The tools are both descriptive and prescriptive, explorative and constructive. "The ability to design", as noted in chapter 2.4.2, depends "on being able to make external visualizations." (Cross, 2008, p. 8).

The tools to sketch, diagram, draw and model in architecture are interrelated and applied jointly throughout the design process (Gänshirt, 2012, pp. 100–102). Degrees of complexity and concreteness usually increase from the fuzziness of a first hand-sketch to a detailed 3-dimensional model for building constructions. The terms 'sketches' and 'drawings' are often used synonymously in the literature, or sketches and diagrams are treated as a sub-category of drawings (Do & Gross, 2001, pp. 135–137), a practice which will not be followed

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[57] For Buchanan (1992, p. 20) the non-verbal means of designers are arguments in a process of design thinking: "The power of design as deliberation and argument lies in overcoming the limitations of mere verbal or symbolic argument – the separation of words and things, or theory and practice that remains a source of disruption and confusion in contemporary culture. Argument in design thinking moves toward the concrete interplay and interconnection of signs, things, actions, and thoughts. Every designer's sketch, blueprint, flow chart, graph, three-dimensional model, or other product proposal is an example of such argumentation."

here. The terms differ in meaning and function for the design process and in the way they contribute to its development. Sketches and sketching are treated as informal aids to think, reflect, communicate and create, while drawings and the activity of drawing provide a higher degree of precision and technical formality for representing information and knowledge in a way that is codified within the profession or acknowledged by professional viewers (Gänshirt, 2012, pp. 113–114, 134–139; Vidler, 2000, p. 7). Diagrams occupy an intermediate position between sketch and drawing as shown in Figure 28.

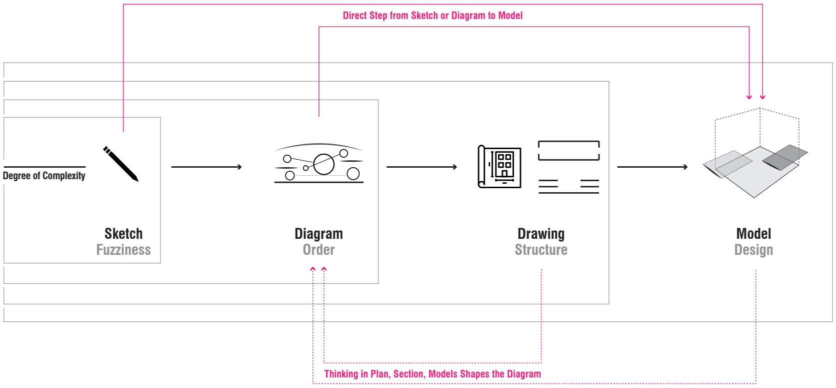

Figure 28: Design Tools in Architecture

Design tools of architects, with interrelation and interdependencies between the tools. Visualization by Chantzaras (2019b, p. 543) in reference to Gänshirt (2012, pp. 113–159).

The sketch is understood here as the first level in the use of non-verbal design tools. It usually precedes diagrams and drawings. The model, as a 3-dimensional means of representing and working with ideas, is developed after each of the previous design tools have been applied. It is also used at the begin of the design process as start of a journey of discovering the problem. This depends on the individual approach of the architect.[58]

Sketch. The main mediums for the representation of ideas and communication in architectural practice and education are sketches and drawings (Cross, 2007, p. 54; Fischer, 2014, p. 146; Lawson, 2005, p. 26; Vrachliotis, 2005, p. 127). The sketch is usually applied at the beginning of the architect's communication with a problem and favored "for changing consciously from the verbal-logical to the visual-spatial mode of thinking" (Gänshirt, 2012, p. 122). The act of sketching is a internal dialogue the architect conducts in his or her commute between problem and solution space. The sketch as a primary tool in design is characterized by immediacy, vagueness and fuzziness, indeterminacy, and to selectively consider particular areas of interest (Fischer, 2014, pp. 147–148; Gänshirt, 2012, p. 117; Lawson, 1997, p. 219; Schubert, 2021, p. 26–28). Creating a sketch involves unconscious ways of working, since the hand sometimes moves more quickly than the mind and "draws something that the eye then re-interprets and gets ideas from" (Architect Denise Scott Brown quoted in Lawson & Dorst, 2009, p. 47). In this respect a sketch promotes "the recognition of emergent features and properties" (Cross, 2007, p. 58) by cross-referencing or cross-relating what has been drawn to new elements. The sketch helps the architect focus on those elements which seem at the time most relevant, while ensuring that other elements are still visible and accessible when needed (Cross, 2007, p. 57). It allows to collect thoughts and information regarding the project, and record them for further processing.

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[58] For example, the architect Frank Gehry (Gehry, 2004, p. 20) begins the design process by making study models of different kinds to understand the client's wishes, retrieve information and evoke collaboration. With "schreck models" (ibid.) he intends to unsettle the clients in order to uncover non-obvious demands.

“Sketching provides a temporary, external store for tentative ideas.” (Cross, 2013, p. 12; and also Fischer, 2014, p. 147). It enables the architect to take rough view of the problem from different perspectives and “to handle different levels of abstraction simultaneously” (Cross, 2007, pp. 54–58). Sketching and drawing are “a kind of intelligence amplifier” (Cross, 2007, p. 58) during the process of design. They support lateral thinking and the dialectic transformation of descriptive information, or ‘seeing that’, into a prescriptive reinterpretation of the information, or ‘seeing as’ (ibid., p. 58; and Gänshirt, 2012, p. 121).

The gestalt of a sketch and its production depends on the architect’s individual skills, experience, talent, preferences and techniques. It is created over time, and is not constrained by drawing codes, geometrical or proportional units and scales. It is open to additions, alterations and changes. In the physical realm, thoughts on paper-based sketch rolls can be depicted in a seamless way and continued endlessly: architects often cut, overlay and redraw their sketches on transparent sketch paper, quickly reflect and adjust the graphic depiction, while keeping former statuses of their sketching in sight (Fischer, 2014, pp. 149–150).[59] Though digital tools advances for sketching, several aspects of the analog mode of work remain of essential value in the architectural design process:

- the immediacy of sketching without “media disruptions” (Schubert, 2021, p. 2) caused by changing the medium of transmitting information during the process of design (Fischer, 2014, p. 152)
- the vagueness of the sketch (Pallasmaa, 2009, pp. 96–99)
- the knowledge created by several sensoric cognition during the making of a sketch (ibid.; Nilsson, 2013, pp. 3–4)
- the simultaneity in viewing the progress in sketching and the parallel lines of thoughts (Cross, 2007, p. 57; Lawson, 1997, pp. 212–219)

Besides the internal communication – the dialogue with the sketch and with oneself – the sketch is an important means of communication and collaboration with others, e.g., to colleagues, consultants, clients and users (Gänshirt, 2012, p. 114). A sketch is a hand-crafted graphical representation of thought. Its nature makes it open to multiple interpretations, facilitating communication or collaboration with others. It may need additional explanation or clarification for the layperson or people unfamiliar with forms of architectural style and expression (Gänshirt, 2012, p. 117).

Diagram. The diagram represents a higher order of thinking and reflection compared to the sketch. It is an abstract, graphical visualization of the “shape and relations of the various parts it displays” (Vidler, 2006, p. 19). Diagrams in architecture range from concrete to abstract, from representative and descriptive to prescriptive and projective (Bouman, 2007, p. 96; Tzonis, 2004, p. 68). In their abstract use, diagrams are performative, explorative and generative tools for ideas and concepts (Allen, 1998; Dortdivanlioglu, 2018; Vidler, 2006). Similar

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[59] Fischer (2014, pp. 149–150) explains the key propositions of a sketch roll as follows: “Es gibt allerdings ein zusätzliches, geradezu geniales Zeichenwerkzeug, das speziell auf die Entwurfstätigkeit von Architekten zugeschnitten ist: die Skizzenrolle. Sie weicht in zwei wesentlichen Punkten - Transparenz und ‚Endlosigkeit‘ – vom normalen Zeichenpapier ab. […] Transparenz erleichtert und beschleunigt das für den Entwurf so wichtige Ausprobieren und Entwickeln von Varianten um ein Vielfaches. Unterlagen, etwa ein Lageplan mit sämtlichen Umgebungs- und Grundstücksinformationen, bleiben ständig unter der Skizzenrolle präsent und als Unterlage intakt, auch wenn eine Variante nach der anderen ausprobiert wird. […] Die Endlosigkeit der Skizzenrolle wiederum entspricht in perfekter Weise dem Charakter des Gedankenflusses, der sich nicht an Papierformate oder Blattränder hält, sondern kontinuierlich abläuft und eines in gleicher Weise kontinuierlichen Mediums bedarf.”

to the sketch, the diagram is an „instrument of thought and its mirror" (Vidler, 2006, p. 20). The inherent vagueness and indeterminateness of a diagram combined with a precision in its form and the relationships it represents keeps it open to different interpretations and perspectives, which then in turn fosters the generation of new or alternative ideas (Allen, 1998, p. 16; Haberer, 2013, p. 213). In this conception the diagram is generative: it elicits new facts and relations, which could not be accessed and perceived without diagrammatic visualization (Hnilica, 2013, p. 247). Diagrams reveal an invisible or "disclose[s] a hidden reality" (Bos, 2007, p. 198) of information and relations (Hnilica, 2013, p. 243). Sketches in architecture are creatively fuzzy, drawings demand precise planning and technical knowledge to be produced and read. Diagrams take an intermediate position. They are a thoughtfully ordered, sometimes latent, communicable conception of an idea, a process, an organization – or "the architecture of an idea and entity" (Garcia, 2010b, p. 18). In this pre-building design state, the architectural diagram is a design tool for representing previously imperceptible and not-yet existing situations.

> *"A diagram is therefore not a thing in itself but a description of potential relationships among elements, not only an abstract model of the way things behave in the world but a map of possible world."*
>
> *(Allen, 1998, p. 16)*

Diagrams are not required to be scientifically correct; they blend quantitative and qualitative information and present a narrative or story (ibid.; Hnilica, 2013, p. 243). They precede – depending on the architect's working process – drawings and function as communication bridges to the other disciplines and stakeholders architects interact with (Henn, 2004, p. 46; Hnilica, 2013, p. 229). As a non-verbal tool a diagram is "architecture's best means to engage the complexity of the real" (Allen, 1998, p. 17).

Drawings. Drawings are the formal structure of an idea towards its concrete realization (Gänshirt, 2012, pp. 135–136). They entail a higher degree of precision than diagrams by consistent arrangements, proportions and dimensions and constructive details depending on the scale they represent. Drawings count in discipline and profession of architecture as means to communicate the building design, to collaborate with the architectural team, consultants, clients, authorities, manufacturing and construction enterprises, and to direct and instruct work (Lawson, 2005, p. 26). In contrast to perspective (or sketch), plans and sections are representing a future reality, what will be constructed. Mandatory standards of precision demand decisions during perceptual analysis: the architect needs to be disciplined about structuring and reducing to what is seen and necessary, and setting hierarchies (Gänshirt, 2012, pp. 136–137).

Plan drawings make it possible to see all the parts of a building project at once together, as they are, or as they are supposed or proposed to be (Leatherbarrow, 2001, p. 89). With the appropriate scale, the entire project is easier to handle for the architect, to manipulate, to see weaknesses and opportunities (Gänshirt, 2012, pp. 134–135). Drawings follow drawing codes or developed graphical languages to communicate, co-ordinate and collaborate with partners, planners and consultants. According to the planning phases the levels of detail increase, displaying construction, materiality and technical requirements. Graphical elements as lines, areas or hatches have distinct meanings, follow codes and take into consideration the different constraints imposed by authorities, legal regulations, technical requirements or construction demands, which often require professional knowledge (Fischer, 2014, p. 170).

While sketches and diagrams emphasize ideation and conceptual stages in architectural practice, drawings are the core of the development stage of an idea and invention needed for realization. They normally exclude imprecise and vague elements like perspective sketches or spatial visualizations (Gänshirt, 2012, p. 118). For the communication and collaboration with related disciplines drawings functions as an integrative and guiding platform for aligned and required technical planning. Based on the drawings structural, infrastructure and performance plans are developed. From this point of view drawings encode and embody the responsibility and reliability of the architect for the construction to be built. The vertical section reveals the inner construction and organization of a building design. It provides views of the entire arrangement of levels, shows how they are related to each other, and gives the construction details for floors, walls, ceilings and roofs. As "x-ray detection" (Leatherbarrow, 2001, p. 89), the section provides insights into a world as it is and fosters the imagination of a world as it ought to be.

Plan and section relate to and depend on each other. Drawings are instrumental in representing; they are interpretative in foregrounding hidden elements which have been objectively observed earlier; drawings are fictive in depicting something not-yet existing and something which is wanted (ibid., pp. 89–90). In a reflective practice drawings have a "rhetorical function" (ibid., p. 91): from the inside, in persuading the individual architect in his intended direction and proposal, and from the outside, in persuading "the client and builder" (ibid.) Drawings constitute a new whole and introduce a 3-dimensional model of relations, spatial proximities and interactions. With the advancements in digital technologies and computer-aided design the sequential development of plan, section and details is transformed into a simultaneous development. Design in this environment starts at a "point in three-dimensional space" (Bos, 2007, p. 196). Multi-dimensional models, as proposed by the methodology of Building Information Modeling (BIM), comprise plan drawings, sections and construction details in 3-D (space), and integrae further dimensions of 4-D (time), 5-D (cost) and 6-D (life-cycle management) (Beetz, Borrmann, Both, Petzold, & Schoch, 2020, pp. 515–516; Gänshirt, 2012, p. 146).[60]

Models. Models, in the presented order of architectural design tools, go beyond 2-dimensional representation and offer representations of an idea, a concept or worked-out drawing in a 3-dimensional, bodily form. They are distinguished here from sketches, diagrams and drawings, which are also viewed as models in the general theory of models, in order to outline their particular use in architectural practice and the process of making in three dimensions. Models in architecture can be virtual and physical, a process and a result of manual making (Nilsson, 2013, p. 1; Wagner, 2000, p. 379). As with the other tools, models are a tool to think, to work with and to design with. As idea-, concept- or volume-models they are used for experimenting and testing in the early stage of projects. They aid reflection, open communication between actors and facilitate their collaboration. As physical models they address several sensoric senses and invite to a playful engagement with the object.

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[60] Beetz et al. (2020, p. 509) define Building Information Modeling as methodology consisting of a semantic data model, a modeling process and a model management, in order to establish "a structured, seamlessly data-supported collaboration between professionals, contractors, and stakeholders on a construction project." As definition of the multi-dimensional model they refer to the National BIM Standard of the National Institute of Building Sciences in the United States: "Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition." (ibid.).

The "ephemerality" (Wagner, 2000, p. 385) of assemblies is an important aspect of the architects' work. Architects and people involved in the design process assemble different kinds of tangible artifacts in their studios or project environments. The objects are collected in relation to the design problem – for example, pictures, images, notes, materials – or created with the design tools – for example, sketches, diagrams, drawings and models (ibid., p. 379; Wagner, 2004, pp. 154–155). These assemblies or arrangements are of a temporary nature and influence the design thinking process. In the case of a model used in architectural practice people can add, take away, shuffle and re-arrange objects in it or they can reconstruct the entire model, "while reflecting and evaluating the conducted actions and their consequences" (Chantzaras, 2019b, p. 543).

Models in architecture are both embodied knowledge and a process of knowledge creation (Nilsson, 2013, p. 1). They integrate the diverse and often conflicting requirements of a design brief by offering a third dimension to explore and test configurations. They deal with materials, joints, loads, perspectives, senses, space, light and shadow. The skill of thinking in bodily models and to think about models, how to physically create them, are important for the prototyping process in engineering and design disciplines. Engineers and designers gain knowledge and insights, test technical feasibility and guide the course of an innovation process (Doll, 2009, pp. 107–110).[61] Architects model at different spatial scales. For example models are used to represent an urban context, a single building design, or a detail for an interior spaces or façade element. With the exception of models for construction related systems, products and materials, models in architecture are not exact prototypes of what is going to be built. They are approximations of minor complexity and they are abstractions from the final result, focusing on its essential function to explore, communicate, discuss or work with, knowing that the building itself will be the final prototype, the hypothesis to test (Crawley, Cameron, & Selva, 2016, p. 208; Rittel & Webber, 1973, p. 163; Sailer, 2019, pp. 287–289).[62]

Digital technologies have extended the use of 3-dimensional models in architecture in different ways. Making physical artifacts is facilitated through digital printing, laser cutting and digital manufacturing. Creating virtual 3-dimensional models is improved through software for algorithmic and parametric design, and technologies for virtual and augmented realities. Information layers can be placed virtually on the physically constructed model, displaying constructions detail, environmental or fluid simulation, occupancies and flows. Spatial-temporal relations can become visible in an architectural model in the form of "performance simulation" (Martens, 2020, p. 478) that

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[61] A prototype is defined acc. Doll (2009, p. 109) as a special type of model for the generation of knowledge during an innovation process. He points out that the distinction between model and prototype blurs: "Prototypen sind Instrumente der Erkenntnisgewinnung und fungieren nicht nur als „Demonstratoren" technischer Machbarkeit. Sie bestimmen maßgeblich die Gestaltung des Innovationsprozesses. Aus diesem Verständnis heraus verschwimmt die begriffliche Differenzierung zwischen beiden Begriffen zunehmend. Modelle und Prototypen werden entwickelt, um wichtige Fragen zu beantworten und neues Wissen für die Gestaltung des Innovationsprozesses zu gewinnen. Die genaue Gestaltung von Modellen und Prototypen hängt davon ab, welche Art von Wissen durch deren Entwicklung gewonnen werden soll. Im Laufe der Zeit kann dabei eine Reihe ganz unterschiedlicher Prototypen im Innovationsprozess zum Einsatz kommen. Aus dieser Sichtweise heraus ist eine klare definitorische Trennung der Begriffe „Modell" und „Prototyp" nicht zwingend notwendig." (ibid., pp. 109–110).

[62] Building designs are referred to as hypotheses, which cannot be tested beforehand, or are tested to limited extent after they are built. Grondzik & Kwok (2019, p. 11) note: "Most buildings are essentially a design team hypothesis: "We believe that this solution will work for the given situation." Unfortunately, the vast majority of buildings exist as untested hypotheses. Little in the way of performance evaluation or structured feedback from the owner and occupants is typically sought. This is not to suggest that designers do not learn from their projects, but rather that little research-quality, publicly shared information is captured for use on other projects. This is not an ideal model for professional practice from the perspective of society at large." Sailer (2019, pp. 287–289) considers this situation as opportunity to experiment, test and evaluate: "Mit dem Entwurf eines Gebäudes wird eine Wirklichkeit erschaffen, basierend auf Annahmen darüber, wie die Menschen, die das Bauwerk benutzen werden, leben wollen – wie sie arbeiten, wie sie wohnen, wen sie sehen und treffen werden, wie sie sich bewegen und fühlen werden. Führt man diesen Gedankengang weiter – ein Gebäude als Experiment und ungetestete Hypothese –, stellt sich unmittelbar die Frage nach dem tatsächlichen Testen der einer Architektur zugrundeliegenden Annahmen." (ibid., p. 288).

shows the behavior of elements when a parameter is changing over time.

Summarizing, architects use multiple design tools throughout the design process in varying degree. Thinking and working in drawings, in top view plans and sections, as well as thinking and working in models iterates back to the development of sketches and diagrams and in this way enables the constant movement between problem space and solution space. The sketch supports the lateral, intuitive and generative thinking, which in turn fosters moments of insights, hunches and connections that have not been observable before (Lawson & Dorst, 2009, pp. 47, 52–54). The application and integration of digital tools has extended and augmented the possibilities for sketching, diagramming, drawing and modeling (e.g., Carpo, 2013b, 2017; Schubert, 2021). Sketches, diagrams and drawings are "powerful tools of thought and communication" (Lawson, 1997, p. 258; 2005, p. 281) with oneself and with others. But shared understandings need to be built (ibid.; Fisher, 2000, p. 29). The artifacts created by these tools make parallel lines of thoughts and generated design alternatives explicit and tangible. They function as boundary objects and as persuasive artifacts during the design process. They are generative, inducing and provoking actions with their particular "kind of openness, immediacy and interpretive flexibility" (Chantzaras, 2019b, p. 543; and Wagner, 2000, p. 388). They allow architects to take multiple considerations simultaneously into account during the processes; they make it possible to experience different scales of a problem; they stimulate action by being visually present to the awareness and critique of others (Samuel, 2018, pp. 67–68). In this respect, the architectural studio environment plays an essential role:

> *"The unique methodological contribution of architects resides within architecture design studio. I argue that is different from other forms of design studio largely because its subject matter, the vast range of issues it deals with, the spatial juxtapositions it tests, the diversity of people that are engaged in its negotiations and, most importantly, the scalar leaps that are characteristic of architectural design thinking."*
>
> *(Samuel, 2018, pp. 67–68)*

The routines of planning, drawing, calculating, approving in architectural practices are kept adaptive and flexible by the presence of the artifacts and their continuous considerations and revision. Architectural practices are ambidextrous in the following sense: they develop and engineer solution for implementation, provide design concepts, drawings and construction documents, ensuring that projects can be built that conform to their professional scope of work in a codified way. At the same time they remain open to changes in requirements and directions in their quest for the new, extend the range of their practice and offer novel solutions, as optimists and futurists.[63] If architects are assigned to transform an organization, they are doing it differently. Their architectural thinking and non-verbal design tools can be applied beyond building design projects to the challenges of organizational structures and processes. The visual, non-verbal tools of architects – sketching, diagramming, drawing and modeling – can support innovation management in designing innovation processes.

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[63] Ambidexterity in organizational structures refers to an organizational capability to operate and exploit the existing business and explore and innovate new business opportunities simultaneously. Architectural practices by this definition would not be regarded as ambidextrous organizations. See O'Reilly & Tushman (2004, pp. 74–76).

5.2 Understanding Organizations by Architecture

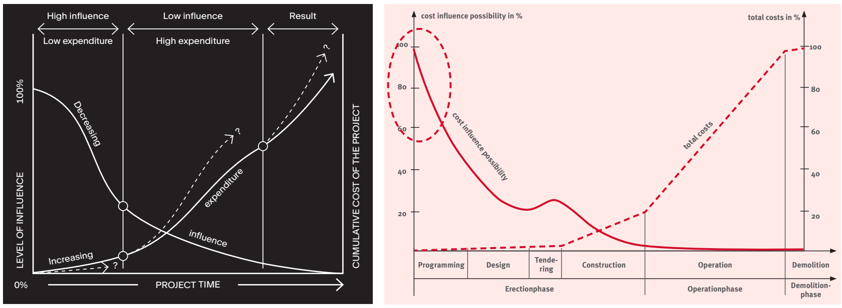
In architectural design work for clients from knowledge-intensive fields with complex requirements – e.g., engineering, information technology, consulting or research – architects analyse the socio-technical structure of people, processes, facilities and their interdependencies; they acquire and create knowledge on the organizational culture and visions (see as reference: Bouman, 2007, p. 96; Henn, 2004, pp. 43–45). The design and planning phases with clients and users generate insights and knowledge about informal organization, processes, organizational deficiencies and opportunities for improvement.

In the early design or pre-design phases of complex projects, architects focus on the nature of the organizational challenges, the systemic relationships and patterns between people and their behavior, the understanding of requirements, needs, goals and visions of the firm (Henn, 2004, pp. 43–45; Hershberger, 1999, pp. 1–5). They apply their architectural thinking and tools to develop an alternative understanding of the organization. As “knowledge architects” (Samuel, 2018, p. 155) they are engaged in generating and “developing knowledge about and for the client.” Complex building projects are ill-defined or wicked. They contain a diverse and large number of stakeholders and consulting parties. They convey a large set of organizational, technical and spatial requirements, and call eventually for an integration of multiple and conflicting goals. Prior to the mandate for a building design to provide the necessary planning, drawings, approval, construction and tender documents, strategic and transformational challenges in these kinds of projects need to be addressed (Knittel-Ammerschuber, 2006, pp. 147–149; Sancho Pou, 2013, pp. 8–9). The organization that is subject to the design and change is understood and depicted by architects in ways that differ from the ones by their counterparts in management practice (Chantzaras, 2019b, p. 537).

The architectural design process with its distinct thinking and non-verbal tools drives this alternative understanding. In particular, in the architectural understanding of an organization for the purpose of designing and re-designing its processes, several aspects are highlighted: conducting architectural programming, applying spatial intelligence, working with architectural immersion and the intentional use of boundary objects and persuasive artifacts. These aspects enable architects to understand and design new organizational structures and processes in ways that are distinct from management approaches, but valuable and comprehensible to clients and their future organization.

5.2.1 Architectural Programming

The set up of the requirement program and definition of the brief is a crucial starting point for a building project (Fisher, 2015b, p. 44; Hershberger, 1999, pp. 1–5). Architectural practices guide the interactions with client and users at the beginning of an assignment in particular ways. They offer consulting services for complex organizational and strategic challenges before the building design starts (Brandner, 2008, pp. 20–23; Sancho Pou, 2013, p. 135). Architectural programmings, pre-design works or brief designs have been developed as approaches and methods to address goals and demands, facts and concepts (Cherry, 1999, p. 3; Faatz, 2009, pp. 80–81; Henn, 2004, pp. 43–45; Hodulak & Schramm, 2019, pp. 27–42; Kumlin, 1995). With a project's progress the influence on a project's direction decreases while the cost increase, as shown in Figure 29.



A

B

Figure 29: Cost-Influence Curve in Construction Projects
Influence and cost development are inversely related in building projects. With progression of design and construction, influence on changes decreases and cost increase as shown in visualization **A** by Königs & Schneider (2020, p. 540), adapted from Paulson (1976, p. 588). Visualization **B** by Faatz (2009, p. 82) outlines the phase to apply architectural programming for raising information at early stage.

Architectural programming addresses the early phases – or the fuzzy front end – of a building project to raise the information level for decision making. With its advanced formal structure, architectural programming is one of the few researched and externalized methods in architectural practice focusing on direct client-architect-interaction in the early stages (Bachman, 2012, pp. 52–53, 68–71; Cherry, 1999, pp. 9–17; Faatz, 2009, pp. 80–81). It integrates elements of scientific research, project management, architectural thinking and the application of architectural tools in a structured way (ibid.). The method has been adopted mostly by architectural practices in the US and UK; in other parts of Europe its application remained limited (Faatz, 2009, pp. 80–81; Hodulak & Schramm, 2019, pp. 32–41). With revisions in guidelines for requirement planning and honorary fees systems in Germany in the last decade its use may increase (Hodulak & Schramm, 2019, pp. 35–41).

Architectural programming aims to create a common understanding of the problem of a project and to develop a shared vision for its resolution (Henn, 2004, pp. 43–45, 49). It is a “research and decision-making process that defines the problem to be solved by design” (Cherry, 1999, p. 3). The discovery of the nature of a design problem is foregrounded, while the subsequent phase of designing a solution is kept separate (Hershberger, 1999, p. 1). The method supports the architectural practice in different consulting activities (Cherry, 1999, pp. 12–18, 40–46; Henn, 2004, pp. 43–45):

- Raising the level of the information required for a building design prior to the start of the design process (see Figure 30).
- Challenging the task given by the client by seeking for the “hidden program” (Cherry, 1999, p. 13 and Silverstein & Jacobsen, 1985, p. 151)[64]
- Structuring qualitative and quantitative information regarding needs, requirements, goals and visions.
- Involving and integrating different stakeholders, e.g., client, consultants, users, authorities and the public, in a participatory, collaborative and co-creative way
- Communicating and collaborating with clients, consultants, users and further stakeholders in an early decision making stage, to influence the project direction.

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[64] Silverstein & Jacobsen (1985, p. 151) raise concerns that an „exhaustive programming“ (ibid.) may not uncover essential requirements for a complex building project: „For each one we can say that there now exists a core, or „hidden program,“ that defines it; that the hidden program is the system of relationships, usually taken for granted, that give the building its basic social-physical form and connect it to the rest of society; and that these relationships, once clarified, can raise questions of such magnitude that they put the very nature of the building in doubt.“

Architectural programming methods vary according to the architectural practice in scope of work phases and their sequence (Cherry, 1999, pp. 40–46; Peña & Parshall, 2012, pp. 14–15). In general, the methods comprise a structured sequence of phases for preparation, collection, analysis, concept and resolution prior to the building design phase, or as its continuous support (Hershberger, 1999, p. 8).[65] Throughout all phases the visual communication of information and knowledge and the direct interaction with client and users is essential (Henn, 2004, pp. 43–47; Peña & Parshall, 2012, pp. 34–46). In the initial phase, preparatory works for research on the project context, for the project set-up and scope are conducted. The subsequent collecting phase, clarifies at first vision and formulates project goals in workshops and interviews. At second, facts, needs and requirements are collected. The received and generated information, as well as the knowledge attained on the subject, are structured for the concept phase. In the concept phase, a systemic and holistic view is pursued through graphic representations, diagrammatic sketches and models on the basis of the structured information. They are assessed with the initially developed vision, goals, needs and requirements to redefine the challenge or problem, to uncover and test concepts. In the final resolution stage, the problem or challenge is stated, which then has to be solved by a subsequent building design phase and design proposal (Peña & Parshall, 2012, pp. 10–11).

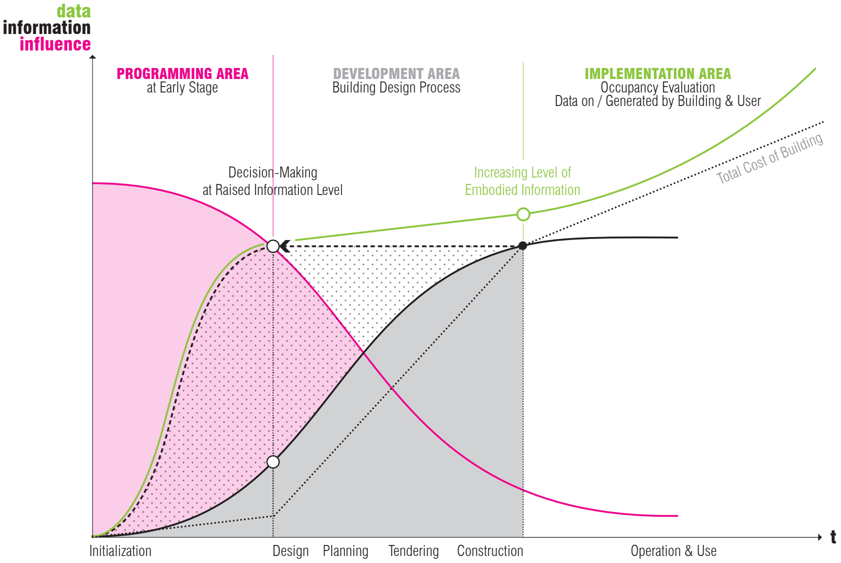

Figure 30: Information-Influence Curve in Architectural Programming

Distribution and availability of information during a building project increase along planning phases (grey area). In conventional projects information regarding the building peaks, when construction is completed. Architectural programming raises the information level regarding the project at early stage to influence its development with a larger information base. It enables architectural practices to access a vital decision-making area (hatched area). Data and information increase after completion further with building operation, if an according data management collects, monitors and analyses performances e.g. of equipment and usage. Author‘s own representation based on Chantzaras (2017, p. 8; 2019a, pp. 4–5), adapted from Faatz (2009, p. 82) and Henn (2004, p. 42).

The efficiency and success of the programming process is based upon a set of principles to be applied during the conduct of work. One of the first methods developed by the architectural firm Caudill Rowlett Scott (CRS) in the 1950s has been practiced and refined in the decades since as “Problem Seeking: An Architectural Programming Primer” (Peña & Parshall, 2012, pp. ix–x).[66] Basic to

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[65] Hershberger (1999, pp. 8–34) categorizes architectural programming methods by their primary focus on: design, knowledge, agreement and values. Design-based architectural programmings are applied concurrently to the building design process. Knowledge-based methods maximize information regarding social systems, behaviors and interactions between people in built environments. Agreement-based methods strictly separate the brief design from the building design phase. Agreement between the stakeholders, especially on the client’s side, is sought regarding the challenge and problem statement prior to designing a solution. Value-based architectural programmings focus on uncovering values and purposes for a design problem and integrating the different stakeholder including users into the programming focus.

[66] The first edition on ‘Problem Seeking: New Directions in Architectural Programming’ was published by Peña in 1969 with the architectural firm CRS. The fifth edition was published in 2012 by Peña & Parshall (2012) and the architectural firm HOK. For an overview on the development see Chantzaras (2019a, pp. 3–8).

this method is the separation of problem analysis from the design of a solution to avoid “trial-and-error design alternatives” (Peña & Parshall, 2012, p. 10). The principles further include the recommendation to continuous involve clients; to communicate effectively through visual and graphical means; to structure data and information in comprehensive ways; to think systemically and holistically; to iterate, include feedbacks and assess preliminary results and agreements; and to combine qualitative and quantitative information as building related information such as spatial areas, technical equipment, mechanical, electrical and climate requirements (Peña & Parshall, 2012, pp. 74–75). Throughout the phases, architects follow these principles and apply their different skills and tools for formulating, moving, representing, reflecting, evaluating and managing as explained in Chapter 5.1.2 (see also Chantzaras, 2019a, p. 7).

The method showcases a consulting service architects can offer at the intersection of building architecture and strategic management. Architects can work at early stages and apply their architectural thinking and tools to influence the course a project takes (ibid.). This consultancy in the ‘Phase 0’ of projects is separated from the scope of work architects fulfill according to honorary fee systems, and accordingly not formalized or unified in its content and process structure.[67] Especially in complex building projects with multiple stakeholders and requirements (e.g., research & development centers, headquarters, universities) architectural programming integrates strategic, organizational and spatial challenges. It leads to new spatio-relational configuration for company at a systemic level before the actual building design begins. It analyzes, collects and challenges assumptions, needs, requirements and goals the client, user and further stakeholders formulate regarding their processes to produce, work and innovate. It is an aid to uncovering culture, values and visions as well as relations and interactions in an organization in order to generate a holistic picture.

With its structured phases and the particular principles of integration of diverse views, collaboration and co-creation, visual thinking and systems thinking, iteration and integration of feedback it shows similarities to design thinking process models explained in Chapter 3.2.3. But, in contrast, architectural programming has received limited attention in architectural education and practice in the past decades (Faatz, 2009, p. 80). Several points of critique need to be mentioned. The separation between programming and design, between analysis and synthesis, between the early-phase consultant and the designer, divides a holistic design process with its constant commute between problem and solution space. Design as inquiry is fundamental for the analysis and deeper understanding of ill-defined and wicked problems. Iterations and learning loops need to span throughout the entire design process (Harrigan & Neel, 1996, pp. 157–158). Formalized steps to conduct the programming work as well as the reliance on collecting, structuring and categorizing data, information and knowledge seem too rigid to adapt to emerging insights and changing requirements. This approach is limited to considering future scenarios and future needs that cannot not be accurately stated or quantified during the programming phase (Brand, 1995, p. 181). The defined solution routines (“definierte Lösungsroutinen”, Nönnig, 2007, p. 57) that a programming method applies through its structure constrain the development of unexpected design outcomes. In conclusion, architectural programming methods in practice have

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[67] Knittel-Ammerschuber (2006, pp. 147–148) describes the ‘Leistungsphase 0’ in her concept of management by architecture without referencing the approaches of architectural programming, pre-design or brief design. She refers to the programming approach offered by the architectural practice HENN as creativity technique (“Kreativitätstechnik”, ibid., p. 108). Hodulak & Schramm (2019) relate their concept of user-oriented requirement planning („Nutzerorientierte Bedarfsplanung“, ibid., p. 56) as "Phase 0” (ibid., pp. 6, 16, 38) and state the lack of a codified description and definition of this phase in the honorary fee system.

"remained a means to the end of planning functional buildings, without being developed further in its potential application to tasks beyond physical solutions." (Chantzaras, 2019a, p. 6). The application of architectural programming, or parts thereof, to fields beyond building design had been considered in the approach:

> *"There should be not an underlying assumption that the solution must be the design of a building, and only a building. Designers should always be prepared to read between the lines of a program."*
>
> *(Cherry, 1999, p. 229)*

Architectural offices have begun to develop their very own approaches of architectural programming and 'Phase 0' services. They foster a closer interference between the problem formulation (analysis) and the design process (synthesis). At an early stage, architects use methods such as architectural programming to cope with complex environments and the fuzzy front end of a design challenge. Besides the principles they formulate and steps they define to carry out the services in this phase, the particular capabilities they apply are of interest against the background of innovation processes. Architects have capabilities to frame formal and informal processes of an organization. They use their spatial intelligence, immerse themselves in the problem space and create boundary objects and persuasive artifacts to see organizations and processes differently, and design systems for their innovativeness.

5.2.2 Spatial Intelligence

Spatial intelligence is a human capability in general and a particularly pronounced capability in architectural thinking and work (Hill, 2013, p. 15; van Schaik, 2008, pp. 8, 13). In the theory of multiple intelligences, "individuals possess eight or more relatively autonomous intelligences" (Davis, Christodoulou, Seider, & Gardner, p. 485) to different degrees of performance: linguistic, musical, logical-mathematical, bodily-kinesthetic, interpersonal, intrapersonal and naturalistic intelligence. Spatial intelligence as one of the eight intelligences is primarily defined as the "ability to recognize and manipulate large-scale and fine-grained spatial images." (Davis et al., p. 488). It comprises different capacities that are interrelated and influence each other in dealing with elements and imageries in order to perceive and recognize, to transform, to conjure, to visualize externally, to sensitively compose and to "discern similarities across diverse domains." (Gardner, 2011, pp. 185–186). As "the other intelligence" (ibid., p. 187) spatial intelligence provides a different way of representation and reasoning that complements linguistic intelligence, or – as noted for visual thinking in Chapter 2.4.3 – is essential to productive thinking (ibid., p. 186; Reichertz, 2013, p. 26).

> *"Individuals with exceptional gifts in the spatial area, such as da Vinci or the contemporary figures Buckminster Fuller and Arthur Loeb, have the option of performing not only in one of these spheres but across a number of them, perhaps excelling in science, engineering, and various of the arts. Ultimately, one who wishes to master these pursuits must learn the "language of space" and "thinking in the spatial medium." Such thinking includes an*

> *appreciation that space allows the coexistence of certain structural features while disallowing others. And, for many, thinking in three dimensions is like learning a foreign language. The number four is no longer a digit larger than three and less than five, it is the number of vertices as well as the faces of a tetrahedron."*
>
> *(Gardner, 2011, pp. 201–202)*

The spatial dimension supports processes of understanding and problem solving both in the physical and the mental realm. In the physical realm tangible objects are constructed as boundary objects to think with, explore, experiment and develop. In the mental realm the spatial intelligence manifest itself in the build-up of mental spaces. These mental spaces are on the one hand memories, thoughts, information and knowledge bound to spatial experiences where they occurred. On the other hand, the spaces are mental models often related to spatial metaphors as buildings, landscapes or machines (Gardner, 2011, pp. 200–201; Tzonis, 2004, pp. 68–69; van Schaik, 2008, pp. 40–54). In both realms, architects and their architectural design process excel.

The spatial intelligence architects possess, develop in practice and apply to cope with complex challenges is regarded as the knowledge base of architecture in addition to "the technologies of shelter" (Van Schaik, 2008, p. 13). Thinking spatially in architecture means to think about problems in a non-linear, 3-dimensional way, to view the different aspects of a problem from varying perspectives and scales (Lawson, 2005, p. 150; Samuel, 2018, pp. 67–68).[68] "Complex phenomena like real systems are impossible to "see" from one station point or standpoint", and therefore require – in a similar way to understanding a building – "moving around between it, up and over it, below and through it." (Nelson & Stolterman, 2012, p. 68). Architects keep goals, requirements and constraints in parallel in mind, while focusing on one in particular, and continuously explore and create connections between related and unrelated fields (Lawson, 2005, pp. 150–151; van Schaik, 2008, pp. 26–27).

The spatial intelligence in architecture offers "at the early heuristic stages of an inquiry a fast "insight" into complex, unidentified, and untried problems before analytical methods take over" (Tzonis, 2004, p. 69). The vagueness and fluidity in spatial thinking keeps the design process adaptive to changes and to the addition of information. Relations of different kinds – between people, functions, areas, technologies, things and between the broader context of the environment and society – have a spatial dimension for architects (Chantzaras, 2019b, p. 542). Proximities matter for the arrangement of the elements, to structure, order and understand the complexities of the project and problem. The third dimension, conceptually as well as externalised through sketches, diagrams, models and eventually buildings, allows architects to place people, functions and spaces in different relations and distances to each other, to rethink their location, to move, exclude or include, and to connect them.

In the spatial realm architects observe and imagine movements between one area and another, flows of people, of materials, of products, of services and of non-physical, intangible goods, such as knowledge information and data.

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[68] Lawson (2005) quotes Alexander Moulton, British engineer and designer of bycicles, along with two British architects, Michael Wilford and Richard MacCormac, on the speed of creative work in a design process. Moulton states: "Thinking is a hard cerebral process. It mustn't be imagined that any of these problems are solved without a great deal of thought. You must drain yourself. The thing must be observed in the mind and turned over and over again in a three-dimensional sort of way. And when you have gone through this process you can let the computer in the mind, or whatever it is, chunter around while you pick up another problem." (ibid., p. 150).

They can speculate about alternative arrangements, place elements below and above each other, merge or exclude them from consideration, propose new connections and movements in between, and create new environments from previously unrelated parts (Buchanan, 2015; Kulper, p. 63). Spatial opportunities arise from the play with proximities and the different perspectives and angles architects can take. The relational and spatial order in the third dimension reveals structures and patterns, which are not observable in two-dimensional representations, or remain invisible.

The spatial intelligence and the practice of making in architecture generate knowledge through non-verbal means but – for the observer – tangible ways. It leads to the design of a new whole as a synthesis of different parts. Architectural intelligence comprises the capability to explore relationships between elements across different spatial scales, to detect possible proximities and to establish new connections between them in the mind for the design of a themed system, i.e. system with a meaning (Tzonis, 2004, p. 68; Bouman, 2007, p. 96; Steenson, 2017, pp. 7, 224; and Chapter 5.3.1). Architectural and spatial intelligence are intertwined and essential "to solve problems dealing with culture-bound, informal human organizations" (Tzonis, 2004, p. 68) for which quantitative, analytical models of management reach limits with their "value-free" and culturally-neutral properties. The third dimension allows "escaping flatland" (Tufte, 1998, p. 1) and represents information spatially, to explore and add further layers for consideration. Space-related intelligence and representation by architectural means create order of people, structures, areas, functions, movements and processes in an organization for a physical world as well as for virtual networks (Bouman, 2007, p. 96; van Schaik, 2008, p. 179). The "spatial-functional thinking" (Tzonis, 2004, p. 69) together with the visual-spatial modes of reasoning is fundamental in architectural work. It supports behavioural change through the creation of a "spatial choreography" (Pallasmaa, 2016, p. 38) in the designs of an organization and its processes (Cross, 1990, p. 135):

> *"All architectural structures are forms of spatial choreography that guides action; space facilitates or prohibits, encourages or prevents, invites or inhibits. This choreography predetermines patterns of movement and behavior, but it also guides experiential characteristics, perceptions, imageries, emotions and feelings. A sensitive and empathic designer intuits human behavior and desire, and this intuitive architectural scripting resonates with the actual user/occupant's natural and instinctual needs and intentions."*
>
> *(Pallasmaa, 2016, p. 38)*

Metaphors of building and architecture used in the fields of management, information technology and engineering reference this spatial thinking and intelligence (Steenson, 2017; Tzonis, 2004). The building metaphor eases the understanding of complex relations and provides a comprehensive approximation to organizational ideas or concepts (Tzonis, 2004, pp. 68–59). In the context of engineering and information technology,

> *"[t]he notion of architecture provides a means for relating elements of a problem that are at different scales to one another. When non-architects adopt the term "architecture," when they use "architect"*

> *as a verb, they are seeking ways to bring complicated issues into relation with each other. They are looking to architecture as a metaphor for how humans interact with spaces."*
>
> *(Steenson, 2017, p. 2).*

In context of engineering systems, architecture influences the functional and emergent behaviors of a system and defines its ilities and complexity (Crawley et al., 2004, pp. 1–3). For challenges of organizations and innovation processes, a spatial intelligence connects the information about who interacts with whom and the content of their interaction with the information on where and when (Chantzaras, 2019b, p. 542). It is a spatio-temporal understanding of people flows, their pathways, movements, encounters and interactions – or their absence – which is transformed in the subsequent design. The spatial and visual construction of an organization can broaden the view of processes in a company as a whole and with its human actors as its elements. It further activates and stimulates the spatial intelligence of the people who are involved in this construction process or engage with its final outcome as a 3-dimensional structure. Spatial intelligence is on the one hand an aid to the architecture and design of innovation processes. On the other hand, it addresses a central human capability with a "staying power" (Gardner, 2011, pp. 187, 215–216). What is thought, experienced, memorized, developed and created spatially remains a "robust" (ibid., p. 215) knowledge over the course of time.

5.2.3 Architectural Immersion

Practice-specific design processes and architectural programming methods support architects in conducting an organizational consulting service. With their spatial intelligence they develop implicit and explicit imageries, mental models and tangible objects of the data, information and knowledge they generate and of the thoughts and ideas they created regarding the organizational challenges. To fully access the beliefs, values, vision, goals and demands of client and users, architects immerse themselves in their perspectives and situations. They seek to discover the latent needs of clients and users and prescribe a desired future state. Architectural immersion is rooted in the special nature of the client-architect relationship. It is characterized by the client's and user's credence and trust in the architectural capabilities and in the design process carried out. The constant commute between problem and solution, the co-evolution of the formulation of the design challenge and its resolution make demands on clients and users for a supportive, risk-seeking attitude and resilience in uncertain, ambiguous situations and situations of conflict (Lawson, 2005, pp. 68, 168).

Architects deal with a broad field of quantifiable information and knowledge regarding an organization, from a masterplan and strategic view to a single tangible functional or constructive detail. They acquire also qualitative aspects of values, experiences, atmospheres and emotions which span from the individual perspective – how someone feels, behaves and acts to groups, organizations and the external social environment of, e.g., the public, the broader industry or the innovation ecosystem. Across these scales and the different kinds of information and knowledge, the architect bears responsibility towards the client and users as well as towards the environment and society. In other words, she or he acts as a strategic designer by being "obliged to always balance the very hard, calculable, finite things like gravity and cost, with the soft incalculable, cultural aspects, like aesthetics and the opinion of the community […] at scale" (Hyde, 2013, p. 140) – from private groups and stakeholders to authorities and urban environments.

The responsibility of architects stems from different sources. Firstly, architects act in a protected liberal profession with a specific knowledge base, the "possession of a special set of skills or training" (Samuel, 2018, p. 29) which are regulated and bound by a common set of values and reliabilities. Secondly, the design attitude implies a responsible acting and caring for client, environment and society. It is optimistic that a betterment can be achieved (Beucker, 2016, p. 35; Vassal & Oswalt, 2016, p. 140); it is generative and directed towards an actual output (Gänshirt, 2012, p. 15; Illies & Nicholas, 2009, p. 1252); it is holistic by relating the impacts and effects of a design in the context of larger environments (e.g., industry, society, natural environment) and long-term perspectives (Düchs, 2012, pp. 424–426); it is integrative, in so far as any design of distinction requires a distinct client and the client's co-creative engagement (Lawson, 1997, p. 85); it is communicative and comprehensive, allowing "the design team to expect the unexpected outcome, in alignment with the client's desiderata" (Nelson & Stolterman, 2012, p. 132).[69]

Architectural immersion and empathy are core capabilities in understanding people, interactions, processes, culture and organization. An architect immerses himself or herself in the project, and "imagines the reality […] on behalf of the client, or the unknown other" (Pallasmaa, 2016, p. 42). Immersion and empathy evolve from the dialectic, critical reasoning the architect performs with the client and user, to question and challenge their beliefs and needs for the future and to simultaneously reflect on the impact on their environment. Architects are usually independent in their practice (Düchs, 2012, pp. 424–426). They associate the obligation to provide a solution with creating an improvement, what ought to be, in addition to what is actually wanted or currently feasible (Chantzaras, 2020, p. 690; Fisher, 2016, p. 440). In this ethical and independent attitude architects are distinct: they are educated, trained and skilled in designs for prototypical built structures, which have a much larger life-span that products and impact on user and environment in multiple, sometimes disruptive ways (ibid., p. 437). Regarding the life-span of a building, users and usages change, which requires an adaptive design solution for "unknown future conditions" (Brand, 1995, p. 181). Regarding the impact on user and environment, the function and use of the building need to be "morally acceptable" (Illies & Nicholas, 2009, p. 1219), the well-being of users considered, the influence on behavioral change incorporated, the "furnishing of cultural and symbolic meaning" (ibid., p. 1220) reflected and the impact on ecological environment foreseen. The structures and systems architects develop need to provide permanence on one hand and be adaptive to changes on the other (Chantzaras & Rung, 2017, pp. 32–33). Therefore, architects expand the brief in a "perpetual inquiry" (Pendleton-Jullian & Brown, 2018, p. 100) to arrive at "a deep empathy with the problem, and with the context in which the problem is embedded." (ibid.) Empathy, a core capacity and skill in architecture, means to immerse oneself in a situation and identify with it through cognition and emotion, and to construct a new perspective from the inside (Chantzaras & Rung, 2017, pp. 34–35; Pallasmaa, 2016, p. 41; Pendleton-Jullian, Brown, 2018, p. 148).

Against the background of the responsibility architects have towards the client and users as well as towards issues besides and beyond their needs,

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[69] For characteristics of architecture as liberal profession see e.g., Rambow (2000, pp. 12–21).

empathy in architectural design process is multidirectional and an invitation to explore new suggestions. Architectural immersion comprises empathy and responsibility. It is necessary to "empathically confront people with transformation" (Chantzaras, 2019b, p. 542) and create alternative frames for their actions. A building design and a building construction may not be the expected answer when assigning an architect (Trüby, 2012, p. 511). Consequently, the architect's scope of work, as hypothesized here, may extend to other fields (Bryant, Rodgers & Wigfall, 2018, pp. 11–13; Fisher, 2015b, p. 45)[70]

The architectural design process is an experience of work-in-the-making. Through listening, observing, asking, and using design tools, architects externalize the stakeholder's thoughts, values, ideas and knowledge. Shared understandings and future possibilities, creativity and empathy unfold on both sides of the client-architect relationships through boundary objects and "persuasive artifacts" (Wagner, 2004, pp. 158–159; and Boland & Collopy, 2004b, p. 268; Lawson, 2005, p. 85).

5.2.4 Boundary Objects & Persuasive Artifacts

Information and knowledge on organizational processes, especially on how an organizations and its members think and act, what their values, prospects, expectation, ideas for the future and visions are, is sometimes hidden, covered and implicitly residing in patterns of behaviors and the individual's mind (as elaborated in Chapter 2.3.2 and 3.3.3). This uncodified, tacit knowledge, these values and emotions constitute an organization's intangible assets, which are distinctive to it and distinguish it from other organizations; they are difficult to imitate or copy and provide the basis for competitive and innovative capabilities (Dodgson et al., 2008, p. 29). To extract tacit knowledge, thoughts, ideas and critique, to trigger and evoke emotions architects create boundary objects and persuasive artifacts (Boland, Collopy, Lyytinen, & Yoo, 2007, p. 16; Wagner, 2000, p. 379). Both are invitations to clients, users and further stakeholders into a collaborative, confrontational, yet co-creative discourse (Lawson, 2005, p. 48; Wagner, 2000, pp. 379, 388; Wagner, 2004, p. 159). While boundary objects are a neutral platform in the context of architecture for generating knowledge, persuasive artifacts contain a conviction of the architects for direction of thought or prepare for a preferred design direction (Wagner, 2000, pp. 386–388).

Boundary objects are objects of an immaterial or physical nature, which function as an intermediary device for communication and collaboration between individuals and groups of different communities of practice (Star, 2015, p. 251; Boland & Collopy, 2004b, p. 268; Gal, Yoo, & Boland, 2005, pp. 804–805; Wegener, Guerreiro Gonçalves, & Dankfort, 2019, p. 1257). In contrast to " "within"-practice objects" (Carlile, 2002, p. 451), which are built upon a similar professional or disciplinary knowledge base, the " "across"-practice" objects (ibid.) are "transferring, translating and transforming knowledge across boundaries" (Wegener et al., 2019, p. 1257; and Star, 2010, pp. 604–605). They are characterized by their flexibility, structure and scale (Star, 2010, p. 601): interpretive flexibility describes the openness to different uses and interpretations; structure refers to the demands of involved parties for

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[70] Fisher (2015b, p. 45) predicts for future architectural practices leadership as its key proposition: "Indeed, by 2050, leadership could become one of the most recognised and well-rewarded skills that architects have to offer. […] Architects lead by helping people imagine futures different from – and ideally better than – what they have now. Every time we design a building, we show people what could be, make concrete plans for how to achieve it, and assuage the fears of those who do not like change and of sceptics who discount anything they have not seen before. Every building project, in other words, builds our leadership skills, and by 2050 humanity will need those skills for problems that extend far beyond those of buildings. Time will tell if we can rise to the occasion."

information and work process; scale outlines the dynamic movements between the generic level at which an object can be viewed and its particular adaptation to a detailed situation (Star, 2010, p. 601).

> *"Boundary objects are objects that are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use."*
>
> *(Star, 2016, p. 251; and Gießmann & Taha, 2017, p. 35).*

Any object in this understanding can become transformed into and serve as a boundary object, if it is used between groups of different communities according to the three characteristics of flexibility, structure and scale (Star, 2010, p. 603). Boundary objects are "based in action, subject to reflection and local tailoring" (ibid., pp. 602–603) and allow for collaborative work without consensus.

The sketches, diagrams, drawings and models, architects create are boundary objects to initiate and facilitate communication without being aligned with the involved parties, and to stimulate the discovery of knowledge, emotions and meanings (Boland & Collopy, 2004b, p. 268). They transform the knowledge of involved parties from implicit to explicit, from intangible to tangible. They nurture the generation of new knowledge through visually addressing and evoking emotions, through confrontation and provocation, through manipulation, experimentation and the play between architect, client and user (Lawson, 2005, pp. 167–170; Mainemelis & Dionysiou, 2015, pp. 122–125). Organizational structures and processes can be reflected and transformed by the use of boundary objects. Questions can be investigated in relation to why, among whom and where interactions occur; the forms of interactions, their rate of usage and formality can be analyzed. By moving the communication from verbal to visual-spatial means of sketches, diagrams, drawings or models, a tentative and evocative collaboration begins, which keeps the design process in a "liquid state" (Boland & Collopy, 2004b, pp. 270, 273; Cross, 1990, pp. 132, 135; Gehry, 2004, p. 20) until a design solution is found. In addition, sketches and drawings call for active participation, if accessible for manipulation (Henderson, 1991, p. 454). As "conscription devices" (ibid., p. 456) they are particularly effective in engaging engineering professionals in the task of creating and developing a design solution. These kinds of devices or boundary objects are closely related to the 'within'-practice use of objects to share understandings and collaborate (Strübing, 2005, p. 260).

In common with boundary objects, persuasive artifacts have an interpretative flexibility and facilitate understanding, communication, development and transformation of a design idea or concept. They convey different levels of information and knowledge, from abstract, metaphorical levels of thought to concrete levels of details for construction. In contrast to boundary objects, the artifacts do not entail a particular structure or scale. They function more as inspirational aid and invitation to engage and contribute to the design process (Wagner, 2000, pp. 386–388). Their persuasiveness resides in the "conviction" they are made with "for the design of a particular solution" (Wagner, 2004, p. 159). The artifacts are created with a design attitude and a design lead, to confront client and user with possible new frames of thinking about their needs and behaviors, and to enable a creative collaboration (Lawson, 2005, pp. 85, 168).

Boundary objects and persuasive artifacts are used to externalize existing and prevailing mental models of user and client; they detach the mental models from personal attribution and reveal the overlaps and differences between individual thinking; they support dialectic discussion of contrarian views in the design process and enable social participation across functional and disciplinary borders (Doll, 2009, p. 150; Norman, 2013, p. 26). In their digital and physical form they "become the terrain on which conflicts and collaboration occur" (Doll, 2009, p. 131; Perry & Sanderson, 1998, p. 275).

In relation to organizations and their processes boundary objects support the construction of new and shared mental models. They convey new organizational designs for a firm's configuration and processes, which in turn shape and influence the behavior of its people (Reiter-Palmon et al., 2012, p. 316). The boundary objects – or the boundary model – are discussed and developed further. Against this background architects design with their „powerful tools of thought and communication" (Lawson, 1997, p. 258), with their spatial intelligence and architectural immersion, using boundary objects as integrative and constructive models of an organization and its processes (Tzonis, 2004, p. 69). Design disciplines and architecture "should be viewed not simply as problem-solving but more importantly as a knowledge generation and integration activity." (Hobday et al., 2012, p. 18). Indeed, creative thinking should be related more to problem finding than problem solving, as Mihaly Csikszentmihalyi (1988a, p. 162) points out in a dispute with Herbert Simon. Motivational and emotional aspects of cognition need to be considered together with rational approaches of problem solving (ibid., p. 173; Csikszentmihalyi, 1988b, p. 184).

> *"By writing that "The unique property of scientific discovery is problem finding, not problem solving," I asserted that the difference between a more and a less creative outcome does not lie in the ability to solve the problem, but in the capacity to formulate it in an original way. Of course, problem solving must also be involved."*
>
> *(Csikszentmihalyi, 1988b, p. 185)*

In seeing the architectural design thinking process as a form of inquiry and problem seeking, more creative outcomes may evolve as new designs and architectures of innovation processes. Architecture synthesizes the vision, values, interactions, requirements and needs of an organization into a new whole, or into frameworks for possibilities to innovate.

5.3 Synthesizing Frameworks for Innovation

Architectural synthesis is created continuously during the design process in the commute and negotiation between problem and solution space. It is "an attempt to move forward and create a response to the problem" (Lawson, 2005, p. 37). The abductive "guessing for very specific reasons" (Clarke, 2016, p. 91) leads to a preliminary problem resolution. If it is refused, architects transfer their learning experience back into the problem space, re-formulate the initial assumption or working hypothesis and develop with their tools an alternative informed guess (ibid., p. 91; Dodgson et al., 2011, pp. 113–115). The different attempts an architect undertakes to frame the client's vision for the future in a comprehensible way are part of the process. The different attempts do not show an ignorance for the client’s needs or a “lack of respect for the user" which "prompted rejection” as Martin observes (2009a, p. 169).[71] In this back and forth approach of different attempts architects uncover, develop and generate the fundamental parts for the final synthesis of design which is – ideally – a distinctive, unexpected but desirable solution. The final synthesis is the building concept that is eventually planned and constructed. In relation to organizations and their processes, the final synthesis is the system concept that encourages behaviors and establishes frameworks for interactions to occur.

Synthesis in the architectural design process is multi-dimensional. It has a spatial and a social dimension; it has dimension of time and a dimension of theme. It integrates space (people and things) and time (interactions and processes) through a new theme (idea and meaning). Elements are allocated in their relational and spatial proximities. Processes are defined and at the same time kept open to change, adapt and emerge in new directions. The theme binds elements and processes together beyond their mere functionality and efficient organization. The theme – in Ungers’ view of architecture as theme (Ungers, 2011, p. 16) – is the imaginative picture, the idea and principle of order for the new whole that guides and inspires people, that frames and provides possibilities for interactions (ibid., pp. 113–115; Gasperoni, 2016, pp. 259–260).[72] The final synthesis in design is not an outcome of rational and analytical problem-solving heuristics (Hatchuel, 2001, p. 263). Its value add lies in the art of arrangement, its thematization ("Thematisierung", Ungers, 2011, p. 16), composition and combination of the tangible and intangible, the implicit and explicit, the informal and formal elements. The final synthesis, the themed configuration, conveys an organization’s thinking about innovation and how it actually innovates.

5.3.1 Architectural Synthesis for Innovation

The two central capacities of architects to design organizational systems is their capacity for synthesis and the strategic use of architectural tools to create and externalize this synthesis (Nönnig, 2007, pp. 200, 223; Tzonis, 2004, p. 68). Architecture as physical outcome gives shape to informal processes of how an organization and its people behave, how they interact, collaborate, innovate at present and in future. It designs the space in-between, because “actually it is what is not drawn that is really important, for architects are really manipulating space.” (Lawson, 2005, p. 284). From a managerial perspective architects design the “ “white spaces” between the boxes on the organization chart” (Hobday et al., 2011, p. 14; Maletz & Nohria, 2001), in which the informal organization exists and evolves. With their design solution for a building behavioral change is set by default or at least intended by default (Illies & Nicholas, 2009, p. 1222; Pallasmaa, 2016, p. 38).[73]

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[71] Martin (2009a, pp. 169-171) inteprets the different design attempts architectural offices offer or insist on as lack of respect for the client. He regards them as failures in the design process to create value for the client. He ignores the relevance and value of boundary objects, persuasive artifacts and a studio environment for the design process, as explained in Chapter 5.1 and 5.2.

[72] Architect and theorist Oswald Matthias Ungers writes in his book ‘Die Thematisierung der Architektur’ (2011, pp. 113–115): „Wenn – um zur Architektur zurückzukehren – Entwerfen als rein technologischer Vorgang aufgefasst wird, dann ist das Ergebnis ein pragmatischer Formalismus. Ist der Entwurf ausschließlich der Ausdruck emotionaler Erfahrungen, so führt dies nur zu leicht zu unkontrollierten Auswüchsen. Geht dagegen der Entwurfsprozess von einem Vorstellungsbild aus, das als Ordnungsprinzip dem Ganzen zugrunde liegt, so kann innerhalb dieses Bildes der ganze Reichtum der Fantasie entwickelt werden. Das Entwerfen in Vorstellungsbildern ermöglicht den Übergang vom pragmatischen zum kreativen Denken, vom metrischen Raum der Zahlen zum visionären Raum der kohärenten Systeme. Es bedeutet einen Prozess des Denkens in qualitativen statt quantitativen Werten, der sich mehr auf die Synthese als auf die Analyse konzentriert.“

[73] “Architectural designs are not only influenced by a certain idea about how human beings live and what they do, buildings can also suggest ideals to their occupants: an obvious way is to make certain actions easy and others difficult or impossible.” (Illies & Nicholas, 2009, p. 1222).

When companies assign architectural practices in early phases with challenges in production, work and innovation processes, the architectural practices reflect the changing context the business and organization is embedded in. The innovation challenges companies encounter in their field require organizational structures, processes and spaces to change and to take into consideration the mutual interdependence of social interactions and space as drivers and facilitators for innovative initiatives (Allen & Henn, 2007, pp. 1–19; Groves & Marlow, 2016, pp. 127–130, 157–162; Katsikakis, 2017, pp. 71–73): knowledge work and creative work are emphasized, which often manifest themselves tacitly in social networks and personal, face-to-face encounters; flexibility and adaptation are required regarding people's behaviors and their problem solving approaches as well as regarding the provision and configuration of physical spaces; self-organization and the building of networks of people are encouraged; values, meaning and purpose of the company are articulated and embodied in the structure of organization and processes as they influence employees' motivation, engagement and performance. Openness as a value or a design attitude for the creation of new meanings (as described in Chapter 3.3.4) becomes transferred and manifested in processes that encourage, e.g., communication, criticism and collaboration over secrecy, group thinking and opposition. These aspects make special demands on the design of the building and the design of the system, which precedes the building design and provides its underlying program as addressed in architectural programming.

In transformative projects architects lead the client to imagine futures, to imagine "what could be, make concrete plans for how to achieve it, and assuage the fears of those who do not like change and of sceptics who discount anything they have not seen before" (Fisher, 2015b, p. 45). Architect and client move forward with conviction on how reality can be improved for a company and collaborate in developing a frame for future knowledge work and innovative behavior (Bruyn & Reuter, 2011, p. 38). The system they design ideally enables, improves, facilitates communication and interaction among different people. The system visualizes established processes and innovative activities. It encourages exploration across the organization and offers opportunities for employees to engage with other members, groups, or external partners. It provides the frame for chance and serendipitous encounters to occur, for knowledge and ideas to flow. The architectural design of the organizational system is the blueprint for the building design as materialization of change.[74]

In this synthesis the concept of a future organization takes shape in its totality, a "visual-sensemaking" to reveal "contextual interdependencies" (Beucker, 2016, p. 39) which have not been thinkable and visible before. It includes the long-term perspective architects consider in their practice and it includes the ethical function of architecture as responsibility towards client, user and the environmental context of the industry, public, society and time (Düchs, 2012, p. 424; 2017, p. 187). Synthesis in architecture is a complex principle of organization (translation by author, Nönnig, 2007, p. 200) to create and develop structures, connections and relations between people, functions and spaces with a new theme and meaning.[75]

The building design translates the system design into a tangible reality.

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[74] For the architect Bernhard Tschumi "[a]rchitecture is the materialisation of a concept." In: Garcia (2010a, p. 196).

[75] „Synthesis betont den kombinierenden und integrierenden Aspekt architektonischer Konzept- und Lösungsfindung: die komplexe Abstimmung von Ideen und Materialien, die Aufhebung und Vermittlung von Diskrepanzen und Widersprüchen in gemeinschaftliche Ordnungsformen, die in den wenigsten Fällen ad hoc, am Stück gelingen wird, sondern vielmehr ein kontinuierliches Zusammenlegen und beharrliches Aneinanderpassen von Einzelpositionen, Bauteilen und Elementen ist. Synthesis ist ein komplexes Organisationprinzip, insofern es nicht bloße Aggregate erzeugt, sondern neue, vielschichtig verknüpfte Strukturen: […].“ (Nönnig, 2007, p. 200).

It can "provide an (practical) answer of how to integrate functional and other claims" (Illies & Nicholas, 2009, p. 1238) and solve tensions in the conflicting goals of purpose, innovative culture and effective innovation processes. Architectural design and physical space are valuable managerial tools for companies to induce, manifest and establish transformation (Allen & Henn, 2007, p. 2; Rumpfhuber, 2013, p. 11; Sailer, 2010, pp. 46–47). Built examples of architectures for higher education, for research and development, for corporate headquarters, in which immaterial knowledge and creative work prevail, embody and reveal to others the cultural and organizational transformational processes in a society (translation by author, Gómez, 2013, p. 76; and Knittel-Ammerschuber, 2006, pp. 13–18).

As "physical embodiments of organizational change" (Van Marrewijk, 2009, p. 290) corporate headquarters surpass aesthetics functions. They transfer through architecture values and culture, knowledge and processes, to shape thinking about organizational issues and the behavior of its people. Architecture in its built form is becoming a "constructed mental space" (Pallasmaa, 2015, p. 54). From a neuroscientific perspective "[c]hanges in the environment change the brain, and therefore they change our behavior. In planning the environments in which we live, architectural design changes our brain and our behavior" (Fred Gage quoted in Farling, 2015, p. 183).

Moving from physical buildings back to the virtuality of organizations and their processes, architectural synthesis offers an organizational design with multiple dimensions: the dimensions of space and time, the dimensions of social behavior and theme. In reference to the way physical buildings shape our thinking and behaviors, the systems and conceptualizations created in advance and in parallel to these buildings shape our thinking and behavior as well. Regarding the context of design thinking and its relevance to transform organizations Buchanan (2015) claims:

> *"[W]e shape our organizations, and then our organizations shape us. Put simply, the challenge for design is how to influence organizations not only to affect the thinking and behavior of individuals, but also to have a positive effect on human experience in an increasingly complex world."*
>
> *(Buchanan, 2015, p. 6).*[76]

The system models synthesized in architectural design processes prior to a building design and physical construction represents a valuable addition to innovation management. It is the visual and tangible extension of the mental space to view, understand and design processes and organizations in multiple dimensions. The architectural system models externalize the innovative processes in a firm as they occur and are suggested to occur in future. This mental space constructed and shaped with the thinking and tools of architecture could address the extended demands regarding innovation, i.e. to frame multi-level complexities, to display social proximities and interactions, and provide a system that is designed with a design attitude. Architectural synthesis for innovation processes comprises

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[76] Buchanan (2015, p. 6) refers to and adapts the quote by Winston Churchill at a meeting in the House of Commons in 1943: "We shape our buildings, and afterwards our buildings shape us." Düchs (2017, p. 192) relates the same quote to the moral relevance of architecture and the mutual dependence of 'good design' and 'good life.'

- the configuration of relational and spatial proximities of people, objects and functions in an organizations
- the display of interactions across space and time
- the creation of a theme or narrative for the kind of configuration
- the design for awareness, e.g., of people, activities, changes, technologies (Allen & Henn, 2007, pp. 85–86);
- the design for interaction, for exploration, engagement, experiment, learning as well as for conflict and critical reasoning (McDonnell, 2015, p. 117);
- the design for flows and emergence, to allow unexpected processes to occur, unfold and overlap (Pendleton-Jullian & Brown, 2018, p. 231).

With the use of non-verbal tools, architects develop and formulate this synthesis. As they are oriented towards a concrete reality – how the innovation processes can actually be implemented in an organization – architects need to make its design solution tangible and comprehensible. At the systemic level of architecting, frameworks for innovation, diagrams and models are essential.

5.3.2 Synthesis in Diagrams & Models

Diagrams and models in architecture are important tools to make a design synthesis for organizational processes tangible. The diagram combines "functional aspects of areas and processes with people, flows, interactions, and relations" (Chantzaras, 2019b, p. 543). It is a holistic, yet abstract view of an organization – and a building – as a socio-technical system (ibid.; Bauer & Herder, 2009, p. 601). Besides its function as a boundary object for collaboration and the build-up of a shared understanding, it serves as a visualization of a finalized (and synthesized) design concept. It depicts sequences of actions, processes and flows, suggested relational and spatial proximities, open spaces for possible connections and interpretations. Enriched with verbal means, its graphical elements can be more easily accessed, understood and used as guiding device (Lawson, 1997; Yi-Luen Do & Gross, 2001). As a general scheme it takes an intermediate position between the invisibility of language that describes functions (e.g., communication, collaboration) and the visibility of organized space that represents concrete matter (Garcia, 2010b; Vidler, 2006). It blends visible activities, processes and placements with invisible elements of symbols and metaphors. As a narrative or rhetorical means it communicates a new reality, is generative, constructive, predictive and projective (Allen, 1998, p. 16; Garcia, 2010b, p. 25; Hnilica, 2013, p. 242). Being a "spatiotemporal abstract map" (Garcia, 2010b, p. 24) it integrates time and movements.

In architectural design it can go beyond two-dimensional plan views and convey further layers of information and insights in a third dimension (Gänshirt, 2012, p. 149). Turned into an abstract 3-dimensional model, the diagram offers new viewpoints, can be cut through vertically or horizontally to provide a diagrammatic section or plan of proximities, processes and relations, which were not visible to the viewer before. The diagram departs from the fuzziness and informality of a sketch, but remains more open and liquid than the architectural drawing and its order of spatial programs. Architectural practices develop their own language of diagrams, with specific functions and purposes. They serves as a medium or "mediator" (van Berkel & Bos, 2010, p. 224) for a diagrammatic architecture to take shape, to be transferred in drawings and built in reality; it serves as a means to understand and structure information and knowledge, to reframe complexities of different kinds, of movements, relations, interaction, functions, processes and context in a narrative way (Hnilica, 2013, p. 243; Knoespel, 2002; Nönnig, 2007, p. 64).[77] As a narrative it is a means to represent and describe time in a concept, as the architect Will Alsop points out: it shows the concept's impact on the environment as well as regarding "the stories of place and people" (Alsop in Garcia, 2010a, pp. 216–217) and how they behave. In an extension of this argument, the diagram also "prescribes performances in space" (Zaera-Polo & Alejandro, 2010, p. 239) and aids the construction of new organizations and new realities (ibid., 237–239; van Berkel & Bos, 2010, p. 227).

From a critical perspective, the broad and diverse use of diagrams in architecture as, e.g., flow charts, relationship maps, abstract models of form and shape, utopian concepts, bricolages, frozen movements, causes difficulties in their definition and understanding and has led to criticism of their applicability and the justifications they provide (Garcia, 2010b, pp. 25–36; Lawson, 1997, p. 251): architectural diagrams do not share a unified theoretical base in the discipline of architecture; they depend largely in their form and use on the theoretical conceptions and practical expertise of the architect or architectural practice creating them, and may therefore convey "ideological" or "polemical" (Garcia, 2010b, p. 33) meanings and may be difficult to read and interpret by others; they are often confined to architectural discourse, shielded from criticism and detached from other disciplines and multidisciplinary interactions.

In architectural models, spatial and relational proximities of people, functions and processes, theme and emotions converge. The 3rd (Euclidian) dimension addresses the spatial intelligence and the experience of the concept with depth. Elements and agents can be viewed simultaneously in their arrangement to each other (below, above, behind, in front, diagonal) and their mutual influence. With a physical model the visual, sensory senses can be involved and invite a playful engagement with the object and its embodied meaning. Time, flows and dynamics can be represented, when the model is built as a system of interacting parts and serves as a 3-dimensional frame for simulations to be carried out. Models in architecture, as mentioned before, are generative and allow to explore and confirm physically or virtually the synthesized solution. Oswalt & Hollwich (1998) differentiate between a diagram and a model in their work at the architectural practice OMA as follows:

> *"The model is the tool in which the sum of the ideas are investigated in their mutual influences and in relation to the context, with which*

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[77] Garcia (2010a, pp. 186–281) and Dirmoser (2013, pp. 311–314) provide an overview of architectural practices using diagrams to understand and build structures (e.g., Peter Eisenman, OMA, UN Studio) and practices using diagrams to understand and reframe complexities at an organizational level (e.g., OMA, UN Studio, Asymptote). Henn (2004, p. 46) uses diagrams as mediating device between text (problem) and product (solution) to formulate the design task to solve.

'Alexander diagrams' are excluded from consideration. They outline and formulate diagrams as descriptive patterns, which are combined to build the end product of synthesis as a "tree of diagrams" (Alexander, 2002, p. 84). In their simplistic structure, their concentration on isolated problems and orientation to form and function they reduce the architectural complexity described in this thesis. These kind of diagrams received limited acceptance in the discipline of architecture. Nönnig (2007, pp. 54–55) summarizes in his chapter 'Unterkomplexe Diagrammatik und „Formfehler" ': „Alexanders vielschichtige Untersuchungen offenbaren ein signifikantes Defizit: seine unterkomplexen und nur ansatzweise entwickelten Organisations- und Darstellungstechniken reduzieren multiple architektonische Zusammenhänge auf kalligraphische Bilder (Notes on the Synthesis of Form), auf technische Netzwerkgraphen (A City is not a Tree) oder auf skizzenhafte, plangraphische Bausteine (A Pattern Language). Der Verlust architektonischer Komplexität in diesem graphischen Reduktionismus ist offensichtlich. In der fatalen Zweidimensionalität der Diagramme können komplexen Eigenschaften kaum repräsentiert bzw. realisiert werden, die über Vernetzungs- und Schnittstellenquotienten bzw. räumliche Komposition hinausgehen. Alexanders Diagramme stellen für die Vielfalt der materialhaften, kommunikativen, konstruktiven, soziologischen, semiotischen, physiologischen etc. Belange keine adäquat komplexen Informationsträger dar, sie bilden kein entsprechendes Instrumentarium. Eine genuine „Pattern Language of Complexity" steht nach wie vor aus."

> *proportions and spatial interrelations are tested. In contrast, the diagrams drawn in thick, black pencil serve to clarify concepts and the investigation of individual parameters."*
>
> *(Oswalt & Hollwich, 1998)*

Digital technologies have extended the use of 3-dimensional models in architecture. Digital printing, laser cutting and digital manufacturing improve the generation of physical models. Software for algorithmic and parametric design and technologies for virtual and augmented realities extend the scope of information and the knowledge conveyed and they also extend the level of interaction and immersion with the design. Against this background, diagrams have evolved by new digital means into spatial and multi-dimensional representations, and are sometimes also referred to as models in architecture (van Berkel & Bos, 2010, p. 223).

5.4 Findings – A Spatial Approach

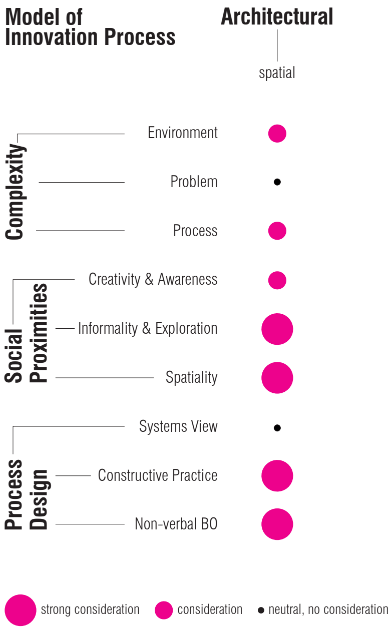
The conditions of architectural work share similarities to managerial tasks. Architects work in environments that are complex and dynamic. The problems they are confronted with are ill-defined, open or wicked. They are dealing with social systems, the interaction of people and seek to facilitate or transform behaviors. With a building design project, they also take a systems perspective and are confronted with strategic and long-term issues. But organizational challenges are understood and developed differently. Against the background of an extended process view on innovation, architecture addresses complexity, social interactions and process design with its architectural design process, its thinking and tools.

The design processes architects conduct is flexible, adaptive and unique. They act in the assignments as change agents, catalysts for transformation, integrators and synthesizer (Nönnig, 2007, p. 223; Speaks, 2002, p. 212; Verganti, 2017b, p. 101). Architects make use of particular design tools and existing and new technologies to integrate different disciplines and specific knowledge. The architects' core capability for synthesis is directed to creating a new whole. And they are committed to delivering an expected "unexpected outcome" (Nelson & Stolterman, 2012, p. 132) that lasts. The design solution or design synthesis, which architects develop and propose to a firm (when assigned a design project), is a holistic system of people, spaces and technologies, with interactions and behaviors in relational and spatial proximities. It integrates the dimension of space and time, of social and theme. The architectural models are purpose-built and custom-designed frameworks for behaviors and eventually frameworks for new routines of people in interaction with each other and in interaction with space. The frameworks serve as a space in which to embed detailed project protocols for innovation management in relation to, e.g., where responsibilities reside, the development levels reached and resources allocated. The behavioral change for innovation, the new or "effective routines" (Tidd & Bessant, 2013, p. 624) that need to be discovered, learned and implemented are fostered and embodied in this framework or architectural concept.

This process design as an architectural concept is related to the architects' understanding of social interactions in a firm and the social interaction of the architects with the client and users. Architects immerse themselves in the clients' and users' situation with an ethical responsibility. On the one hand, they investigate, visualize and empathize with different and conflicting needs and requirements. On the other, the architects consider the broader impacts of a design solution for the organization and its industrial and social environment. The architectural practice confronts the firm with alternative, imaginable futures in a long-term view, as usages and users change. Non-verbal boundary objects – or "graphic/spatial modelling media" (Cross, 1990, p. 135) – are created for this process. They enable a collaboration and co-creation with client and user to retrieve tangible, codified, formal and, more importantly, intangible, tacit and informal information and knowledge on the firm's structure, its relationship patterns and work processes. Through these objects, and the convictive lead towards a design solution, architects, clients and users develop a shared understanding of the challenges they face. They re-frame existing mental models clients (e.g., management executives) and users (e.g., employees) have regarding organizational structure and processes. And they create new mental models of configurations of the organization and of behaviors, which envisage how the people in an organization will work in the future. The boundary objects and persuasive artifacts are on the one hand models to describe the principal functions, relations and interdependencies. On the other hand, they are models to develop, provide and hypothesize a frame for possible interactions and new realities to occur.

The spatial intelligence in architectural work leads to a 3-dimensional understanding of relations and interdependencies in a firm. Consequently, in architecture organizational processes as innovation processes have a spatial dimensions. They are unique to the firm in its 3-dimensional configuration, and – in common with the design process itself – liquid and open. Through its thinking and tools, architecture adds a third and spatial dimension to the analysis, understanding and design of innovation processes. As the questions of 'when' and 'where' innovation happens become increasingly relevant to innovation management, to organizations, industries and authorities, architecture make a contribution to their answers (Chantzaras, 2019b, p. 539). Architects work for the client and users, and with the client and users. The thinking, tools and processes they apply are their way of dealing with complexities at different levels, and allow them to design models for "complexity and contradiction" (Venturi, 1992, p. 16) and to design frameworks for awareness and possibilities related to human behaviors, social interactions and the purposes of an organization. Related to the use of models in innovation, the architectural models – as constructed mental spaces – can foster alternative ways to manage innovation processes: "If our mental models are limited, then our approach to managing innovation is also likely to be limited."(Tidd, 2006, p. 4; and Tidd & Bessant, 2013, pp. 76–77).

However, innovation processes are not directly addressed in architecture as they are in the management field. Sequence models as analyzed in Chapter 3.2 with phases of initiation, idea, invention and implementation are not explicitly named or described. Operational questions – for example, relating to decisions on the problems to address, tasks to be managed, and the choice of performance indices to be measured and controlled – are not raised. The applicability of architectural thinking to innovation processes does not imply a successful implementation. Innovation processes in architecture are approached by observing, listening to and understanding the individuals, teams, departments together with the spaces in which their activities and interactions occur. Architects seek to understand the problems and challenges an organization has in its existing behavioral protocols as well as the communicated demands and requirements to improve existing processes or develop new processes and spaces. While the levels of complexity of innovations considered by architecture remain vague and conceptual, social interactions are intensively analyzed, understood and represented. In the process design an architectural design process is well suited as a constructive practice and in its use of non-verbal boundary objects. The systems view is rather abstract than explaining causes and effects in detail (see Table 5).



Model of Innovation Process		Architectural spatial
Complexity	Environment	●
	Problem	•
	Process	●
Social Proximities	Creativity & Awareness	●
	Informality & Exploration	⬤
	Spatiality	⬤
Process Design	Systems View	•
	Constructive Practice	⬤
	Non-verbal BO	⬤

⬤ strong consideration ● consideration • neutral, no consideration

Table 5: Innovation Processes by Architectural Spatial Models
Architectural spatial models can display innovation processes and address aspects of an extended process view.

The architectural design process may offer innovation management a novel creative approach and design attitude. Managerial tools such as tables, calculation sheets and organizational charts are limited in their capacity to provide these perspectives (as discussed in Chapter 2.3, 3.2.3 and 3.3). Simon et al. (1986) noticed the comparability of the problem spaces in architecture and management very early on, but focused on rational problem solving with the aid of computation, and less on the abductive architectural design process:

> *"Most corporate strategy problems and governmental policy problems are at least as ill structured as problems of architectural or engineering design. The tools now being forged for aiding architectural design will provide a basis for building tools that can aid in formulating, assessing, and monitoring public energy or environmental policies, or in guiding corporate product and investment strategies."*
>
> *(Simon et al., 1986, p. 29)*

The intuitive, creative and abductive thinking in an design process and design outcome exceeds problem-solving with analytical tools and heuristics (Csikszentmihalyi, 1988b, p. 183). Reducing design and creativity to special forms of problem-solving, which could be rationalized and simulated, can hardly capture the emergence of a design synthesis, which is of relevance in this thesis (Hatchuel, 2001, p. 263; Hobday et al., 2012, pp. 20–21):

> *"What I argued is that computer models of the creative process do not include affect, motivation and curiosity and hence could not be said to replicate what goes in the mind of a person confronting a problem creatively. Computers simulate some of the rational dimensions of cognition, leaving out the rest"*
>
> *(Csikszentmihalyi, 1988b, p. 183)*

The advantages architectural thinking, its design process with architectural programming, and its tools have for innovation processes is concluded from a literature review, literature analysis and experiences in architectural work. An architectural approach to re-thinking and structuring innovation processes has much in common with the contextual, dynamic, network and design-oriented process models in innovation management as investigated in Chapter 3. Before making a comparison, it will be necessary to examine practical cases of architectural consulting in order to assess the benefits of architecture for innovation management in practice. Firstly, the case studies serve themselves as boundary objects to document a practice-proven approach to addressing the challenges of innovation with architectural means. Secondly, they provide a basis for discussion and for developing an approach to architect and design innovation processes.

In this chapter the prerequisites have been elaborated to develop an architecture-based approach to innovation management. The discipline and profession of architecture have been reframed by academic scholars and architectural practices to extend the field of action, and also the scope of work.[78] Publication as 'The Other Architect' (Borasi, 2015b), 'Future Practice: Conversations from the Edge of Architecture' (Hyde, 2013) or '2050 – Designing Our Tomorrow' (Luebkeman, 2015a) offer an overview of the different directions architectural practices can take and the theoretical argumentation they use. Their conceptions deviate from traditional conceptions of architecture. To expand the scope of architecture in order to meet the challenges of designing innovation processes in organizations a new mental frame is required. This mental frame serves both sides, architects and management executives, enabling them to see architecture in a different light while finding common ground in their conception of innovation process design:

- architectural thinking is a valuable form of design thinking applicable to management challenges;
- the work of architect in interaction with commercial clients generates a deep understanding and knowledge on the organization, its social interactions, relationships and processes.
- the resulting design synthesis in architectural work is an externalized model of an adaptive and emergent system.

The unique proposition of architects and their work lies in uncovering new patterns of relational and spatial proximities in order to visualize interactions

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[78] For example from the academic field: Burke & Tierney (2007) edit in 'Network Practices – New Strategies in Architecture and Design', twelve contributions from theorists and practitioners in the context of changing environments in a network society. Shamiyeh (2007b) collects twenty-five papers from theorists and professionals in 'Organizing for Change \ Profession – Integrating architectural thinking in other fields.' Samuel (2018) provides in 'Why Architects Matter – Evidencing and Communicating the Value of Architects' a broad overview of the profession's strengths and opportunities.

and flows of people and processes, and to synthesize new structures, in which the human factor, processes and culture converge. In this kind of architecture, designs for innovation processes in an organization are 3-dimensional frameworks of possibilities for people to interact and act. Particularly for knowledge intensive industries and for communication and knowledge exchange, structures for creativity and learning, for flexibility and adaptation are building blocks for their innovative capabilities (Carlgren, 2013, pp. 14–18; Maletz & Nohria, 2001). Architectural design can influence and change behavior by default settings: the designed spaces and routes of circulation can determine the way people act and move in space and eventually experience.[79] Two examples from architectural consulting practice will provide further arguments for an architectural approach to innovation management.

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[79] Schumacher (2016a, p. 110), German architect, researcher and partner at Zaha Hadid Architects, notes: "As a communicative frame, a designed space is itself a premise for all communications that take place within its boundaries. Designed spaces deliver the necessary predefinition of the respective designated social situation, thereby reducing the otherwise unmanageable excess of possible actions that exist in our complex contemporary societies. They 'frame' social interaction. Spatial communication/ framing is thus architecture's core competency."

6

6 – Architectural Consulting in Practice

The theoretical foundations of the applicability of architecture – its thinking, tools, processes – in management are supported by concrete examples of practice. They showcase how the understanding of spatial and relational proximities through the use of non-verbal tools unfolds into a new process structure for companies. The academic literature and published work examples relating architecture to strategic, organizational and innovation objectives have paid little attention to explaining approaches and tools in detail. The methods of architectural programming and its derivatives outlined in Chapter 5.2.1 provide a valuable basis, but have gained limited acceptance among architectural practices. In its "obsession with space" (Speaks, 2002, p. 212) and the "obligation to construct" (Koolhaas & McGetrick, 2004, p. 20), the discipline and profession of architecture foregrounds designs of built constructions and physical outcomes (Samuel, 2018, p. 161). Since the turn of the millennium, alternative applications of architecture as a consulting practice have received wider attention. The discourse is beginning to shift from offering an architectural product to providing a process (Brandner, 2008, pp. 20–25; Castle, 2018, pp. 78–79; Reinmuth, 2017, p. 93). It investigates, explains or postulates the value and potential of architectural thinking, skill-sets and tools for the issues of management and organization apart from building design (Bryant et al., 2018, pp. 11–13; Fisher, 2015a, pp. 226–227; 2015b, p. 45).

In this chapter, a review of the literature introduces the development of architecture as consulting practice in the pre-design phase. Following this, two practical cases are described and interpreted against the background of an extended process view of innovation; i.e., to illustrate how architecture can approach complexity, social interactions and process design. They serve as boundary objects to externalize and document an approach for organizational transformation with architectural methods from the perspective of this thesis. In the concluding part, a discussion of the strengths and limitations of the cases identifies the implications and requirements for an advanced consultancy approach to architect and design innovation processes.

6.1 Case Studies of Architectural Consulting

Consultancy has been part of the architectural scope of work over the last century, but has remained subordinate to the outcome of a building design. Over the past century, architects have consulted their clients in strategic decisions for their organization and businesses (Knittel-Ammerschuber, 2006, pp. 9–16; Sancho Pou, 2013, pp. 8–9; Vogel, 2011, pp. 4–14).[80] Consultancy has been conducted

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[80] Architects who have dealt economically successful with strategic challenges can be studied in the following examples: Peter Behrens (1868-1940), German painter, architect and designer, designed a new typology of factory buildings and the corporate design for the electric company AEG; see Vogel (2011, p. 6) and Pevsner et al. (1992, p. 80). Charles Eames (1907-1978) and Ray Eames (1912-1988), US-American architects, ariststs and designer developed new manufacturing methods and furniture designs, explored new construction and designs in buildings and developed exhibition concepts; see Pevsner et al. (1992, p. 179) and Smith, Goessel & Shulman (2019, p. 424). Charles Luckman (1909-1999) and William Pereira (1909-1985), US-American architects lead their architectural practice also as consultancy to assess financial, organizational, marketing and strategic issues for clients; see Sancho Pou (2013, pp. 22, 36–37, 51). John Portmann (1924-2017) developed new typologies of hotel buildings, e.g., as unique selling proposition for the Hyatt hotel group; see Sancho Pou (2013, pp. 111, 115–119) and McFadden (2017). Frank Gehry (1929), Canadian/US-American architect founded Gehry Technologies aside of his architectural practice as consultancy for geometrically advanced building design projects offering digital project software. In 1989 he was awarded The Pritzker Architecture Prize; see Gehry et al. (2020), Pevsner et al. (1992, p. 228), and The Hyatt Foundation (2022a). Arthur Gensler (1935-2021), US-American architect begun his career with shop, interior and workplace concept designs. He developed his practice Gensler to one of the world's largest architectural service firm consulting in issues of urban life, community, real estate and work strategy; see Sancho Pou (2013, pp. 135, 144–148), Gensler & Lindenmayer (2015) and Friedman (2021).

as a preceding and supporting service for building design assignments, or offered separately for real estate development, re-organization of production and work processes, or for strategy developments in relation to urban planning (ibid.; Hodulak & Schramm, 2019, pp. 30–38). In the past decades consultancy by architectural practices has taken on a broader role which extends the field of architecture beyond and independently of its role in building design and construction (e.g., Hyde, 2013; Schürer & Brandner, 2004; Shelden, 2020b). The consulting role of architects, previously confined to architectural programming, has expanded. They are now employed as knowledge architects (Samuel, 2018, pp. 154–157), spatial agents (Awan et al., 2011), strategic designers (Hyde, 2013, pp. 134–142) or change managers (Speaks, 2002, p. 212). Consequently, the works studied in this thesis are not drawings and realized buildings, not building related consultancies regarding environmental, construction or approval issues, but methods, diagrams and system models for the structure of an enterprise in the phases, that precede these works.

Building designs and buildings are seen as mediums through which a client's strategy becomes tangible and manifested. This strategy however needs to be developed in advance and offers architects as consultants a new field to act in. As a "trusted advisor" with a 'long view' (Gensler & Lindenmayer, 2015, pp. 230–233), as the architect Art Gensler suggests, they can advance in strategic positions and support the design of businesses that companies intends to start. Also in existing businesses, corporate performance in a growing knowledge economy is assumed to be "determined by knowledge design", a design for a physical construction in which a company operates and innovates (Henn, 1998, p. 429). Architects, experienced in dealing with complex structures of interactions and organizational knowledge across space and time, are literally "designing companies" (ibid.) through their knowledge architecture. Diagrams and models created for analyzing, understanding and designing these knowledge architectures are essential, but are often subordinated to the building as the final result and synthesis, as the physical embodiment of the organization.

By considering "Managing As Designing" (Boland & Collopy, 2004b, p. xii) the architectural design process and value of architectural thinking is viewed in its applicability to the "manager's role and responsibility as designer" (ibid.). At the same time, publications and presentations based on that conception began to treat architecture as a business design and consultancy service, transitioning "from an architecture of form to the architecture of organization" (Shamiyeh, 2007a, p. 9; and OMA et al., 2004, p. 20). As a discipline and profession being challanged with – and prepared to – creating new wholes it will have to separate its services from designs for building constructions and from engineering service fee systems (Fisher, 2015a, p. 222; 2015b, pp. 44–45). Organizational re-structuring, transformative design processes and the definition of pressing managerial problems will become a core scope of work and not remain an additional service or by-product of the architectural design process (Bouman, 2007, pp. 95–96). Architecture as strategic consulting gives priority to the needs and requirements, vision and values, knowledge and culture of an organization, and in this capacity provides a service that is independent from a building design assignment or the creation of spatial solutions (Budds, 2016; Fisher, 2015b, p. 45).

Despite these claims and the increasing awareness of architecture as consulting, the methods and tools applied are sparsely documented and explained in academia and grey literature. On the one hand confidential issues constrain the accessibility and dissemination of information. On the other hand, the focus is directed to the final building design and the realization of a tangible proof of concept. Consulting work, which precedes the building design within a larger architectural work scope, remains secondary. The publications mentioned in Chapter 5.4 are exceptions in so far as they address alternative modes of practice and give an account of working methods and principles in basic descriptive and anecdotal ways. Designers, including architects, tend to focus on describing the outcomes of their work rather than the process and the particular activities (see Chapter 5, Cross, 2013, p. 6). As a result, design scholars use different methods to study design processes and design abilities. In addition to interviewing designers and architects, "observations and case studies" of particular design projects are reviewed "contemporaneously or post hoc" (Cross, 2013, p. 5). Similarly in this thesis, the examples of consulting projects are integrated as case studies of the work process prior to the assignment for a building design. The two projects make it possible to observe and analyze in retrospect an architectural service which involves the direct interaction of architects and management executives in relation to organizational structures and processes. In both cases the service is analyzed against the background of an extended processes view of innovation. The analysis is concerned with how the service

- approaches multiple levels of complexity in an organizational transformation,
- understands and integrates social interactions,
- models and designs organizational processes.

In this study the service is evaluated from a theoretical and a practical perspective. At a conceptual level, the service is evaluated in its capacity to reframe complexities, integrate social proximities and perform a process design. At a practical level, its method is evaluated according its degree of collaboration and modeling. The tools applied during the service are evaluated according to their ability to provide the essential features of being dynamic, multi-dimensional, systemic and visual. This allows us to indicate the implications for the transfer of architectural consulting into management and the build-up of an architectural approach to innovation process design.[81]

The two consulting cases are selected for several reasons. The process steps are well documented in the architectural service for the client; they explain the knowledge they generate and the structure they design as a solution. The projects have been partially published and have been provided by the clients and the architectural practice for the benefit of this thesis. The projects represent a distinct type of project among architectural services, in which architects work at an early decision phase with management executives on issues of organizational design, work and innovation processes. It includes an architectural understanding of organization and its processes, externalized in intermediate and final persuasive artifacts. The service represents a modified process of the architectural programming method described in Chapter 5.2.1. The extended scope of the two projects includes the design, planning and realization of buildings. For this thesis the pre-design phases of consultancy and decision making are central here.

In both projects a similar architectural service was provided with the author as a member of the core team (Chantzaras, 2019b; HENN & WITTENSTEIN AG, 2009a, 2009b; HENN & attocube systems AG, 2015a,

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[81] Eisenhardt (1989, pp. 533–534) explains in detail the process of building theory through case study research "involving single or multiple cases" (ibid., p. 534). The case studies explained in this thesis are completed consulting projects, analyzed ex post in terms of how the processes were designed with architectural means. The case study approach as detailed by Eisenhardt is not applied here.

2015b; HENN & WITTENSTEIN AG, 2016). The projects were conducted in 2009 and 2015 at two companies of different size and structure. Both enterprises belong to knowledge-intensive industries with advanced manufacturing and production facilities. They were in a transformation phase regarding their organizational structure and self-conception. In the first case, a successful large-sized enterprise in mechatronics sought to adapt its innovation processes to pressing developments of that time with a new building. In the second case, a successfully scaled start-up required a new physical counterpart to embody its growth and organizational evolution.

The assignment for the architectural service was to develop a shared concept model of the future organization of the companies and provide a decision basis for a new building design. The companies' organizational structures and innovation processes, the demands and needs of client and users, and their vision, values and culture were the central aspects of analysis during the consulting phases. They included the formulation of a space concept, a room and requirement program, and an outline estimate of building construction costs. Several aspects have been excluded from consideration because they involve information on confidential financial or legal issues and detailed project protocols for operations. External partners, e.g., suppliers, clients of the company, talents to work for the company, were not involved in direct interaction. Their needs and requirements were taken into account through communication with management executives and employees. Information and knowledge in both cases has been retrieved from internal documents, reports, and presentations on the project provided by the architectural practice for this doctoral project. The internal documents, reports and documentation include visually recorded interviews and workshops, retrieved and processed information on company structure, organization and processes, requirement tables and space schedules, flow-charts for processes, diagrams, virtual models and images of physical models. Published documentation on the projects as well as the author's experiences, personal notes and interviews with stakeholders after completion have been used.

6.2 Mechatronics Innovation Factory / 2009[82]

The first example refers to an architectural consulting service for an industry leading family-owned enterprise in technologies for mechatronic drives, precision gears, and micro-devices. The project context and the scope of work will be described first. Secondly, the case will be studied in terms of the architectural approach to complexity issues, its understanding of social interactions and its process design.

By the time of the project in 2009 the company employed around 1300 people (and around 2900 in 2021, WITTENSTEIN SE, 2021, p. 1). The competencies and capabilities to continuously invent, innovate and successfully apply new developments in the market have been central to its steady growth, and are the core of the company's culture (Chantzaras, 2019b, pp. 544–546). In 2009, employees involved in new developments (e.g., mechanical engineers, electrical, software engineers, scientists) led 80% of the innovation projects, whereas

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[82] The sources for the case study description and analysis comprise reports, presentations and project documentations handed over for this thesis by the consulted company through the archtitectural practice. The sources also comprise published articles, company websites and author's notes. The author was team consultant during the project in 2009. Quotations from internal documents have been revised for reasons of confidentiality where necessary and referenced with 'HENN & WITTENSTEIN AG, 2008a; 2008b; 2009a; 2009b.' Capital letters are used to refer to the respective company and architectural practice.

external customers initiated 20% (ibid., p. 544). The increasing relevance of customer-driven innovations required a better integration of external demands and ideas. For the future of its business, the management decided to treat its customers as equally important drivers for innovative projects as its internal resources. The co-creation with customers should become a central part of the company's innovation processes. The company's main goals were to maintain its speed of innovation and continue building capacities for permanent technology- and market-driven innovations (Chantzaras, 2019b; HENN & WITTENSTEIN AG, 2008a; 2008b; 2009a; 2009b). In future, the drivers for innovation projects shall be initiated by 50% in-house drivers and by 50% external impulses (Chantzaras, 2019b). The development time of new products and services should be reduced by half through the integration of digital tools and modularization. Regarding the company's culture an innovative mind-set should be fostered and greater attentiveness developed for innovative opportunities across the firm. The self-organization of teams and of departments should be enabled. The company emphasized the importance of the human contribution at the core of every innovative endeavor. The headquarters and central development departments were located in a regional area. This required initiatives to allow the company to attract talent and remain competitive with urban centers such as Stuttgart, Frankfurt a. M. or Munich. In the company's vision, a "center of gravity" (Allen & Henn, 2007, p. 19) for innovation should integrate engineers, developers, and clients to work together and be able to support the process from idea generation to development and realization in production (Chantzaras, 2019b; HENN & WITTENSTEIN AG, 2016).[83] To address these challenges a new building was considered as a solution (WITTENSTEIN SE, 2022b). It should on the one hand satisfy the requirements relating to space and proximities. On the other hand, the building should give form to and embody the organization's innovation-oriented structure and culture. The architectural consulting service should analyze and develop the concept for the inner organization and theme of the building, based on the formulated goals and vision. The architectural practice's first step was to use a modified method of architectural programming to approach the complex demands of the project; secondly, it investigated proximities and interactions; thirdly, it modelled an appropriate organizational structure, as a spatial frame for innovative and operative processes to occur.

6.2.1 Approach to Complexity - Environment, Organization, Process

The architectural programming was set up in four work modules: analysis, development of space and functional program, concept, and cost estimates. To describe the strategic consulting the first two modules are reviewed here. In these modules, the company's vision, goals, and the systemic aspects of its organization were emphasized. The third and fourth modules were dedicated to concrete building concepts concerning the cost estimates for the building design and construction. The basic principles of architectural programming were applied to approach the complexity of the project; for example, separation of analysis from synthesis, continuous integration of executives and employees, visual recording and communication, abstract and holistic thinking. The

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[83] 'Centers of Gravity' are considered as organizational and physical elements to attract, promote and guide interaction between people. Allen & Henn (2006, pp. 24, 82, 88–89, 100) describe, for example, the project atrium of an R&D building or the indoor walking route of a university building as a center of gravity.

information and knowledge acquired was externalized and kept comprehensive by using a common visual language, by continuously documenting information, knowledge and findings, and by conducting frequent iteration and feedback loops (Henn, 2004, pp. 45–49; Peña & Parshall, 2012, pp. 74–75). With the particular programming method used by the architectural practice the elements of design and synthesis were integrated in virtual and physical concept models and preliminary abstract spatial designs. The models supported the analysis of existing organizational structures and the exploration of alternative arrangements of the company's departments.

In the first module, the architectural practice analyzed the company at an environmental, organizational and operational level. At an environmental level, it reviewed the industry sector's current and future challenges and the societal aspects of the company's regional location. At an organizational level, it collected information on the company from company reports, data sheets on employee structure and internet sources. Markets, products and organizational structures were explained through organizational charts and tables, and discussed in workshops with management executives, employees and industry experts. The architects visualized the data and information acquired with pictograms and graphical tools such as maps, diagrams and word clouds. At the organizational level, the vision and goals of the company were articulated. They were reflected against the background of current and future challenges in the respective industry. The company envisioned a holistic approach for its innovation activities by integrating internal and external aspects of the organization a single building concept as a center of gravity. The practice analyzed this picture of the company. The department for new business generation should be located in between existing business units for mutual interaction. As a cross-functional entity it should comprise creative work, development of innovation projects and workshop areas. The project goals regarding the building design purpose also addressed the future innovation processes of the firm. The architectural consulting service should develop a spatial concept that

- fosters exchange and interaction between business units and eventually the innovation performance (HENN, 2009, p. 55)
- increases the integration of organizational functions as production and sales, supports the network intelligence of parties and improves their interfaces.
- nurtures the motivation of employees for innovation and development by providing physical spaces for communication and generation of knowledge
- conveys the company's vision, values and culture in a way that employees can relate to and identify with.
- Is adaptive to changing demands and offers options for the extension of business units.

The last part of the module referred to the complexity at a process level. In-depth interviews and workshops with management executives, representatives of business unites and cross-functional departments deepened the understanding on work flows, interaction patterns and development processes. Quantitative and qualitative information regarding functional requirements and organizational needs were collected. The information was visualized graphically to reflect upon and generate new ideas for re-configuration. With the aid of architectural diagrams, flow charts, mood boards and word clouds, the relational and spatial proximities between cross-functional departments, support functions and core business unit activities were discussed. The visual representation were continuously adjusted to reflect the advanced understanding of interactions, processes, requirements and needs. The visual analysis and discourse offered new perspectives on the company's organizational structures and the interdependencies of its units and departments. In parallel, the company's vision and goals were evaluated against the background of the visualized processes and organization.

As one outcome of this analysis phase, innovation was emphasized as a social process dependent on the interaction of people. Management executives sought to foster appropriate actions, motivations, and mind-sets in the internal behaviors towards innovation. The organizational structure should nurture networks at work, in physical face-to-face interaction for innovative ideas, and increase the possibilities and probabilites for communication and chance encounters. The initial assignment of the project was redefined as an "innovation factory" (WITTENSTEIN SE, 2021b): the term blends the area of innovation with the area of production, and outlines the importance of innovation throughout the entire value chain (HENN & WITTENSTEIN AG, 2016, p. 2).[84] Since the project was completed and operations began, the innovation factory has become a facility to "manage increasing complexity" (WITTENSTEIN SE, 2022a) in the development of industrial products caused by customization and shorter innovation cycles.

6.2.2 Understanding Proximities and Interactions

In the second module, the analysis of interactions, processes and relations was deepened through workshops and interviews. These formats were essential for several reasons. They supported to frame needs and requirements regarding the processes in their relational and spatial proximities to each other. They explicated quantifiable spatial and technical building issues. They facilitated the integration of multiple stakeholders who were involved in new product development and innovation, and encouraged the development of a shared understanding of the programming project. While the workshops were conducted with a larger group of participants and two to four architects, the interviews were held on an individual basis, with one architect interviewing and one architect visually recording the information. Questions in the interviews addressed the topics of vision, values and goals as well as functional aspects of the organization and its processes. The information gained helped with re-assessing the vision and goals articulated in the first module. Throughout the workshops and interviews the information communicated was graphically recorded, discussed with the participants, revised and extended with further project-relevant aspects. To achieve a visual clarity drawing rules were followed, e.g., by applying a color code or by pairing each piece of information and statement with an iconic explanatory sketch on paper cards (Henn, 2004, pp. 48–49; Hodulak & Schramm, 2019, pp. 140–155). Core statements from interviews and workshops outlined the importance of taking into consideration every element in the value chain for innovative initiatives. The guiding principle was that knowledge, expertise and people should be interconnected across the entire network. The innovation factory provides a blueprint for permanent innovation processes, encompassing technology development, engineering and production.

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[84] The original German terms for the project were "Produktionsarena" acc. HENN & WITTENSTEIN AG (2008a) and "Innovationsfabrik" acc. HENN & WITTENSTEIN AG (2016, p. 2).

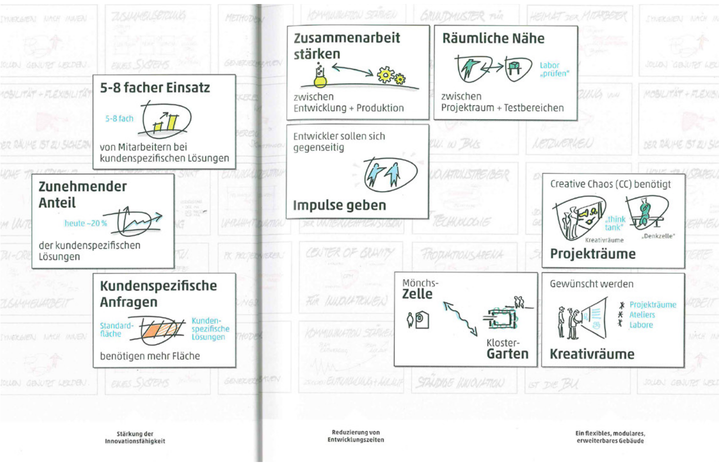

Figure 31: Examples of Programming Workshop Cards

Workshop cards display core statements raised by management executives and employees. One colour is used for text in a special type of capital letters surrounding an explanatory pictogram in the center. Visualization by HENN & WITTENSTEIN AG (2016, pp. 8-9).

Proximities and interactions in the innovation and development processes were analyzed with different kinds of visualization. The first kind of visualization provided a review of departments and functions according to their physical location in the buildings of the company. The company had been steadily growing in the number of employees, products and spaces. As a result, the structure of the organization and its departments had become dispersed. Relations between departments and the flow of projects were depicted visually in a spatially dependent way. Existing spreadsheet tables and lists in Excel (e.g., room lists, cost center tables) were transferred and mapped on a site-plan according to the location of departments and functions. The visualizations helped to show the fragmentation and dispersion of knowledge in the company together with the reduction in awareness of existing knowledge, and also showed process inefficiencies. For management executives and employees the company was in a state, that required improvement. The visualizations served as boundary objects and neutral platforms to develop a shared understanding of the current structures and collaborate during workshops and interviews in its reconfiguration (Henn, 2004, p. 46). Individual contributions and further details were added visually to ensure the information was accessible for the people involved

In the second group of visualizations, diagrams were used to frame the product development and innovation process. The information retrieved from interviews, workshops and internal documents (e.g., organigrams, business reports) was transferred to simplified 2-dimensional graphics. Interdependencies between stakeholders and functions were mapped regardless their actual physical location. The steps a new product or innovation passed through were visually displayed, showing the exchange and flow of knowledge and the flow of physical entities like prototypes, samples or products. The flow of communication in the firm and the flow of knowledge were further analyzed in terms of their dependence on face-to-face interaction. Management executives and employees were asked to identify the steps where the exchange of ideas, comments and knowledge required a direct planned and unplanned interaction. The question of who and what kind of element was relevant in the innovation process was related to the question of its physical location.[85] On-site visits of

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[85] An interaction or affinity matrix and netgraph, to represent the communication and proximity between entities, which is often applied in programming projects for large enterprises, was not used in this case. For netgraphs and affinity matrix see Allen (2000, p. 157); Kumlin (1995, pp. 104–105); Sanoff (1977, pp. 150–151).

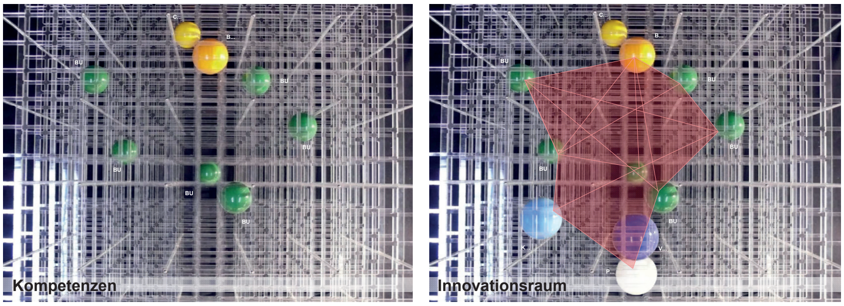
existing spaces, facilities and work-flows enriched the understanding further. Diagrams were continuously reworked and revised. The reflection in action, during the visual recording and adjusting of information, allowed the architects to immerse themselves partially in the work of management and employees, their interdependencies and interactions, their needs and requirements.

In a third kind of visualizations, the architects interpreted the conceptualization the company followed regarding its innovation process. The company's mental model of how the innovation process should ideally take place, and who should interact with whom, was redrawn and adjusted during the analysis. The resulting innovation process diagram integrated spatial and relational dependencies between departments based on the understanding generated in the visualizations. It further overlapped with the technology-push and market-pull approach to innovations formulated in the company's vision to establish innovation processes that are initiated in half of the cases internally and in half of the cases driven by clients. Through interpreting and redrawing the innovation process, spatial and relational dependencies were emphasized. Possible new connections and missing linkages between departments and functions could be discussed (HENN & WITTENSTEIN AG, 2009b).

The interviews and workshops enabled the architectural practice to empathize in architectural ways with the demands and needs of management and people. It immersed itself in the challenge of an integrative innovation process and introduced a spatial intelligence into the discussion. The information and insight gained, especially through the use of the visualizations, helped to create a common understanding of vision, goals and future innovation processes. This was a prerequisite for modeling and designing an appropriate spatio-organizational concept. The architectural programming enabled management executives to re-think their processes and organization in non-verbal and non-linear ways. To some extent the architects acted as an intermediary to bridge communication gaps within the organization.

6.2.3 Modeling and Design of Processes

The final part in the second module addressed the development of a systemic concept for the spatial organization of the innovation factory. The different non-verbal means of sketching on cards and flip-boards, of diagramming were treated as approximations of a future 3-dimensional structure. Before concluding with a spatial building model, the architectural practice sought to develop a "multidimensional model "of" processes, mutual awareness and interaction that make up the company" (HENN, 2009, p. 55). For this, different spatio-visual tools and techniques were again applied. The diagrammatic analysis of processes and interactions was transferred to a 3-dimensional, physical and tangible wireframe model. Colored spheres represented departments, business units and cross-organizational functions that were fundamental to the innovation process. The spheres were placed manually in the wireframe model in order to understand, reflect and explore their relational and spatial proximities in three dimensions – below, above, to the sides, at the back or in front of each other. The elements were moved and arranged depending on their importance for innovation projects. The physical boundary object allowed us to analyze existing configurations and to play with alternative placements, while retaining an overall view of the entire organization and its elements. Creating, constructing and using alternative representation of organization, process and spaces raised the understanding how the position of an element can manifest hierarchies, impede visibility and hinder connections elements. By finally connecting the different elements in the wireframe model, a 3-dimensional innovation space in between was constructed.

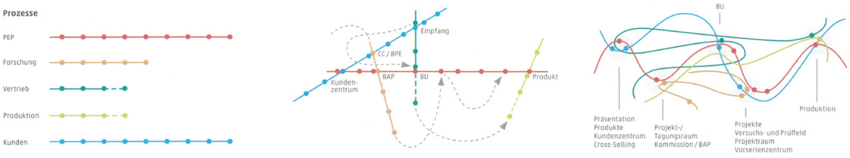


A B

Figure 32: Wire-frame Model of Organizational Configurations

In **A** business units and functions are placed in a physical wire-frame model with spatial and relational proximities. In **B** further functions for innovation are added and connected. The resulting network represents an innovation space as 3-dimensional structure. Visualization and source by HENN & WITTENSTEIN AG (2008c).

With another visual technique the process paths of particular development functions were displayed as separate lines. Points in these lines that were considered by executives as relevant for innovative initiatives were marked as crossing areas, where the different functions intersect and exchange information, knowledge or intermediate artifacts, prototypes or products. The separate lines were superimposed at the crossing areas; the relevant points of interaction between the single path were connected (Chantzaras, 2019b, p. 545). Because the process lines needed to cross each other several times at different stages, the 2-dimensional representation was not sufficient. The addition of a third dimension allowed us to graphically link and bend the linear lines to meet the intersection points. The resulting 3-dimensional structure displayed the areas of intersection as spatial centers, where the process lines could pass through from different directions without being interrupted or having their flow broken (ibid.).



Mapping Processes & Movements **A**

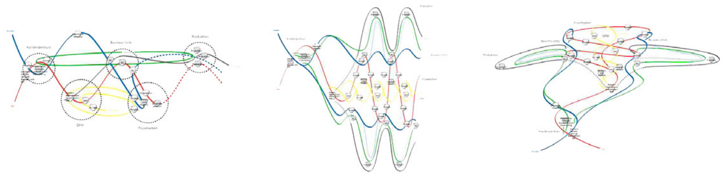
Connecting Processes Lines **B**

Bending and Overlaying in Space **C**

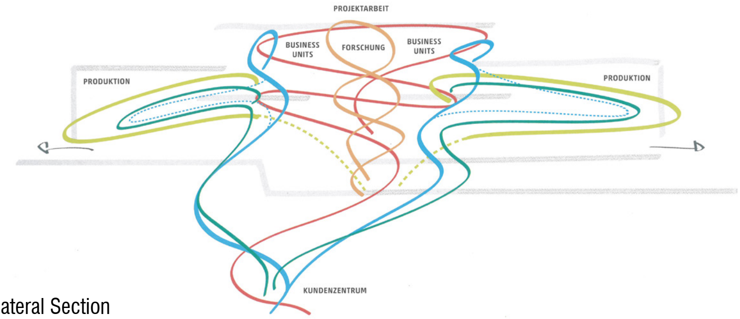
Figure 33: Spatialization of Organizational Processes

Organizational processes for new product development and innovation are **A** first mapped as separate linear sequences. Secondly, **B**, intersection points are connected. Thirdly, **C**, the lines are superimposed and bended to meet at several locations. Visualization by HENN & WITTENSTEIN AG (2016, pp. 10–11). See also Chantzaras (2019b, p. 545).

The spatial model of process flows and centers developed offered a new representation of the complex interactions between the different functions and departments. The lines were not restricted in their route through the model from beginning to end. In between the different centers they could follow different continuous trajectories in parallel, below, above, behind and in front of one another, but always meet at the specific crossings. The spatial configuration was compared with the preceding visualizations (e.g., the wire frame model and envisioned innovation process), discussed and adjusted to reach a shared understanding of a preferred organization for the future. The architects handled the spatial model of process lines as an architectural model. They generated different viewpoints and sections of the structure to reflect on it and revise it. The spatial diagram was cut through to see, explore and adjust its inner structure in an interpretive and constructive way. Horizontal sections – floor plan views – allowed us to view different levels of the spatial diagram from above in a similar way to architectural drawings. Vertical cross-sections offered insights into the inner organization of the spatial diagram. They made it possible to reflect on, revise and design relations and connections between lower and upper levels. Representing the work in a diagrammatic section provides an additional instrument to adjust the placement and routes of lines in order to pass through the intersection nodes. For the architectural practice the spatial visualization represented a multidimensional organizational system, in which processes can intersect important centers or nodes, while remaining visible to each other and open to changes in between the nodes (Chantzaras, 2019b). Linear mental models of organization were supplemented by a systems view of processes in space and time. In an architectural interpretation the model of spatial and relational proximities represented several main goals for the company. The self-organization of units and teams could be fostered by providing central nodes where they could meet and space in between to ensure the continued awareness of each other's activities. Development processes and innovative initiatives gained a larger degree of freedom and autonomy to flow between the nodes and across the other lines. Through this the knowledge exchange between business units and the integration of external value chain partners as customers and consultants could be supported. People’s explorations and engagements throughout the spatial model could be facilitated by keeping nodes and the spaces between them visible and accessible.



A Spatial Diagram, Longitudinal and Lateral Section



B Lateral Section

Figure 34: Spatial Diagrams of Organizational Processes
The spatialized process lines are considered as spatial diagrams, from which longitudinal and lateral sections are retrieved in visualization **A** by HENN (2009, p. 54). The lateral section serves as concept diagram and principle structure for a building design concept, shown in visualization **B** by HENN & WITTENSTEIN AG (2016, p. 10). See also Chantzaras (2019b, p. 545).

To communicate the architectural interpretation of organizational goals in a comprehensible form to the client a further design step was necessary. The diagrammatic section retrieved from the model was used to create a physical architectural building model. The designed section was treated as a snapshot of human activities within an imagined building. It showcased at different levels and locations different work processes between development and production. A possible organization of business units and of cross-functional departments was offered with proposals for spatial and technical requirements (e.g., clear height, spaces, technical infrastructures). The possibilities to see, connect and move through the section were considered as flows of knowledge, movements of people and products. The diagrammatic architectural model proposed "a future way of working and innovating in a multi-dimensional, integrative and simultaneous way" (Chantzaras, 2019b, p. 545) to the company.

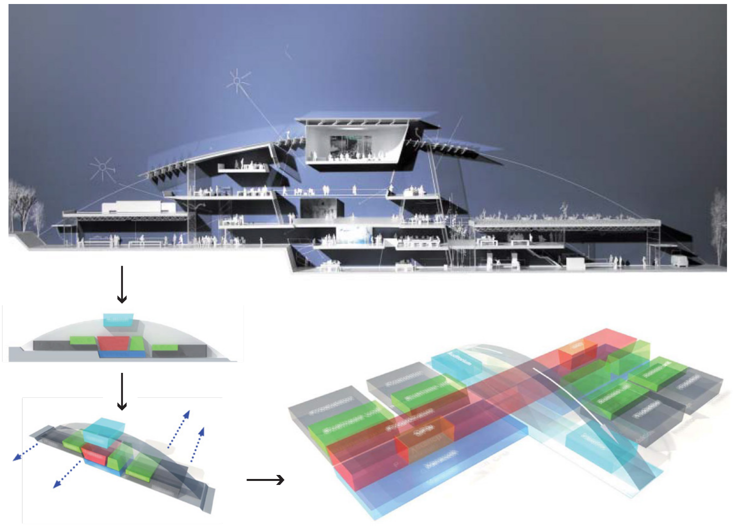


Figure 35: Diagrammatic Section Model and Extrusion Model
The physical model of the diagrammatic section serves as boundary object, to simultaneously display different process lines and working modes. The functions are again extruded in a 3-dimensional model the functions to retrieve a building concept. Visualization and source by HENN & Wittenstein AG, (2009a). See also Chantzaras, (2019b, p. 546).

The final step in this conceptual phase consisted in unfolding the processes that were superimposed in the physical diagrammatic section model. By adding depth to the model, a 3-dimensional structure could be designed. The section was extruded in the z-axis. In the subsequent phases the architectural programming work segued into an architectural design work for spatial building concepts.

6.2.4 Review

The programming showcases an architectural consulting approach to organizational processes with six phases: information collection, linear process mapping, 3-d process visualization, sections, diagrammatic sections, and systems modeling (Chantzaras, 2019b, p. 544).

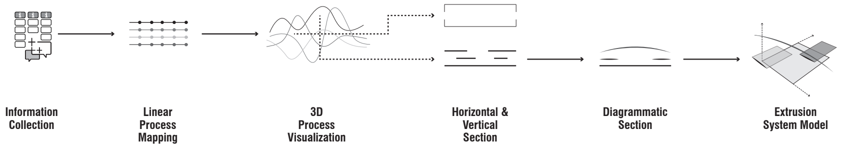


Figure 36: Process Phases in the Innovation Factory Case Study
Six phases are outlined for the development of a 3-dimensional system model, that defines a new configuration for new product development and innovation processes. Visualization by Chantzaras (2019b, p. 544).

The engagement and involvement of management executive and employees in the design process were fostered by translating information in non-verbal, spatio-visual depictions, using virtual and physical models as boundary objects and working face-to-face in direct interaction. The people involved became participants in the analysis and design dialogue. The stakeholders were invited to enter visual fields as playgrounds and encouraged to imagine their future work space and organization for innovation. The understanding between the parties involved grew by being integrated in the pre-design process, by sharing overall vision and reflecting on process paths, centers, needs and requirements.

Regarding the complex industrial environment and the complex processes within the firm, the different visual techniques and tools of architectural programming created an understanding in a non-sequential way. Workshops results, visualization and models were cross-referenced and revised. They enabled the client to gain insights and reflect on how third parties (i.e. architects) saw his organization, vision and goals. The initial conception of space prior to the programming anticipated a more linear organization and functional separation of spaces. Through the programming work space was considered more as framework, where functions overlap and (physical) boundaries are removed to allow processes of knowledge exchange and creativity to unfold freely (WITTENSTEIN SE, 2020). The framework emphasized social interactions between employees, teams and departments. The conceptual model integrated the relational and spatial proximities and proposed a new configuration of departments and functions. Allocating the processes visible to other processes in the model should raise the awareness between employees and facilitate their exploration and engagement across functions and department.

The process design resulted from constant reflection on and evaluation of different representations, and on the individual approaches and "quirks" (Rowe, 1987, p. 2) of the architects involved. It did not clearly favor a distinct sequence of design steps and set of visualizations. Steps and visualizations contribute differently to the construction process, and eventually to the design resolution.[86] In the example presented – as in works of design and innovation in general – the different elements functioned like pieces in a "jigsaw puzzle" (Berkun, 2007, p. 8) to synthesize a new whole. The moments of insights or epiphany "when the last piece of work fits into place" are not predictable beforehand, and depend on the abductive reasoning, skills and expertise of the architects.[87] The innovation processes indirectly described the organization of spaces and integrating areas inbetween. The extruded architectural framework model provided the basis for a subsequent building design. After its finalization, when the construction was completed and the building was in operation, the innovation projects could be conducted more quickly, through the integration of process partners and networked working (HENN & WITTENSTEIN AG, 2016, p. 2).[88]

> *"With the Innovation Factory we have created space for our perception of Production of the Future. Here we can establish new types of work environments and bring to life our understanding of how all process partners interact. The entire added value process – from the idea to the finished product – takes place within a radius of 30 meters in the trend-setting business. […] The Innovation Factory promotes and supports creativity and the exchange of knowledge among employees."*
>
> *(WITTENSTEIN SE, 2022b)*

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[86] Visualizations are e.g., interview cards, sketches, diagrams, concept drawings, diagrammatic section, wireframe model, section model, 3D volumetric model and physical volumetric model.

[87] Berkun (2007, p. 9) compares the process of innovation to a search, collection and combination of parts, where "the last piece isn't any more magical than the others, and it has no magic without its connection to the other pieces."

[88] Founder and chairman of the board, Manfred Wittenstein, notes an increase in projects performance (from start to completion) of 30% on average (Wittenstein, 2016, p. 2). As far as the author knows an evaluation has not been conducted by the architectural practice before and after building occupancy. For a study maesuring "the impact of building spaces on social interactions using wearable sensing devices" (Brown et. al., 2014, p. 822) in an organization before and after moving into a new building see Brown et al. (2014).

The architectural consulting approach was limited regarding its direct applicability to innovation management. Company software and possible existing innovation management software were not considered or integrated for the development of the model. From the opposite perspective, the conceptual model – to the knowledge of the author – was not transferred or integrated into innovation management. The final building design and constructed building realized the intention to foster innovative work and innovative production. It served as medium to foster innovation, resulting from a collaborative and constructive discourse between management executives and architectural practice. The group of customers, external clients and partners have not been directly interviewed. The programming required high involvement in terms of time and knowledge from the participating parties. The different visualizations developed were occasionally redundant in their content, difficult to communicate or of minor relevance for management executives. Though displaying dynamic processes and relations, the diagrams developed were static depictions. The processing of information and generation of new knowledge relied to a major extent on the architects' abilities and interpretations. Proximity matrixes, netgraphs or network analyses to visualize the communication patterns of people in spaces based on large data sets were not conducted at large scale and with digital tools as practiced in other projects (Allen & Henn, 2007).

6.3 Nanotechnology R&D Headquarter / 2015[89]

The second example showcases a similar consulting service for a smaller and differently structured organization. In the first case, an established company developed its existing processes for innovation towards higher integration between business units, clients and customers. In the second case, a successful start-up moved to its next evolutionary level of "structure, organization, processes and a clear focus" (attocube systems AG, 2018) while maintaining its flexibility and agility (Chantzaras, 2019b, pp. 546–548).[90] The company is a leader in high-precision manufacturing of nanoscale applications. It combines visionary thinking with engineering expertise. In 2015 the number of 90 employees was predicted to double in the coming years through internal growth and acquisition. The employees, with their high level of motivation and curiosity at the interface of science and industry, were central to the company's success. The company sought to address several challenges through architectural programming.

As in the first case, the client intended to address these challenges by using an architectural programming concept to build its first headquarters. They calculated that the concept and building would meet the increased requirements for spaces at an operational level. At a strategic level, the company aimed to combine the organizational structures of an enterprise with its flexible start-up spirit. The product portfolio should be balanced by increasing the share of industry projects to the same level as that for projects for research institutions and academia. This required a better integration of management departments in the innovation processes, in research areas and in highest-precision production. The programmed concept and subsequent building design should

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[89] The sources for the case study description and analysis comprise reports, presentations and project documentations handed over for this thesis by the consulted company through the archtitectural practice. The sources also comprise published articles, company websites and author's notes. The author conducted the project as architect in 2015. Quotations from internal documents have been revised for reasons of confidentiality where necessary and referenced with 'HENN & attocube systems AG, 2015a; 2015b.' Capital letters are used to refer to the architectural practice.

[90] Attocube systems AG was acquired in 2011 by the company of the first case study.

communicate and embody the company's distinct culture, mind-set, values and ways of working. The company was open to reflect through an architectural programming their vision, values and processes. The programming project was structured in two modules of analysis and concept. The first module addressed the topics of vision, values, culture, interaction, processes, requirements and needs. During this period diagrammatic concepts and models were developed as a basis for a spatial building concept. The second module focused on the design of the spatial configuration.

6.3.1 Approach to Complexity

Information on the company and its products were retrieved from available reports, documents, internet sources and interviews with management executives and the founders. Its successful growth challenged the young corporation regarding spaces and facilities, organizational structure and processes. To understand the transition from start-up to enterprise semantic differentials with visual mood boards and collages were used. Challenges arose from the tension between two conflicting aspirations. On the one hand it wished to retain its character as a community with deep roots in academia and the region, a situation which allowed it to be dynamic and be driven by research, development and innovation. On the other hand, the company intended to move towards globalization and increase production with highest-precision and quality products for industry partners. Information on spatial requirements as well as thoughts on vision, culture and mind-set were visualized, reflected and summarized in key figures and key statements. During the programming, a metaphorical claim evolved, describing the company's purpose regarding its product and regarding its new headquarters: as a developer and manufacturer of nanotechnology solutions, it was making the invisible visible. The company provided solutions for a sustainable world, implemented for instances in satellites and used in nano applications for research.[91]

Regarding the new headquarter, making the invisible visible related to the aspiration to externalize, give shape to and embody its values and culture in its way of working, innovating and producing. Human beings were at the center of the company's entrepreneurial activities. Its developments and products were aimed at the global market for human uses of applications in nanotechnology. On the other hand, the individual employees as human beings were the source for ideas in the company and the driving force behind its success. Accordingly, it decided its management hierarchies should remain flat; it should retain a culture of transparency and openness, in which creativity was fostered, and concentrate on developing and manufacturing highest-precision solutions. The integration and close interaction of customers from both industry and academia should be increased in the development and innovation processes. The openness to collaboration and co-creation should be also conveyed to the public, to visitors and the community. Innovation processes and manufacturing processes should become to a certain degree visible and tangible.

6.3.2 Understanding Proximities and Interactions

In the second phase of the first module detailed interviews and workshop were conducted on the areas of production, research & development, human

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[91] Nano scale is defined as 10^{-9} = 0,000.000.001; atto scale is defined as 10^{-18} = 0,000.000.000.000.000.001.

resources, sales & marketing, administration and finance. The in-depths interviews on an individual basis with management executives and employees were structured around the topics of strategy, goals, process, needs, requirements and facts (HENN, 2015a). The information and answers were recorded visually on cards and boards. The outcome of this was that creativity, empathy, openness and collaboration were retained as central values and principles, which should remain present in the company's various development projects. Development projects for the research market focused on innovative systems and prototypes, while development projects for the industrial market offered both quality and quantity in components and systems. Both development processes were visually mapped in flow charts with spatial dimensions. The flows of information and material as well as the activities and individual process steps were diagrammed according to the relations between them and physical proximities. The visualizations were presented as plan view diagrams and section diagrams. The process of materialization from ideas to product was represented from left to right in the plan/top view diagram, and from top to bottom in the section diagrams. The different visualizations supported the reflection on existing configurations and their revision for the future. They made it possible see processes from different perspectives and develop an optimal flow of innovation and development.

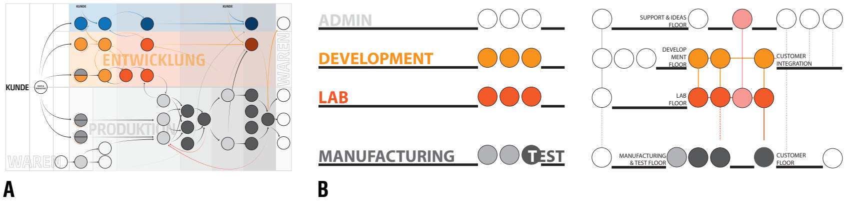


Figure 37: Systemic Layout of Innovation and Development Processes

Systemic ground plan view **A** and section view **B** of innovation and development processes. Visualization and source by HENN & attocube systems AG (2015a).

In addition to the visualization of process flows, the interactions of employees and departments were visually analyzed. Spatial areas and the number of employees including expected growth rates were proportionally related to each other. The relational and spatial proximities of these elements were incorporated on the basis of the previously developed plan views and section diagrams. In alignment with management executives the positions of each department were transferred to a 3-dimensional model. The model provided the basis for exploring configurations and discussing the flow of development processes as well as the path employees, customers and visitors take.

6.3.3 Modeling and Design of Processes

The digitally created and rendered 3-D model displayed departments and their functions as colored spheres with relational and physical proximities to each other. As a boundary object, the visualization facilitated collaboration between the practice and the client. The architects modelled alternative perspectives, integrated flows of interactions and tested division and pooling of elements. Connections between the spheres represented the face-to-face interactions, the exchange of knowledge and tangibles. The intensity of interaction was represented by the thickness of the connections, based on the frequency of face-to-face communication and content of communication. The model offered a different view of the organizational structure. The practice interpreted the configuration spatially; for example, the model showed where one department was impeding the connection between two others, and where the distances between departments should be reduced or departments could collaborate more effectively when grouped in clusters. The model was revised in feedback loops with management executives and employees, until a configuration was confirmed that represented the preferred arrangement of organization and work practices. In its final state, the research and development area was in the center. Employees could interact with each other and explore developments across the organization, and at the same time be provided with areas for concentration and engagement. The configuration balanced openness and transparency around its center with concentration and confidentiality at its edges. The configuration enabled new connections between weakly related or unrelated parts. Flows of movements were added as spines passing through the nodes and superimposed on the existing connections. The movements followed the process steps reflected in the flow plan diagrams and section diagrams. They were adjusted by further information and formulated needs gathered from interviews with management executives and employees on how the course of the project should be conducted.

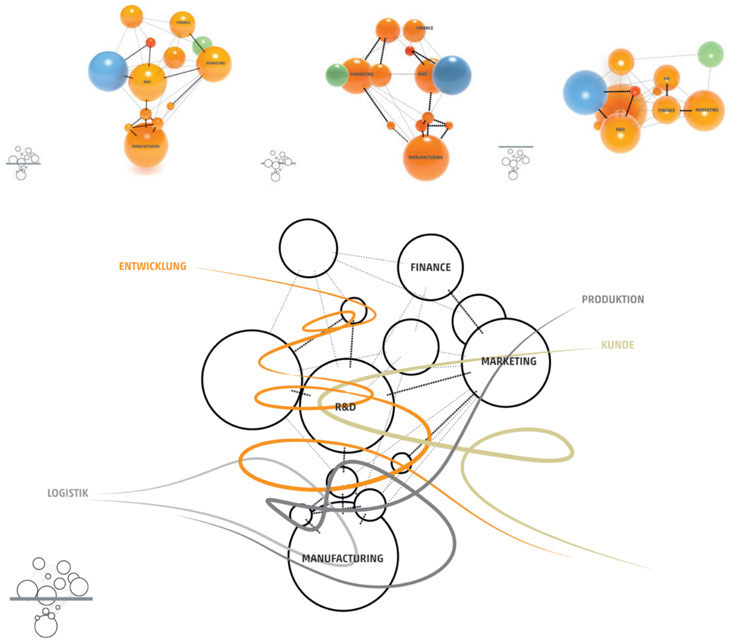


Figure 38: 3-dimensional Model of Organizational Structure

The 3-dimensional model displays functions according to their number of people and in relational proximities to each other. The model offers viewpoints from different angles, e.g. from side and top, to develop a preferred configuration. Visualization, and source by HENN & attocube systems AG (2015a). See also Chantzaras (2019b, p. 547).

The finalized model of spheres was interpreted by the architectural practice as a 3-dimensional organization structure. It was intersected to extract a diagrammatic section for further analysis and refinement. The resulting functional diagrammatic section was used by the practice as an intermediary visualization combining strategic and an operational considerations. Firstly, from an operational point of view, the proximities between the elements as well as their placement represented the preferred process flows and interactions. The processes were diagrammed in a layout to run efficiently and intersect each other for mutual awareness and knowledge exchange. Secondly, from a strategic point of view the proximities and the art of placement represented the values of transparency, openness, accessibility, concentration that were set out in the vision and mission (Chantzaras, 2019b, pp. 546–547). The diagram conveyed the narrative, how the company worked and innovated in its actual organization. The open arrangement of the research and management department in the center represented the company's commitment to transparency and openness in ideas and impact. Visual access and awareness of the developments should be fostered. The company's commitment to concentration and precision in production and quality was indicated by placing the respective departments at the base in the diagrammatic section. It represented the engineering foundation, which was visible but secured from other process flows intersecting it.

In the same way as with the conceptual model section of the innovation factory, the functional diagram was graphically extruded in a further spatial dimension. It allowed the viewer to explore connections and cross-references between areas, which could be not reviewed in a 2-dimensional representation. The 3-dimensional spatial representation framed development processes that proceeded through dedicated areas, while remaining visible and accessible to other areas. With the spatial diagram the architectural practice intended to organize awareness between people, of each other, of their location and activities, and of the products manufactured.

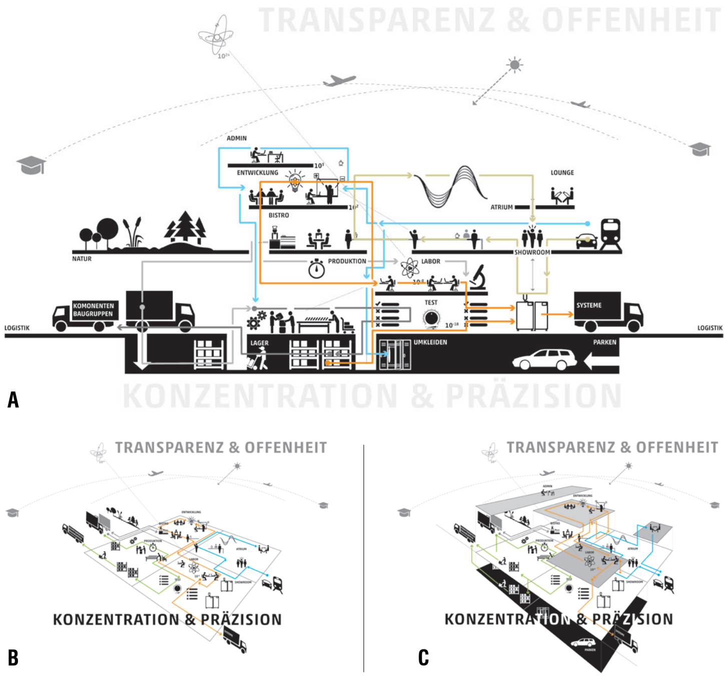


Figure 39: Diagrammatic Section and Extrusion Diagram

The diagrammatic section **A** comprises values, stated by the company, arrangement of functional areas and exemplary paths employees, clients, products and visitors take. Visualization by HENN (2016, p. 108). The diagrammatic extrusion **B, C** proposes a 3-dimensional configuration that maintains the different areas in visual connections. Visualization, and source HENN & attocube systems AG (2015a, 2015b). See also Chantzaras (2019b, p. 548).

On one side, in an architectural interpretation, project processes should unfold intentionally and efficient in sight of other employees. On the other side, idea and knowledge exchange or new initiatives should be supported to occur unintentionally and explorative. The diagrammatic arranged areas and levels were considered as one possible configuration. They provided, together with the prior elaborated visualizations the basis for reflection in the subsequent building design phase.

6.3.4 Review

The programming supported the company in reflecting its organization and processes with architectural means. Existing innovation and development processes were visualized and transformed to meet vision and goals of the management board. Innovation was core to the company's forthcoming and should be integrated with advanced manufacturing processes for small batch production. The development of the system model for the future organization followed six phases: information collection, process section, 3-D process visualization, section, diagrammatic sections, and systems modeling (Chantzaras, 2019b, p. 546).

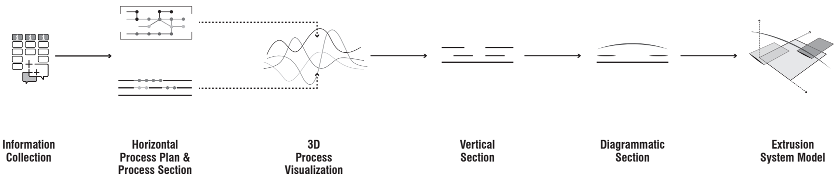


Figure 40: Process Phases in the Case Study Nanotechnology Headquarter

Six phases are outlined for the development of a 3-dimensional system model, that defines a new configuration for manufacturing, development and innovation processes. Visualization by Chantzaras, 2019b, p. 544).

The close interaction with key personnel made it possible to iterate quickly, review and revise the visual depictions. Because of the company's smaller size in comparison with the first example, the interview phase and workshop sessions took less time. More time was spent on the creation and development of charts and diagrams. The discussions supported by these boundary objects addressed the company as a whole. In the second module, building design concepts were developed based on the functional diagrams and 3-dimensional representations. The resulting building design and building construction followed the principles established with the modelled system.

The application of this process and its outcome to innovation management has several limitations. As in the first example, managerial issues regarding innovation project protocols, budgets and delivery were not discussed or integrated. Innovation management from a managerial perspective (in terms of, e.g., idea sourcing and selection or project management) was kept separate. The different types of visualizations displayed redundant information and were in some cases difficult to understand and interpret. The visualizations provided were in the form of graphics and illustrations. The dynamics and flows they represented were not based on an interactive and responsive medium. After the project had been completed, the client remarked that an adaptive model would have been beneficial to support strategic decisions. Because the team composition, the configuration of processes and the use of areas were continuously changing, a dynamic model could support the generation of alternative configurations for decision making, prior to new spatial arrangements. Adjusting the teams and knowing where best to locate them for development and innovation would have been desirable.

6.4 Findings – Advantages & Limitations

Both examples demonstrate an approach to the analysis and design of organizational processes with thinking and tools of architecture. The conception of innovation processes, methods and tools differs from approaches in innovation management.

Firstly, the conception of innovation processes is based on face-to-face interaction and behavioral change through spatial configurations. Innovation is seen as a social process, driven by interaction and unplanned encounters. Face-to-face personal interaction is regarded as the most effective way to create novel ideas and implement their development. Consequently, to foster innovative initiatives people need to be aware of each other and approachable.

The relevant activities and processes need to become visible in their complexity and simultaneity. Secondly, the approach follows an architectural programming method consisting of six phases: collection and structuring of information, mapping of linear processes, 3-dimensional process visualization, model sections, diagrammatic sections and extrusion, and systems modeling. Throughout these phases the project architects apply their spatial intelligence, immerse themselves in the problem space and interpret the data, information and knowledge they acquire. Thirdly, the architects use non-verbal tools to represent, collaborate and model the organization. They create boundary objects and persuasive artifacts to integrate the client and users in the construction of the organizational model and communicate an architectural interpretation of the organizational structure. As a 3-dimensional and tangible object it externalizes the processes of working and innovating. Elements (e.g., people and spaces) are placed in their relation to each other and in their relation to the organization as a whole. Existing operational and innovation processes of the firms are continuously reflected and revised, until a final configuration is reached and confirmed by the client. The models proposed provide new tools for the management executives to review and revise their organization. Indirectly, they also provide new tools for the management of innovation. They are company-specific spatial structures with an operational optimization of processes and a visual narrative for vision, values and culture. The models anticipate and hypothesize behavioral changes for innovation, and are proposed by the architectural practice in alignment with the client. When the models are developed into a building design and building construction, the hypothesis becomes a physical reality. The changes they recommend in people's behavior then become the spatially-set default.

However, several limitations need to be considered regarding the value and influence of these models on innovation processes. With these two examples, the architectural practice's assignment was for a pre-design architectural service. The strategic innovation management explained here was not directly addressed and therefore should be seen as a by-product of the architectural consulting work. Its hypothetical proposal for the future organization, its separation from innovation management, and the characteristic use of visual boundary objects limit the approach. Firstly, the proposed conceptual models, the building designs based on these models and the final buildings are untested hypotheses ("ungetestete Hypothesen", Sailer, 2019, p. 285) and "predictions" (Brand, 1995, p. 178) about what will happen in the buildings and what behaviors will emerge. Because planning projects are often ill-structured or wicked, a final test or proof of concept is not possible in advance. Predictions or hypotheses may be proved wrong in reality or require adjustment in the use or configuration of spaces. For these reasons, the efficacy of the architectural model of organization and innovation described in the two cases cannot be fully confirmed until it is embodied in a physical building and tested. To the author's knowledge, the models were only indirectly evaluated after completion of the two buildings. An increase in project performance rates was emphasized in the first case study:

> *"Die Zusammenführung aller Prozesspartner sorgt für optimale Schnittstellen und ein eng vernetztes Arbeiten. Die Innovationskraft wird gesteigert, das Innovationstempo erhöht. Projekte werden im Durchschnitt um 30 Prozent schneller erledigt. Die Time-to-Market verkürzt sich. Und das verschafft unseren Kunden wertvollen Vorsprung."*
>
> *(Wittenstein, 2016, p. 2)*

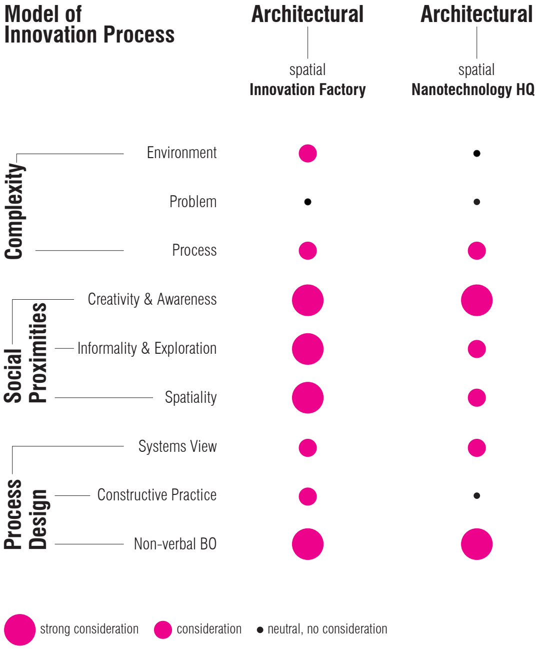
It remains to question to what extent the improvements were induced and caused by the 3-dimensional configuration of processes, by moving into a new spatial environment or by other managerial measures. The architectural programming method developed a conceptual model that theoretically could be adaptive to changing needs. The changes seen in processes structures afterwards could have been modelled and investigated in order to revise organizational and spatial arrangements. This would have created further possibilities to continuously learn and adjust the configuration of departments and functions to improve innovation processes. As one of the clients in the second case study remarked, the speed of change in team and project allocation would have required a dynamic and adjustable model.

Secondly, in the two case studies the architects were not concerned with the issue of integration with existing innovation management systems or programs. The companies were analyzed from a strategic perspective with limited integration of innovation project management. The proposed models represented innovation processes in their principal routes through the organization. Operational information on innovation projects – for example, their type, content, status and duration, as well as information on informal personal relationships – was not conveyed. The proposed conceptual model provided the basis for subsequent building design. It was implemented to different degrees in the physical building. To the author's knowledge, the model was not maintained as a virtual model for exploring alternative organizational structures or developing spatial organigrams for team allocation in innovation management.

Thirdly, the visual depictions were limited in their usability for clients and laypersons. Visualizations of information and knowledge were created by the architectural practice with a specific knowledge of and expertise in graphic media and CAD-programs and an expertise in understanding and interpreting the visualizations. The issue of expert-layperson communication in architecture is a recurring challenge for architectural practices (Rambow, 2000, p. 11). On the one hand, architects need to communicate their concepts and design proposals to laypersons such as clients, authorities and the public. On the other hand, they tend to use forms of communication that are specific to the profession and pay little attention to a layperson's level of knowledge (ibid.; p. 245). In the cases reviewed, the client and users were confined to the role of observers and commentators during the actual construction of the models. The majority of the models and visualizations were created internally by the architects for the purpose of analysis and understanding. But the visualizations were not developed with adaptive or dynamic features. Changes in parameters or revisions regarding the location of people and areas, the size of areas, interactions and interconnections needed to be manually implemented. In addition to this, no provision was made for creating an interface to digital company tools (e.g., enterprise architecture software) and enterprise data sources, or for creating a timeline to simulate and visualize process flows over time.

The significant implications for architectural innovation design concern the ways in which the specific thinking and tools of architecture support clients in their understanding of organizational processes. The case studies demonstrate that architectural consulting services offer management executives new perspectives on their processes, structure and organizations, prior to and independently to providing a building design. The architectural work can contribute to a company's transformation processes with alternative forms of analysis, visualizations and synthesis. On the one hand, architecture's non-verbal and spatial tools provide effective ways of conveying information about organizational structures and processes. On the other hand, they translate a company's visions, values and culture for work and innovation into a visual representation. In the first example, the company transformed its linear system of working practices into a system based on a more open, networked and distributed innovation process model. In the second example, a medium-sized enterprise with a semi-informal structure and the potential for growth was transformed into a consolidated, open and adaptive organization.

The case studies do not directly address innovation process design. They combine a particular form of architectural thinking in relation to innovation process with a programming method and the use of architectural tools. The thinking and methodology in both case studies need to be viewed against the background of an extended process view of innovation. The architectural practice addressed issues of complexity, social interactions and process design. While issues of complexity were dealt with at a generic level and with limited integration of innovation management, social interactions were intensively analyzed. Architectural thinking emphasized physical proximities and sought to externalize informal process structures by visualizing face-to-face interactions, communication networks and flows of services, prototypes or products. Awareness of the different processes as well as the possibilities for exploring the organizations were considered in the architectural model construction. Regarding the process design the use of non-verbal boundary objects facilitated the development of a new structure. A systems view, shaped by an architectural understanding, was used to synthesize a spatial structure based on the companies' borders defined by physical extents. Interorganizational relationships and co-operations were only addressed to a limited degree.



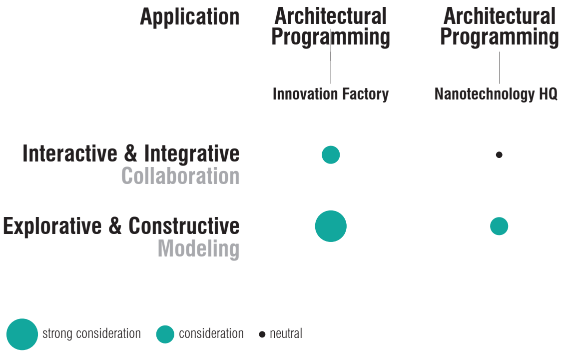
Model of Innovation Process		Architectural spatial **Innovation Factory**	Architectural spatial **Nanotechnology HQ**
Complexity	Environment	●	•
	Problem	•	•
	Process	●	●
Social Proximities	Creativity & Awareness	⬤	⬤
	Informality & Exploration	⬤	●
	Spatiality	⬤	●
Process Design	Systems View	●	●
	Constructive Practice	●	•
	Non-verbal BO	⬤	⬤

⬤ strong consideration ● consideration • neutral, no consideration

Table 6: Architectural Process Models

The architectural process models developed through an architectural programming are compared according to the requirements of an extended process view on innovation.

The programming focused on providing a basis for a subsequent building design. Accordingly, the constructive practice relied largely on the architectural interpretation and the spatio-visual work of the architects. Though the models were constructed a variety of different tools – physically and virtually – the clients and other people involved in the project were not in a position to actively participate in a process of co-creation. The models and visualizations, and eventually the process flows, could only be created and manipulated by the architects themselves.



Application	**Architectural Programming** Innovation Factory	**Architectural Programming** Nanotechnology HQ
Interactive & Integrative Collaboration	●	•
Explorative & Constructive Modeling	⬤	●

⬤ strong consideration ● consideration • neutral

Table 7: Comparison of Architectural Programmings by Functions

The case studies show a blended approach of thinking, playing and doing. Theoretical conceptualizations on innovation and innovation processes are not explicitly separated from the method and tools used. Method and tools comprise the spatial imperative for innovation, and aid the creation of according spatial boundary objects. Method and tools need to be evaluated by the criteria posed in Chapter 2.5. A methodology for an architectural innovation design needs to enable collaboration and modeling for the involved people (see Table 8). The case studies demonstrate a close interaction and the integration with client and employees. The possibilities to actively collaborate and contribute intermediary results independent from the architects' involvement remains limited. Exploration and construction is fostered through the tools and objects created. The enabling and empowerment of laypersons and non-architects to model alternative structures, integrate information and knowledge, as well as to generate new knowledge through the design process, was hardly addressed.

Architectural tools were used for sketching, diagramming, drawing and modeling in the context of organizational and innovation process design. Evaluated by the appropriate criteria for assessing tools that support an innovation processes design, these tools have strengths and shortcomings. The tools used in the case studies aided the creation of visualizations and tangible models.[92] Architects and people involved in the project from the client side deepened their understanding of organizational structures with spatio-visual tools not usually available in managerial tool-boxes. The practice explored and designed alternative configurations. Non-linear and systemic representations were developed with an emphasis on their visual appeal. In the first case study, a broader mix of visualizations and models was created to analyze organizational structures and processes. In this case, the tools could only be used by the architects. The architects performed the design tasks. The tools, visualizations and models created with them, did not feature dynamics. Changes in parameters, additions and subtraction of elements, movements and connections were manually drawn and integrated. The dimension of time could not be displayed; further attributes, such as information on particular innovation projects, were not considered.

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[92] For example, Vectorworks CAD-software, Rhinoceros 3D modeling software and the Adobe Creative Suite (Adobe Illustrator, InDesign, etc.) were used.

Application	Architectural Programming Innovation Factory	Architectural Programming Nanotechnology HQ
Dynamic	•	•
Multi-dimensional	•	•
Non-linear/ Systemic	⬤	●
Visual	⬤	⬤

⬤ strong consideration ● consideration • neutral

Table 8: Comparison of Architectural Programming Tools by Features

As mentioned earlier, both case studies prepared a conceptual basis for a subsequent building design. Accordingly, there was no requirement for an innovation process design. However, both studies have useful implications for the development of an architectural innovation design. Innovation management functions and stakeholders need to be integrated for mutual understanding and engagement. Collaboration in the analysis and design of new configurations needs to be enabled for parties unfamiliar with architectural thinking and tools. Communication gaps in language and visuals between different disciplines and professions need to be bridged. 3-dimensonal models need to be interactive, adaptive and dynamic in order to facilitate collaboration and co-creation. The parties involved need to work strategically, to explore alternative configurations and compare them with each other. To support innovation management, the constructed models should be integrated in the initiation and management of innovation projects. With their dynamic representation of relational and spatial configurations, innovation management can allocate required resources, track the activities of new initiatives, and reflect future changes in an organization through collaborative design.

The architectural consulting services analyzed in the case studies are two examples of the use of architectural thinking, especially its spatial intelligence and visual thinking capabilities, for innovation management. Spatial structures and people's behavioral patterns are regarded as interdependent in this approach. For a better evaluation of the applicability of architectural thinking to innovation process design, related works need to be reviewed that take a similar approach to the relevance of spatial proximities, social interactions, 3-dimensional environments and visual representation.

7

7 – Related Works: Methods and Tools with Space-Behavior-Focus

The methods and tools considered in this section present a space-behavior relationship as fundamental for the emergence of creativity, productivity and innovation. The section reviews works in the disciplines of architecture, information technology and social sciences that show conceptual affinities with the architectural consulting service in the case studies. The works investigate the relationship between communication, interaction, space and innovation. They refer to spatial environments and spatially dependent visualizations. They develop and apply digital tools to analyze, model and visualize the existing and future configurations of organizations. The common feature of the works discussed is their origin in academic research of the particular disciplines. The theoretical developments also suggest a subsequent consulting approach. For each of the works with a spatial focus, an established method, a research project and a theoretical approach have been selected. The "space syntax" (Hillier, Hanson, Peponis, Hudson & Richard, 1983, p. 49) method from the Bartlett School of Architecture has been successfully transferred to applications in practice, while the research project "Laboratory for Architecting Innovation" (Henn, 2010, p. 1) and the approach of parametric "social functionality" (Schumacher, 2016d, p. 17) are theoretical concepts.

In the group of approaches with a behavioral focus, a research project and a research field are reviewed. The science of "social physics" (Pentland, 2015, p. 4) from the Human Dynamics Lab at MIT provided the theoretical basis for consulting services; the "Innotracing project" (Reichwald, Möslein & Piller, 2016, p. 24) funded by the Peter Pribilla-Foundation remains a conceptual work. The research initiatives with a space-behavior focus have important practical implications for an innovation process design. The chapter closes with an evaluation of the methods and tools regarding the application to innovation process design and regarding the features required in the tools for a constructive process.

7.1 Space-related Applications

The selected space-related applications address the interdependence of spatial proximities, physical interaction, communication, visibility and accessibility of people for the generation of new ideas and their development. The social sciences and management science have studied the performance of engineering teams in relation to their physical proximities (e.g., Allen, 1995). Architecture and management science have investigated the design of physical buildings as R&D centers and their influence on productivity and innovation (e.g., Allen & Henn, 2007; Gómez, 2013). Architectural research and the social sciences have analyzed the spatial configurations of built structures and their influence on social behavior (e.g., Hillier, 2007; Penn, Desyllas, & Vaughan, 1999; Waber et al., 2014). Physical proximity and direct interaction in face-to-face communication have been found to be essential drivers for new ideas and innovation initiatives; they are impacted, enabled and promoted by spatial settings (Allen, 1995, pp. 235–248; Hillier, 2007, pp. 211–213; Pentland, 2015, pp. 93–103).[93] Despite this empirical basis, only a few approaches address the support for innovation processes with a spatial approach (Allen, 2000, p. 153; Wineman, Hwang, Kabo, Owen-Smith & Davis, 2009, pp. 427–428).

7.1.1 Space Syntax Method

Space syntax describes a "theory and method" (Hillier, 2007, p. 1) developed at the Bartlett School of Architecture from the University College London.[94] It studies and designs the interdependencies of spatial configurations and human behavior at different scales of the built environment (Hillier et al., 1983, p. 49; The Bartlett School of Architecture, 2020). It is also described as social network analysis applied to physical space, which sees space as a generative medium (Hillier, 2007, p. 196; Ratti, 2004, p. 4): it shapes and motivates the behavior and relationships of people, configures patterns of activities, and is – at the same time – formed by these activities (Karimi, 2012, p. 304; Wineman et al., 2009). Initially conceptualized as set of techniques for urban analysis of pedestrian movements, it has been extended to the fields of traffic analysis, air pollution measurements, retail developments and design of work environments in buildings (Hillier, 2007; Ratti, 2004, p. 2; Space Syntax, 2022).

Space is considered in its topological characteristic, i.e. in its relation to other spaces of providing access, visibility and influencing people's vision and movement. The configuration of spaces – the „set of interdependent relations in which each is determined by its relation to all the others" (Hillier, 2007, p. 24) – shapes the way people circulate, behave and act from street settings to interior floor plans With mathematical models, specifically developed software and computer-aided visualizations, the existing configurations of spaces are depicted with "line maps […] and visibility graphs" (Sailer, 2010, pp. 69–71): line maps are sets of axes that display the system of straight movements and straight view lines; visibility graphs depict the area, which can be seen from a specific point in a 360 degree view. Using this analytical approach several attributes of a space are measured and assessed in their influence on human behavior (Dettlaff, 2014, pp. 287–289; Hillier & Hanson, 1984, pp. 108–109; Wineman et al., 2009, pp. 431–434): connectivity describes the axial connection of a space to other spaces; degree of depth summarizes the required minimal movements (or steps) to access a space from a given position; control value measures the control a space has over its neighboring spaces; local integration considers the embeddedness of spaces within the surrounding spaces; global integration captures the connection and embeddedness of spaces "in relation to every other space in the system" (Hillier & Hanson, 1984, p. 109). Local and global integration of spaces correlate with the social structure of people (Dettlaff, 2014, pp. 288–289). Local integration shows the cohesion and engagement of small communities and groups; global integration expresses movements and explorations of groups to other areas. For a balanced urban structure, Hillier concludes:

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[93] Also: Khazanchi, Sprinkle, Masterson & Tong (2018, p. 590); Penn, Desyllas & Vaughan (1997, pp. 12.4–12.5).

[94] Hillier et al. (1983, p. 49) define space syntax as follows: "What is space syntax? Space syntax is a method we have developed at the Bartlett Unit for Architectural Studies to describe and analyse patterns of architectural space–both at the building and urban level. The idea is that, with an objective and precise method of description, we can investigate how well environments work, rigorously relating social variables to architectural forms. We can thus simulate the performance of real and hypothetical schemes on the computer, so that it can be used as a suggestive and evaluative design tool. Obviously the design tool will only be effective to the degree that we can establish general principles relating spatial form to social outcome, checking observations against computer simulations."

> *“Good urban networks are not self-contained groups but distributions of probabilities within a larger, continuous system. The key to ‘urbanity’, we have concluded, lies in the way the local and global scales of space and networks relate to each other.”*
>
> *(Hillier, 2007, p. 203)*

Local and global integration of spaces have implications for organizations and innovation processes. Social networks in space syntax emerge from a balance of the local and global integration of spaces and buildings. They reflect spatially the theory of strong and weak ties (Granovetter, 1973). For example, engineering teams perform better if they act in close interaction inside and engage with a distributed network outside their group (Allen, 1995 p. 122–123; Hillier, 2007, pp. 201–203; Penn et al., 1999, p. 195). Despite the engagement in a team, the integration across an organizational building drives communication, collaboration and creativity. In this regard, physical space enables social interactions, raises the probability of encounters and eventually the generation of new ideas. If the building layout and its spatial configuration is analyzed in its spatial syntax, the implications for its re-design and adjustment can be deduced, which then improve the innovation processes in a firm (Wineman et al., 2009, pp. 431, 439). In consideration of structural holes in social networks, space can function as a “tertius iungens” (Wineman et al., 2009, pp. 430, 440). Space acts as a third party connecting diverse and locally dispersed people or groups of people, firstly to generate new ideas and secondly to drive the further development of actions. Space can resolve or diminish two problems in the context of innovation processes: firstly, space connects people and in this way addresses the “action problem” (Wineman, Kabo & Davis, 2008, p. 430) of structural holes that lack a joint impulse to proceed with a novel initiative; secondly, space confronts people with other impulses and addresses the “idea problem” (ibid.) of dense networks, which lack novel insights or inspiration from outside.

Space Syntax Limited – a spin-off from the research at university – is applying the theoretical concept, the sets of methods and techniques in practice (Space Syntax, 2022). Spatial configurations of urban environments and development areas as well as spatial layouts of buildings are analyzed using a 2-stage approach with digital technologies based on mathematical models (Space Syntax, 2021b). As consultancy for work environments the approach analyzes first the movements and interactions of people and the actual use of spaces. This “baseline study” (ibid.) comprises surveys, interviews, data analytics, predictive computing and spatial layout models, and the current state of space use and operation. In the second stage, a “design strategy” (ibid.) is developed to transfer the findings into actionable recommendations. Existing spaces and building layouts are improved in their intended purpose, e.g., to enable informal interaction, collaboration and eventually processes of innovation. The design strategy further ensures a “cultural ‘fit’ ” (Space Syntax, 2021a) between organization and space:

> *“Different organisations use space in different ways. Some want to be more open, some more closed. Spatial layout can reinforce cultural identity if handled intelligently, or it can undermine business performance if handled badly. Understanding the quantifiable*

> *differences between different building designs can ensure cultural ‘fit’ and avoid costly mistakes.”*
>
> *(Space Syntax, 2021a)*

With its academic background, scientific collaborations and exchange, Space Syntax combines a science-based modeling approach with and human-behavior oriented analysis in urban environments, building and floor plan layouts (Space Syntax, 2021b). Though it does not directly address innovation processes with its offerings, the consultancy seeks to improve the prerequisites, which foster creativity and new initiatives with architectural and computer-aided tools: the increase of interaction in a balance of local and global integration of spaces; the increase in the possibilities and probabilities for informal and chance encounters as well as for co-awareness; the re-design of spatial configurations as a binding element to connect and engage people.

7.1.2 Analysis Tools for Communication-Space Relationship

The ”Laboratory for Architecting Innovation” (Henn, 2010, Executive Summary) is a research project from the Center of Knowledge Architecture at the Technical University of Dresden. It investigates how to increase the innovation capabilities of enterprises with tools and consulting services at the interface of architecture, management, informatics, psychology and production planning (Henn, 2013). The intended goals are to research, develop, prototype and implement new tools for innovation processes in an organization. The basic proposition is that communication structures, organization and spatial configurations are essential drivers for efficient knowledge management and innovation processes (Henn, 2010, pp. 2–3). Similar in its approach to the arguments in this thesis, the project is based on the idea that traditional methods of management and of process optimization are not feasible to drive innovation processes in work and knowledge networks (translation by author, Henn 2010, Executive Summary).[95] Innovation is a complex social process of interaction; it requires an integrated consideration of communication, knowledge and space (ibid.).

The laboratory set up three interdisciplinary research teams to investigate separately the subjects of communication, of knowledge, and of space with architecture as an anchor discipline present in all. The first research team focused on communication structures, and the development of analytical software tools in combination with a consulting service. The software tools supported the analysis of communication patterns in organizations by visually displaying it in a “matrix representation of a communication network” (Allen, 2000, p. 157) termed a netgraph. One column and one row in the netgraph represents one individual in an organization, so that his or her intensity of communication with any other peer can be rated and registered in the intersecting squares of the matrix. Through interviews and surveys the group under consideration (e.g., employees, team, department) provided a measure of the intensity of their interaction with other groups, assessed by different parameters: the frequency

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[95] “Das LAI bietet Unternehmen innovative Lösungen für das Problem, dass die herkömmlichen Methoden des Managements oder der Prozessoptimierung ungeeignet sind, die Innovationsprozesse in Arbeits- und Wissensnetzwerken – komplexe soziale Interaktionsprozesse – zu steuern.“ (Henn, 2010, Executive Summary).

of interactions; the duration of interactions; the content of the interaction; the medium of interaction, a category which distinguished between direct interaction face-to-face or indirect by phone and digital communication (Henn, 2010, pp. 3–5). The resulting netgraph enabled a visual analysis of strong and weak communication structures across the organization, i.e., where communication was dense, where it remained one-directional or where it was absent, though required (Allen, 2000, p. 157; Henn, 2010, p. 4). With the complementary consulting service, it was intended to model alternative communication structures and develop strategies for re-designing interactions and processes. The re-design could then improve operational business processes and the generation of new knowledge (Henn, 2010, pp. 2–5). Finally, the spatial configuration of the organization could be transformed according to the intended improvement in communication and processes, e.g., through spatial shifts and interventions (ibid.). The project concluded with the development of different digital tools for conducting surveys, storing data, visualizing netgraphs and matching business processes with communication patterns. Further tools helped to annotate work places with spatial information regarding distances and proximities in a building, visualize communication flows in a building layout and assign work places in alternative configurations to improve interaction (Henn, 2013, pp. 15–18). Though tested in practice, a strategic consulting service for organizational design was not developed.

In the second research team, a concept for a software application was proposed that could support the creation of a "knowledge productivity report" (Henn, 2010, p. 5). In this set-up, the existing available knowledge resources of a firm residing in its employees and communication structures could be localized and listed in order to foster innovation initiative. Employees were described with knowledge profiles ("Wissensprofile(n)", Henn, 2010, p. 7) which include their competencies, their expertise, the type of knowledge they had, and their spatial proximities and spatial behaviors (ibid., pp. 5–7). Additionally, the report could outline missing and required knowledge. In the subsequent consulting phase, strategies for organization and re-organization of relevant knowledge resources would be visually modeled, in order to improve communication, exchange, interaction and collaboration among the employees assigned to a specific project. Changes in the organizational and spatial configuration would be measured and adjusted if the productivity in knowledge did not increase as expected (ibid.). The scope of the project was adjusted and reduced to a skill tool, which represented the skills and competencies of employees, and supported a company in filling vacant positions (Henn, 2013, pp. 10–11).

The third laboratory set-up intended to develop a spatial planning software application for complex projects. The software would relate functional requirements to physical areas and display its organization as a system of interrelated spaces in a process- and communication-optimized way (Henn, 2010, pp. 8–10). The resulting space program would support architects in the building design phase. In the end, several tools were developed to model and visualize spatial areas in relation to each other, assign and modify their locations. However, in all three research areas, software development did not progress beyond the early stages (Henn, 2013, pp. 11–12).

7.1.3 Parametric Social Functionality Method

An architectural design approach to provide physical frames for behaviors and social interactions is rooted in the method of parametric design and in its intended "stylistic" (Frazer, 2016, p. 21) interpretation termed "parametricism"

(Schumacher, 2016b, p. 11). Methods and applications derived from as parametricism do not address organizational processes of innovation, but are used to define the parameters of geometric properties, concrete building demands, human needs and preferences, as variables in a "network of relations or dependencies" (Schumacher, 2016b, p. 3). By creating interdependencies and relations between different and diverse types of parameters with "algorithmic thinking" (Jabi, 2013, p. 196) and a set of rules, a design structure is generated that incorporates social behaviors and anticipates people's interactions. Parametric design is a generative method: it defines a process based on different parameters interrelated by sets of rules to generate computer-aided complex design forms or optimized design solutions (Hirschberg & Fritz, 2020, p. 149; Jabi, 2013, p. 196). In the case of optimized design solutions, design iterations normally performed by the architect, are conducted by computational means against defined design criteria that independently adjust and test different values of parameters to generate a satisfying solution (ibid.). The relation between the design intent (what is aimed for as a preferred state) and design response (what is proposed as a solution) can be defined and embedded through the use of algorithms and computing technology, for small-scale solutions for interior spaces to large-scale concepts of urban environments (ibid.; Schumacher, 2013, p. 241).[96]

Parametricism represents a particular interpretation of parametric design as architectural style, conceptualized and developed by Patrick Schumacher and Zaha Hadid Architects (Frazer, 2016, p. 21; Hirschberg & Fritz, 2020, p. 165). In the following section parametricism will be described as the application of a parametric design method in the conceptual framework of the respective architects applying it. Parametricism is seen as a novel application in the discipline and practice of architecture that relates architectural elements to each other and develops "dynamical compositions that react to "attractors" and that can be made to resonate with each other via scripts" (Schumacher, 2016b, p. 11). In its further development as "Parametricism 2.0" (Schumacher, 2016c, p. 10) the application addresses the challenges of a network society related to the built environment with computational means (Schumacher, 2016b, 11). By outlining the social function of architecture and buildings to frame and guide social interactions, parametricism incorporates organizational challenges and human behavior in the building design process (Schumacher, 2016a, p. 110). Social functionality, "the spatial ordering of social processes" (Schumacher, 2016b, p. 13) for an intended purpose, is considered as a core competency of architecture, while the technical functionality of a building is regarded as the domain of engineering disciplines. Schumacher (2016a) proposes that designed spaces need to communicate information to different users regarding their function, social belonging and location, in order to facilitate interaction processes.[97] The legibility of spaces, e.g., for orientation and navigation enables the users to make intentional moves, to enter and "to participate in the respective interaction scenario" (ibid., p. 111) with other users. Design spaces and spatial structures become "a system of signification" (ibid., p.

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[96] "Parametric design is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response." (Jabi, 2013, p. 196).

[97] Schumacher (2016a) terms the new kind of architectural design as "parametric semiology" (ibid., p. 108), through which a variety of information on physical space is communicated to users of that space.

109) that transmit cues on space and vision (or sight), frame and guide the users' interactions, and support their performance and the performance, i.e., the social functionality, of the design. To reach this social functionality in design crowd and agent-based modeling is integrated into the architectural parametric design model. The agents possess different behavioral scripts that become activated if spatial settings are crossed. In this way, architects can model human behaviors, assess the functionality of the spaces and explore further design solutions. Applied to work environments, utilization of space, efficiency of navigation, flow of processes and the quality of interactions regarding frequency, duration, variety and duration can be simulated. In this way, "work satisfaction, learning and productivity (ibid., p. 113) can be increased.

Parametric design methodology and tools as graphical algorithmic editors (e.g., Grasshopper) in combination with 3-D modeling and visualization tools (e.g., Rhinocerus) are used by architectural practices to cope with large data sets, with complex relational and physical proximities, with movements and flows of people, information and tangible elements. The examples of Space Syntax and the Laboratory of Architecting Innovation incorporate partially parametric and algorithmic design tools in their approaches and services.

Parametric design applied to workplace analytics offers spatial visualizations in 2-D and 3-D. This kind of analysis builds upon spatial requirements for work processes in existing structures and designed layouts. Work performance behaviors are related to the experience and well-being of the employees in their physical environment, and their productivity and collaboration levels in dependence to their spatial proximities to each other and to specific areas, such as meeting, coffee or amenities spaces (Kaicker, Blum, Siedler, & Espaillat, 2019, pp. 152–153). The criteria, and hence parameters, influencing people's experience, well-being, productivity and collaboration are defined by the individual architectural practices conducting the analysis. The natural daylight provision, level of visibility, potential for communication, distances of access points and focus potential for concentrated work can be observed and measured; the characteristics of each workplace location can be matched with "individuals, teams and departments, with their unique work styles, processes, and activities to support their performance" (ibid., p. 153). For example, in changing the values for daylight provision, visibility areas and connectivity of places, different layout designs can be configured, analyzed and evaluated, to address challenges for productivity and innovation (Kaicker et al., 2019). This kind of parametric social functionality for organization and their work processes is based on physical building designs or existing physical structures. It does not question the organizational structure at a strategic level, but foregrounds a building as solution and provides optimized work layouts for a subjective parametrically designed form.

Parametricism, as the stylistic application of parametric design, applies architectural tools to the larger context of societal and organizational challenges, to their analysis and design (Carpo, 2013b, p. 240; Gage, 2016, p. 130). The neglect of client and direct user integration, the absence of interdisciplinary exchange and the claim of "full authorial control of design at all scales" (Carpo, 2013b, p. 239) make the application questionable (Trüby, 2012, p. 501).

7.2 Behavior-related Applications

The increasing awareness of social interactions in organizations and their relevance for innovation has spurred alternative research in innovation and leadership (Lundberg et al., 2014, p. 222). Behavior-related approaches in the context of this thesis seek to analyze people's movements, activities and interactions by tracking and sensing their cognition, body language and body sensation in physical space. Behaviors that support innovation can be changed at the level of an individual perspective and from the perspective of communal or social activities.

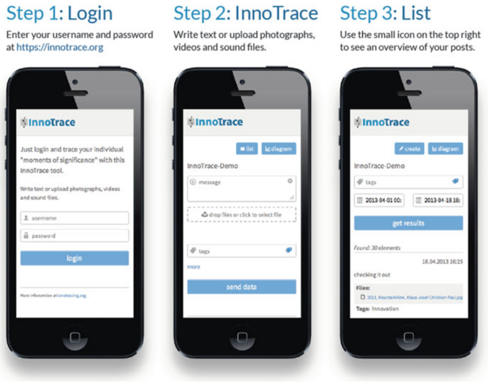
The examples selected are related to physical space and spatial configurations, where multi-sensoric experiences occur and team dynamics for productive and creative outputs evolve. They comprise the elements of space, social interaction and innovation processes, with an emphasis on social interactions. The InnoTracing application combines academic research on innovation processes with empirical studies (Penzenstadler, Sutherland, Lundberg, Blazek, & Habicht, 2013). The theory of social physics provides a broader perspective on social interactions in organizational processes (Pentland, 2015). It can be applied to workplace environments through the use of commercial software applications.

7.2.1 InnoTracing Application

The InnoTracing research project focusses on the "micro-level" (Lundberg et al., 2014, p. 222) of social interactions for innovation and leadership from the perspective of a single actor. In contrast to Space Syntax and the tools developed at LAI, physical space is regarded as background, in which "moments of significance" (ibid.) occur. These moments are perceived from an individual perspective as relevant for creativity, innovation and leadership. The single actor is the central source, to recognize, detect and report situations, which drive creative work and eventually innovation. The InnoTracing framework provides an InnoTracing methodology and an InnoTracing software application to understand "more clearly where, when and with whom the most productivity arises" (Sutherland, Lundberg, Blazek, Penzenstadler, & Habicht, p. 9). The methodology and application support the analysis of social networks with regard to creative and innovative processes, and generate implications for managerial actions at team, departmental and organizational levels (ibid., p. 9; (Lundberg et al., 2014, p. 229). Within this framework innovation is a collaborative action and constructed bottom-up by single actors regardless of their hierarchy levels. The framework avoids observation and interpretation biases by researchers and enables a direct data sourcing by the participants themselves (Lundberg et al., 2014, pp. 221; 224). InnoTracing enables people in working environments to collect data on their interactions, which are later processed and analyzed with sociological methods.

The application for mobile devices allows single actors to collect, rate and tag their significant moments in user-friendly ways through pictures, movie clips and notes (Lundberg et al., 2014; Penzenstadler et al., 2013, p. 6) The collected data of each actor constitutes "individual and group cognitive maps" (Lundberg et al., 2014, p. 222) of interactions regarding creativity, innovation and leadership, which are then analyzed and interpreted jointly by the researchers and participants. Software applications and generated cognitive maps were tested in a pilot study with participants at a conference and in a study with the employees of an innovation department (ibid., pp. 224–228; Lundberg et al., 2017, p. 287). In the pilot study, participants at a conference on leadership and innovation used the application to record their individual moments of significance regarding knowledge exchange, information exchange, learning or other aspects significant to the participant. The analysis of the collected data and information revealed interesting aspects in three categories (Lundberg et al., 2014, pp. 224–228).

Firstly, the analysis of the frequency of data points offered insights on where and when moments of significance occurred for each individual and for several individuals at the same time. Secondly, for the analysis of the content of the recorded moments of significance, the InnoTrace app provided visualizations showing what kind of ideas were captured and what kind of social interactions took place (ibid., pp. 226–228). The cognitive maps visualized the diversity of ideas collected and the congruence of ideas, where similar perceptions were recorded by different participants. Regarding the social interactions, the cognitive maps provided visualizations of situations where participants of the study came into contact with important people at the conference, made new acquaintances or had a "conversation in action" (ibid., p. 227). The app also allowed conversational exchanges to be traced to their physical location. Thirdly, the analysis of user experiences with the tool revealed its positive features. Participants used the tool as a personal notebook during the conference; they became more aware of and sensitive to their environment; they experienced a kind of community building with other participants of the study by using the tool's facility for showing the type of moments of significance that had occurred (without knowing the participant and the content of the significant moment).


Step 1: Login

Enter your username and password at https://innotrace.org

Just login and trace your individual "moments of significance" with this InnoTrace tool.

Write text or upload photographs, videos and sound files.

Step 2: InnoTrace

Write text or upload photographs, videos and sound files.

Step 3: List

Use the small icon on the top right to see an overview of your posts.

Found: 30 elements

18.04.2013 16:25

checking it out

Tags: Innovation

Figure 41: InnoTrace App (Lundberg et al., 2017)

Screen views of the InnoTrace App and principle steps for its use. Visualization by Lundberg et al. (2017, p. 290).

The framework has not been developed further in studies with larger sets of participants and has not been implemented as a market product. Its value for designing innovation processes as integrative and explorative systems resides in its emphasis on tracing individual actions through individual perspectives and using visualizations to detect patterns of where and when significant moments occur.

7.2.2 Sociometric Tools

Social interactions and people's behavior is central in the science of social physics. In contrast to empowering people to generate and collect data they consider relevant for creativity and innovation – as proposed in InnoTrace – social physics uses mathematical models to analyze and predict human behavior, based on large data sets collected over a long period of time (Pentland, 2015, pp. 4, 10–11, 81; Penzenstadler et al., 2013, p. 6). As an applied science it deduces findings from empirical studies of real-life settings and real-life interaction patterns.

The core focus is on idea flows within social networks, interaction patterns in social networks and their relation to social learning for changes in behavior and actions (Pentland, 2015, p. 15). The prediction of how people behave depends on their exposure to the behavior of other people, in physical and digital realms (Pentland, 2015, pp. 45, 171). Transferred to questions of productivity, creativity and innovation the measurement of interaction patterns provides empirically supported insights on the drivers of team performance and success (ibid., p. 92). As explained in Chapter 2.3.2 in the section on the relevance of informality and exploration, engagement within a team and the exploration of new inputs from outside the team contribute equally to successful performance. For productivity and creative output, physical proximity and patterns of face-to-face interaction "remain a major factor" (ibid., pp. 93, 171; Waber et al., 2014). As a consequence, interaction patterns and individual communication behaviors need to be measured, including people's conscious and unconscious social signals like energy levels, tone of voice or physical proximity (Pentland, 2015, pp. 106, 220–221). Organizations can improve the productivity of their employees and their teams, foster creativity and eventually innovation by shaping the interaction patterns and facilitate a group intelligence among the people working the teams.

> *"By moving away from a static org chart to a focus on the real interaction network, we can bring everyone into the loop, to make it more likely that good ideas will turn into coordinated behaviors"*
>
> *(Pentland, 2015, p. 6)*

Based on large data sets retrieved through "reality mining" (Pentland, 2015, pp. 218–219) via, e.g., sociometric badges, smartphone devices, tracking of e-mail traffic and social media activities – by an "opt-in" (ibid., p. 181) regulation – the interaction patterns were analyzed and the performance of teams predicted (ibid., p. 92). Put differently, independently of knowledge about the content of interactions, it was found "that the patterns of face-to-face engagement and exploration within corporations were often the largest factors in both productivity and creative output" (ibid., p. 93). Face-to-face interaction, as similarly demonstrated by (Allen, 1995), and interactions via phone are "the most valuable flows of ideas within an organization" (ibid., p. 220). Being able to measure these kinds of interactions with multiple variables, at a large scale over time and space (i.e., with large data sets), has significant managerial implications. Based on the theoretical concept of social physics and its empirical findings, organizations can be supported in optimizing their work processes. Understanding the relation between employee interaction, communication and work productivity, enables them to redesign the configuration of teams and spaces. At the same time, people can see their interactions and communication patterns visualized and receive instant visual feedback on their current actions. Accordingly, they can improve their acting to engage and synchronize with their team, and thus increase the performance of the team they are working in (ibid., pp. 108–111). Besides using smartphone devices for mobile sensing, sociometric badges can capture different behavioral and human body related metrics. Sensors in these micro-wearables record, e.g., location, physical proximity to others, movements, body language in "the amount of extraversion and empathy" (Pentland, 2015, p. 221), voice, when speaking to others, and tone of voice, to decipher personal moods (ibid., pp. 220–221; Matheson, 2014; Fischbach et al., 2010, p. 6391). With these badges individual behaviors as well as team behaviors can be analyzed against the background of their performance. Based on the experiments and technical development, a spin-off of the MIT Human Dynamics Lab was set up. It manufactured the badges for implementation in the market and to advise companies on issues of work performances in the physical workspace (Matheson, 2014). The consultancy segued into a broader workplace analytics company, to improve collaboration at an organizational and spatial perspective (Humanyze, 2021). Its core solutions address organizational health and workplace strategy. Organizational health constitutes itself by the engagement of employees, the productivity of teams and the organizational adaptability (ibid.). Data from enterprise applications, communication tools and location systems are analyzed and continuously measured, to derive insights, informed decisions and actions for management to restructure work processes. The "Organizational Health Score™" (Humanyze, 2021b) aggregates the values of engagement, productivity and adaptability captured in the field of study and offers executives indications of current status or the impact of implemented organizational measures. Regarding workplace strategy, the company provides digital tools for organizations to manage the physical workplace requirements of teams and people, to analyze the actual use and performance, and propose settings for improvements. Hybrid and remote work are integrated in the consideration for an optimized workplace strategy.

By quantitatively studying and modeling human interaction with mathematical models social physics and the market applications derived from it uncover basic routine patterns. The mechanistic and engineering view of human behavior neglects the unpredictability of human agency and the development of an innovative intent. Therefore, the alignment of individual behavior by considering and following metric performance indices needs to be critically viewed (Dooley, 2004, p. 370).

7.3 Findings – Simplification of Processes

The applications selected address managerial challenges of innovation processes through space and social behavior. Human agency and physical space are foregrounded as key parameters for change. Innovative performance is seen as a social and spatially embedded process. Interactions of people with the environment, with other people and with spaces, influence human cognition, perception, sensory and behavior. Innovation evolves from these interactions, from thought and knowledge exchange between people, chance encounters, engagement, exploration and team dynamics. A spatial configuration or a social configuration is considered as an inhibitor or driver of innovative behaviors. The applications and their theoretical underpinnings analyze and design environments for innovative behaviors. On one hand, they seek to increase the probability of effective communication, interaction, and collaborative engagement when people meet. On the other hand, they offer possibilities that people freely discover and explore in the organization and other areas. The perspectives on space and behavior do not propose innovation process models outlined in Chapter 3. Operational aspects of innovation processes, as different phases to undergo, or issues of managing time and budgets are not addressed.

The applications selected argue for an interdependence of space (physical and virtual), social interactions and innovative outcomes. In particular, by contrasting the InnoTrace tool's method with parametric social functionality and the space syntax method with sociometric tools similarities become visible. The 'system of signification' in parametric social functionality is a spatial and holistic view of the 'moments of signification' collected by individuals with the

InnoTrace app. Both application integrate incidents across time and space.

The space syntax method analyzes social behavior and social networks in terms of their response to physical space. With changes in the spatial configurations it induces changes in the social behavior. In contrast, sociometric tools use the human body to uncover the individual social behaviors. Both applications address the social network, from a physical, spatial perspective on the one hand, from a human, community perspective on the other.

The applications in practice, derived from the theories of spatial syntax, parametric design and social physics, are directed at the optimization and efficiency of work processes. The use of mathematical models and parameters de-emphasize the unpredictability of human agency and creative action. Qualitative aspects such as organizational culture, motivation and purpose are sparsely considered. In the spatial applications, the arrangement and configuration of physical spaces are the main medium to drive innovative behaviors. The applications collect and process information from the parties involved as data and information providers, without actively involving them in the development process of the new configuration. Interaction and integration are therefore limited. The examples of tools developed at the LAI and the method of a parametric social functionality are primarily used by architects to explore and construct. Here, the space syntax method provides an analytical basis for design, while the tools of LAI and parametric design tools offer possibilities to directly design and iterate.

The applications of social physics and InnoTrace differ from this architectural design approach. In the case of social physics, the collection and analysis of large data sets provides the basis for physical and organizational measures to improve work processes. The reliance on data, and the engineering perspective on social processes, constrains an interactive and constructive involvement of the consulted clients, as proposed in co-creative design processes. In InnoTrace, the individual takes an active part, but again as a collector of information. In sum, the applications presented offer new perspectives for understanding and fostering innovation processes. But they have a limited functionality in support of collaboration and modeling to develop new models of innovation processes.

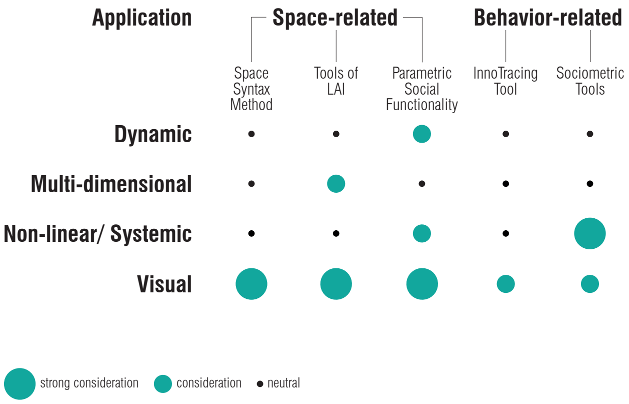
Table 9: Comparison of Space-/ Behavior-related Applications by Functions

Applications related to space and behavior compared to functions of collaboration and modeling for a new model of innovation processes.

Application	Space-related			Behavior-related	
	Space Syntax Method	Tools of LAI	Parametric Social Functionality	InnoTracing Tool	Sociometric Tools
Interactive & Integrative Collaboration	●	•	•	•	•
Explorative & Constructive Modeling	•	⬤	⬤	•	•

⬤ strong consideration ● consideration • neutral

An extended process view of innovation comprises multi-level complexities, social proximities, and a process design approach. A tool to support this view needs to offer a feature for dynamics, for multiple dimensions including space and for systemic relations, emergence and interdependencies in a visual way. While the visualizing feature is well addressed in all applications, only parametric design and sociometric tools consider dynamics. Systemic views are best provided in the underlying theory of social physics.



Application	Space-related			Behavior-related	
	Space Syntax Method	Tools of LAI	Parametric Social Functionality	InnoTracing Tool	Sociometric Tools
Dynamic	•	•	●	•	•
Multi-dimensional	•	●	•	•	•
Non-linear/ Systemic	•	•	●	•	⬤
Visual	⬤	⬤	⬤	●	●

⬤ strong consideration ● consideration • neutral

Table 10: Comparison of Space-/ Behavior-related Applications by Features

Applications related to space and behavior rated by their provision of features to model and design innovation processes holistically.

In the examples selected it is difficult to integrate spatial aspects with behavioral aspects while at the same time enabling a collaborative design approach between provider (e.g., the architectural practice) and the client (e.g., a company). An architectural approach to innovation process design offers an opportunity to integrate both sides and create a bridge between the spatial, social and the design perspectives. The design of innovation process models needs to be seen, adjusted and modelled by people from different disciplines.

8

08 – Voids & Requirements

The disciplines of management and architecture have their respective approaches to analyzing, designing and fostering innovation processes. In innovation management, models have shaped the thinking about innovation and how its processes should be managed. From linear representations of reality, innovation process models evolved into non-linear sequence models and system models. System models propose a holistic concept for organizations. They address new challenges in the management of innovation as the consideration of dynamics, networks, and adaptation, and the design of the innovation process itself. The design perspective is attracting growing attention especially through the methodologies and methods of design thinking. At an operational level, digital and analog applications transfer theoretical process models into practice. The applications support companies, management executives, innovation managers, employees, partners and other stakeholders in coping with increasing complexities in innovation challenges. They help to leverage the potentials of social interactions as a vital driver for successful innovation.

Architecture as a discipline approaches innovation in organizations differently. It adds a spatial dimension to the analysis of processes. Innovation research shows that innovation is sparked by social interactions, for which architecture provides a relational and spatial configuration. Architectural practices consult companies by developing a spatio-visual frame for possible interactions to occur and human driven processes to evolve. The building as tangible outcome serves as a medium to promote innovation processes. Applications as methods and tools for practice can be found with a focus on spatial settings and with a focus on behavioral analysis in spatial environments. Approaching innovation processes from management disciplines and from the discipline of architecture has benefits and limitations. The limitations, or voids, become visible in the way both disciplines consider complexity at different levels, integrate social interactions and enable a design of processes as a dialectic and constructive form-giving. Against this background, the voids in models and methodologies in innovation management and architectural consulting will be summarized. Secondly, the limitations in the applications in practice will be aggregated. Thirdly, the elements will be outlined, to develop an integrative approach for an architectural innovation design.

8.1 Voids in Models

Innovation management and architectural consulting consider complexity, social interactions and process design with different models, methods and tools. The examples of innovation process models are decision oriented to manage innovation processes in time; the architecture related approaches are design orientated to frame the spatial environment for innovation processes. Deficiencies and limitations in the approaches are considered as voids. These are open areas which both disciplines have not simply failed to address or neglected. Furthermore, the continuously changing context of innovation requires a refocus and consideration of new perspectives. It is less a failure or neglect but matter of time for addressing open areas. Both disciplines are therefore drawn to these new perspectives. The ostensibly distant and different fields of innovation management and architectural consulting show particular similarities in their environments, functions and activities.

Innovation management and architectural consulting are embedded in dynamic, complex, open and networked environments. They deal with complexity, uncertainty, ambiguity and risk. Architecture and innovation management are confronted with the new. As applied sciences, they are dedicated to successful realization, application, and implementation. Innovation management and architectural consulting are interdisciplinary and have an integrative and synthesizing function. They work with people, work processes and organizational culture. Both focus on singular, unique and not repeatable projects. They seek to balance development phases (planning) with experimental phases (designing). Their activities are searching and discovering. They are forward moving and mediating. They apply a holistic and systemic thinking to organizations. They create, build and develop organizational cultures and future capabilities for a company or client. Differences, limitations and voids reside in the particular thinking, working process and tools applied to cope with complex environments.

8.1.1 System Models

In Chapter 3 sequence and system models in innovation management were reviewed. Advanced non-linear sequence models consider increased demands for interactive and integrative elements in the innovation process. They consider higher flexibility for impulses, contextual factors, qualitative assessment criteria and adaptive structures. In these structures cross-functional teams are granted autonomy to proceed with their innovation projects. Non-linear thinking is foregrounded, for example in the design thinking process model with constant iterations and feedback loops. But the design thinking process in innovation management follows a linear or circular path. Similarly to stage-gate models it defines and describes sequential phases to be conducted, with principles and tools transferred from design thinking and design work. Design thinking is introduced as creative collaboration in non-design related fields by transforming design-specific expertise of intuitive thought, abduction, aesthetics and critique into easy-to-use, “digestible” (Verganti, 2017a, p. 101) guides. It formulates manageable phases for an innovation process in order to accelerate the processes of innovation. Sequence models are not well suited to capturing the structure of the innovation process for a whole organization. Complexities of environment, problem and process remain unconsidered. Social interactions, and the informal organization, are not displayed. The route an innovation project follows is predefined in the sequences.

Systems models develop a holistic understanding of the process as a structure of interrelated, interconnected and interacting elements. The innovation process is a contextual, dynamic and fluid networked system. And it is a practice of design thinking across an entire organization. Though sequential steps that need to be conducted, are embedded in the system, the system models provide an open framework for processes. Innovation processes begin, unfold and evolve at different levels of an organization, throughout different departments and functional entities. System models describe enabling environments for innovation. They are compared to journeys, constructive discourses or social networks, in which structural holes are bridged or new connections between former unrelated fields are made. Design and design thinking in systemic views is used to create a dialectic environment of awareness, communication and interaction, and thereby to build a design thinking culture. In this culture, people, teams, departments are engaged in a process of constant search and discovery. They have the capabilities and freedom to connect and to align with others to follow a "slow hunch" (Johnson, 2010, p. 78), synthesize an idea and develop the idea further. The permanent renewal within a firm, enabled and nurtured by an appropriate innovation system, is presented in one of the model examples as "creative construction" (Pisano, 2019, p. 9).

The system models examined in Chapter 3.3 convey several evolutionary transitions regarding context, complexity, attitude, the idea of men, culture and work processes. Context turns from a given, unmodifiable environment to a transformable entity; complexity is embraced and sustained, rather than reduced and simplified. The attitude regarding innovation becomes positive and constructive, to empower and motivate people for innovative endeavors. Employees are considered as entrepreneurs and intrapreneurs, designers and makers, instead of executers of innovation decisions who are continuously controlled and assessed. In the system view, innovation processes become fluid and dynamic. They are cultural, subjective and specific to each company. System models address multi-level complexities, but value differently aspects of social interaction, process design and qualitative aspects like vision, culture and strategy. Regarding the functionality they offer for collaboration and modeling, they are limited.

In the example of a contextual model, social interactions and the construction of new processes with non-verbal boundary objects are not addressed. Innovation management develops an appropriate innovation process by selecting, combining or adjusting already existing sequential models. Dynamic system models value social interaction by emphasizing creativity, understanding, learning and collaboration as instrumental to "maneuver" (Van de Ven, 2017, p. 39) through unchartered areas. The entire process is seen as a journey or play with constant iterations and modifications of the course of action towards a desired outcome. Regarding appropriate visualization of a fluid process, the models only provide descriptive or prescriptive figures.

Network models excel in the visualization of interrelation, connection, communication and interaction of people. For example, strong and weak ties, structural holes and clusters of intense performance are made visible. This approach offers valuable insights into the structure of an informal organization with its relational as well as spatial proximities. But social network models exclude a design approach. They do not foresee to directly transform the innovation processes within the network, while the models visualize the network. Its reliance on quantifiable data and data analytics collides with a fuzzy design attitude, to construct new formations through reflection-in-action and intuitive guesses.

In this respect, design-based frameworks outline the complexity of problem formulation and the lengthy process of building up innovation capabilities in an organization. An innovation system results from a culture of design, design thinking and creative construction. But the conception of construction in the example of Pisano (2019) is more metaphorical than based on architectural design practice. The meaning of abduction and the constructive process of design to explore, iterate and constantly reformulate the innovation process is not recognized. Non-verbal access to conceptualizations of innovation processes is only provided via simple box-and-arrow diagrams. As a text-based methodology, this approach has the advantage of supporting an interpretive flexibility about the shape of an organizational structure. But its disadvantage is that it does not support an explorative and constructive design practice. Furthermore, aspects of vision, culture and strategy – though emphasized in all examples of system models – are not represented visually. In regard to the need to increase motivation and to decrease resistance among employees and within the organizational structures, system models should convey a positive narrative. The distinct cultural subjectivity of a company's culture and its specific innovation processes are not made explicit and tangible to the obeservers.

In conclusion, the system models examined are limited in their support for collaboration and modeling. They do not invite the people who are involved with the company's innovation strategy and those responsible for the management of the innovation process to perform the following activities: to interact with each other, to discuss the theoretical model, to transform it in ways appropriate to their particular organization and specific requirements, to engage in collaboration, to create a shared and new mental model and eventually to design the process system for the entire organization. With the exception of the examples resulting from a social network analysis, system models abstract from different kinds of interaction, neglect informal organizations and the possibility of reconfiguring relational and spatial proximities. From a spatial perspective, innovation managers and employees are limited in their capabilities to localize, experience and change their position in an organizational innovation system.

The examples of fluid models, design frameworks and the SNA include spatial proximities as a relevant dimension, but do not offer means to engage, collaborate and model the structure. In the case of social network models, visualizations are generated from data analysis and are not drawn or constructed figures. This, again, constrains a reflection-in-action process, as understood in the architectural design process. Non-verbal boundary objects, if used in system models, are limited in their use. They explain as "competing conceptualizations of the world" (Godin, 2017, p. 125) the theoretical approach and methodology to involved stakeholders. But they offer few opportunities to adjust, transform and develop the visualization (and the underlying model) further. Unlike to the discipline of architecture the system models in innovation research are "not an instrument to explore, manipulate, and experiment with a theory, to stimulate the world and get better theories" (Godin, 2017, p. 208). These system models are descriptive or prescriptive (Chantzaras, 2019b, p. 541; Cross, 2007, p. 29; Nilsson, 2013, p. 3). They are ideal abstractions of reality, which vary in their implementation in practice. They promote a general innovation process model based on empirical findings and theoretical conceptions, applicable to different organizations. A custom construction of processes with the purposes and characteristic needs of an organization is not foreseen.

8.1.2 Architectural Consulting Models

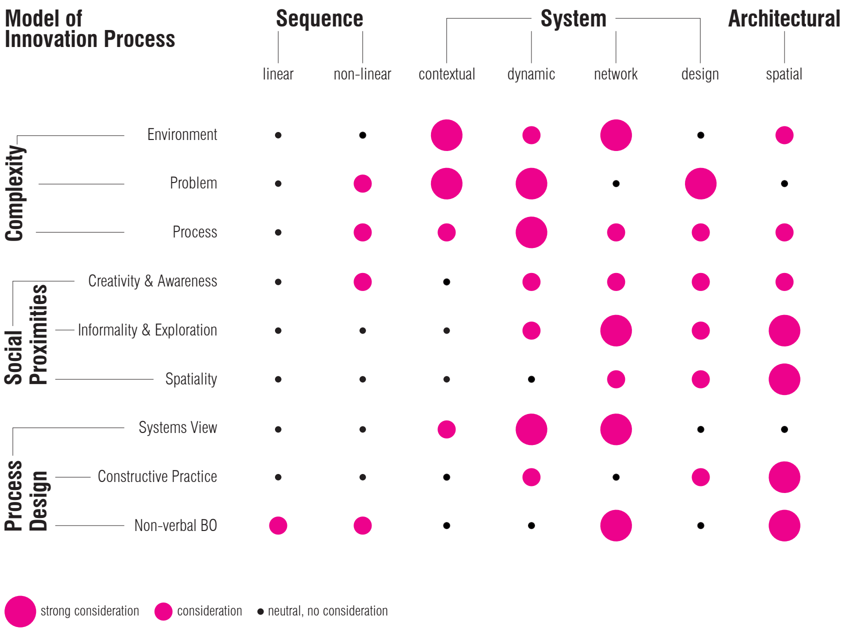
Architectural consulting models on innovation are different to models in innovation management. They do not represent an experienced or proposed conceptualization of the innovation process. They are constructed concepts and tangible artifacts at early stage of an architectural design process. In this specific case, architectural consulting analyzes and understands organizations through their inner workings, the way they innovate and intend to innovate in future. On the one hand, the model developed visualizes on a preferred state of how the different parts should interact and be related to each other; on the other hand it supports the build-up of innovative capabilities and a culture of innovation by being a spatio-visual framework. In contrast to system models, architectural consulting models for innovation provide a spatial configuration for people and facilities to interact, collaborate and innovate. Decoupled from the design and planning of a physical building the architectural consulting process and the resulting constructed model offer literal viewpoints of a firm's innovation processes. In collaborative exchange with the parties involved a future shape of the organization is created. Requirements and demands for spaces and proximities, for interactions and behaviors, for a synthesizing form and a unifying theme are foregrounded. The architectural consulting model of innovation is constructive. Through permanent reflections with non-verbal means and negotiations it tests configurations of what the current status is and what a preferred one might be. It addresses human acts of imagination and play, as well as the senses of spatial intelligence and feeling. If successful, the model synthesizes the concepts and theories of a particular organization and manifests them in tangible ways. With its design attitude, architectural consulting addresses the opposite aspects of managerial approaches: the space-behavioral and informal configuration of organizations. It creates spatio-visual frameworks of possibilities for innovation processes to occur, rather than prescribing how the steps towards innovation should be undertaken. Despite these advantages, several limitations become apparent.

In architectural consulting, innovation project management and decision making are only superficially integrated. The main arguments from an architectural point of view for improving innovation processes remain generic and focus on the increase of social interactions and the provision of spatial configurations to nurture innovative behaviors. Activities, knowledge and idea sharing, guidelines, steps to follow or tasks to complete, as well as assessments, time and budget constraints are not represented. Non-verbal communication and the qualitative substantiation of the innovation process are central in the architectural approach; they create understanding, influence perception and drive acceptance. Architectural language, thinking, tools and visualizations may be difficult to access and are not always easy to comprehend, especially if parties from other disciplinary backgrounds are involved. Externalized thoughts, ideas, analysis and concepts may be understood differently by laypersons, or be perceived as unnecessary for managerial consideration. The general challenges of communication between experts and laypeople in architecture, as analyzed by Rambow (2000), are in play here as well.

Architectural design and consulting processes have seldom been related to the management of innovation. If the architectural consulting service is not distinguished from building design and the discourse of form, its contribution and value for innovation management may not become visible to management executives. The prevailing mental model of architectural design related to built structures – among architects and managers alike – hampers the discussion on organizational processes. The architectural consulting model is not an evidence- or data-based model of improvements. It is – in analogy with the building design and building construction approach discussed in Chapter 6.4 – an untested hypothesis. Its application in practice is the final test that serves as proof of concept and usually demands further adjustments. Changes in behavior for innovative action depend on further factors beyond architecture's control.

Regarding their functionality, architectural consulting models foster collaboration and modeling. They integrate stakeholders but also keep them passive in the process of design, since particular tools, analog and digital, require specific knowledge for their use and the interpretation of the outcomes they create. The models created are dynamic, fluid and constructive. They are tools to think with and are used in a design process as a "reflective conversation with the situation" (Cross, 2007, pp. 37–38; Schön, 1983, pp. 76–79) to solve individually or in collaboration with others. They are constructive and prospective for the purpose of creating an alternative reality. They are primarily tools to design with, and secondarily tools for decision making. Tools in architecture are used as tools to reflect, represent, communicate, propose, provoke, construct, and test in action. They allow architects to externalize their thoughts, ideas, concepts, but are also subjective and shape the thinking and making of a solution to a design problem. The ambiguity in their usage, as well as their dependence on architectural skills, capabilities and experience, make it difficult to secure quality and success in different consulting projects. The uniqueness of an architectural innovation management, to construct a distinct model of innovation processes, bears an uncertainty and risk, that a design synthesis may not emerge in the end.

Comparing the different models of innovation processes against the background of an extended process view, system models show advantages in capturing multi-level complexities, while architectural consulting models provide benefits in integrating social interactions and design innovation processes constructively. Architectural consulting models can further convey a narrative or theme, which shows how an organization innovates, but are limited in their ability to display the project management aspects of innovation management and offer concrete advice for work processes



Model of Innovation Process		Sequence		System				Architectural
		linear	non-linear	contextual	dynamic	network	design	spatial
Complexity	Environment	•	•	⬤	●	⬤	•	●
	Problem	•	●	⬤	⬤	•	⬤	•
	Process	•	●	●	⬤	●	●	●
Social Proximities	Creativity & Awareness	•	●	•	●	●	●	●
	Informality & Exploration	•	•	•	●	⬤	●	⬤
	Spatiality	•	•	•	•	●	●	⬤
Process Design	Systems View	•	•	●	⬤	⬤	•	•
	Constructive Practice	•	•	•	●	•	●	⬤
	Non-verbal BO	●	●	•	•	⬤	•	⬤

⬤ strong consideration ● consideration • neutral, no consideration

Table 11: Comparative Overview Process Models by Extended Process View

The reviewed models from innovation research, innovation management and from the discipline of architecture address differently the aspects complexity, social proximities and process design in an extended view of innovation processes.

8.2 Voids in Design Thinking Methodology

Design thinking has been examined from different points of view. In Chapter 2.4.2 the activity of design is defined as reflective and constructive practice. This definition provides a basis for an architectural approach to innovation process design. The disciplines of sociology, psychology, architecture, engineering, industrial design and management have contributed to the theory and practice of design thinking (Rowe, 1987; Buchanan, 1992, 2015; Dorst, 2011, pp. 521–522; Johansson-Sköldberg et al., 2013, pp. 121–123). The various perspectives comprise thinking and doing (Buchanan, 2015, p. 12). In the thought space, design thinking is a specific mode of reasoning; in practical terms, it is a structured method which uses the tools of designers for a creative reflection-in-action process (Schön, 1983, pp. 54–55; Dorst, 2011, 2015).[98] Both spaces are intertwined, but are expressed and emphasized differently in design research,

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[98] Brenner et al. (2016, p. 3) classify design thinking "as: mindset, process, and toolbox." Design thinking as tool-box is not elaborated here; tools and techniques of design thinking are subsumed in design thinking as method.

management and architecture (Dorst, 2015, p. viii; Lawson & Dorst, 2009, p. 17).

In design research, design is broadly defined as "the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual and collective purposes" (Buchanan, 2001, p. 9). Products are signs, objects, actions and thoughts. The design of systems – in a categorization of four orders of design thinking by Buchanan (1992, pp. 9–10; 2015, pp. 11–12) – represents the fourth and highest order of design. It turns surroundings into environments and integrates the previous orders of design of signs, thing, and actions together (Buchanan, 2001, pp. 11–12; 2017). This fourth order of design or system design "addresses the fundamental question of how a collection of in-dependent parts becomes an inter-dependent whole […]" (Buchanan, 2015, p. 12) and is therefore relevant to the field of management and organization. It does not primarily focus on business and markets, but seeks to improve existing situations to better states (Buchanan, 1992; Huppatz, 2015; Nelson & Stolterman, 2012). Design thinking can be an individual act of imagination, a collective culture, an action-oriented or dialectic endeavour, which does not reside in a specific discipline, but is a common and integrative discipline (Buchanan, 1992; Lawson & Dorst, 2009). Design and design thinking are distinct to the sciences and to the arts and humanities. They should be separated and regarded as a third tradition or culture for thinking and creating situations, which ought to be (Cross, 1982; Nelson & Stolterman, 2012).

In management disciplines design thinking is considered and implemented differently. In Chapter 3.2.3 design thinking is considered as a sequential model for innovation processes following particular phases. In Chapter 3.3.4 design-based frameworks delineate design as a way of working based on design thinking principles. The latter two expressions have contributed to a design perspective in innovation processes and their management (e.g., Brown, 2009; Buchanan, 2015; Martin, 2009a). It is used as a methodology and applied method to address ill-defined or wicked managerial, strategic and organizational challenges by thinking and acting like a designer (Carlgren, 2013; Johansson-Sköldberg et al., 2013). It incorporates principles of reasoning and creative working in phase-structured, iterative ways (Dorst, 2011; Liedtka, & Ogilvie, 2011; Lindgaard, & Wesselius, 2017, p. 84; Verganti, 2017a). Understanding of the user's needs, ideation, conceptualization, prototyping and implementation is performed in phases of convergent and divergent thinking (Brenner et al., 2016; Lewrick, Link, & Leifer, 2017). Design thinking is described as "a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown, 2008, p. 86; and Brown, & Martin, 2015; Martin, 2009a, p. 62). In this context, design thinking is geared to economic success and growth. It does not necessarily involve a trained and educated designer. Thinking, methodology, methods, principles and tools are taught in ways comprehensible to non-designers, i.e., people without a foundation in design-led disciplines (Carlgren, 2013; Auernhammer & Roth, 2021, pp. 2, 13; Johansson-Sköldberg et al., 2013, pp. 121–123; Buchanan, 2015; Verganti, 2017a).

Though management scholars and practitioners refer to architects as examples for design thinkers, differences becomes apparent in the meaning and use of the terms design and design thinking.[99] By de-emphasizing specific

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[99] Buchanan (1992; 2015) references the ideas of the architects Walter Gropius, George Nelson, Christopher Alexander, Richard Rogers. Brown (2009) references the architects and designers Charles and Ray Eames, Frank Lloyd Wright, Richard Buckminster Fuller, Eilel Saarinen, Ludwig Mies van der Rohe. Liedtka (2013) refers to the works of the architects Jørn Utzon, Antoni Gaudí, Frank Gehry and built architectural ensembles to emphasize the different approach of designers to complex and apparently unsolvable problems.

design abilities, design expertise and design skills – rooted in a craft, engineering and design oriented discipline – design thinking is applied a support activity in management to improve innovation processes and business operations (Beucker, 2016, pp. 35–36; Dorst, 2011, pp. 525–526; Leatherbarrow, 2001, p. 84; Schön, 1983, p. 77). The use of defined phases and the application of selected tools as sticky notes, empathy maps or canvasses is limited in conveying and transferring the constructive value of design thinking to innovation research and innovation management (Dorst, 2011, p. 531; Verganti, 2017a). From a cognitivist perspective in which "[e]veryone designs who devises courses of action aimed at changing existing situations into preferred ones", has framed the specific characteristics of educated and experienced designers as a problem-solving process. As a consequence, it is argued, that the design process can be objectively mapped, modelled and optimized, while intuition, creativity and aesthetics are ignored in their relevance (Gänshirt, 2012, pp. 28–30, 48–49; Hatchuel, 2001; Huppatz, 2015; Johansson-Sköldberg et al., 2013). Defining, scientizing and formalizing the creative process, as it has been pursued by the design methods movement in the 1960s, is questionable (Cross, 2001, pp. 49–50).[100] Rowe's conclusion (1987) from his research on particular approaches of architects underlines the design thinking understanding in this thesis:

> *"And it is here that we discover that there is no such thing as the [highlighted in cursive in the original text; author] design process in the restricted sense of an ideal step-by-step technique. Rather, there are many different styles of decision making, each with individual quirks as well as manifestations of common characteristics."*
>
> *(Rowe, 1987, p. 2).*

A managerial understanding of the design thinking process in terms of phases and principles prevents a design attitude from taking part in the management and design of innovation processes. Innovation management can benefit from a design thinking approach rooted in a form-giving and synthesizing discipline like architecture, provided it is not treated as a supporting, ancillary activity, but as central to the construction of innovation processes.

8.3 Voids in Applications

The examples of applications in Chapter 4 and 7 demonstrate how theoretical frameworks are transferred to operations in practice. The applications, methods and tools in management practice correspond to a sequential model of innovation processes with project management directives, time orientation

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[100] Cross (2001, p. 50) summarizes: "The 1960s was heralded as the "design science decade" by the radical technologist Buckminster Fuller, who called for a "design science revolution" based on science, technology, and rationalism to overcome the human and environmental problems that he believed could not be solved by politics and economics. From this perspective, the decade culminated with Herbert Simon's outline of "the sciences of the artificial," and his specific plea for the development of "a science of design" in the universities: "a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process."

However, in the 1970s, there emerged a backlash against design methodology and a rejection of its underlying values,notably by some of the early pioneers of the movement. Christopher Alexander, who had originated a rational method for architecture and planning, now said: "I've disassociated myself from the field... There is so little in what is called "design methods" that has anything useful to say about how to design buildings that I never even read the literature anymore... I would say forget it, forget the whole thing." Another leading pioneer, J. Christopher Jones, said: "In the 1970s, I reacted against design methods. I dislike the machine language, the behaviorism, the continual attempt to fix the whole of life into a logical framework." "

and metric performance indications. Software applications for enterprise architecture and innovation management follow a linear methodology of idea generation, development and implementation. Social interactions are mainly nurtured to generate ideas through digital platforms, competitions and collaboration formats. The ideas are developed further in a digitally supported process. The innovation process itself is not the subject of design. The digitization of workflow processes favors efficiency, optimization and control with the aid of information technology and social media features. As a downside, this can also lead to an "over digitalization" (Huesig & Endres, 2019, p. 311) of the elements and phases of an innovation process, that develop its relevance in direct, face-to-face environments. Drivers for innovation and innovation processes, which – to the present are difficult to digitize – are neglected or excluded: the exchange of tacit knowledge; serendipity in the workflows by unforeseen incidents; exploration and chance encounters; group dynamics and emergence; critical confrontation; non-verbal aspects of motivation, purpose, meaning and vision. Engagement and collective experience as well as exploration and the collision with contrarian views are relevant in the design of an innovation process. In the examples examined, enterprise architecture and innovation software tools are based on a linear theoretical model and methodology. It is therefore questionable whether differentiation can be achieved by organizations using applications of this kind and whether they can attain a competitive advantage. Regarding the unique structure of innovation processes in each company, the introduction of standard digital applications, as well as streamlined design thinking methods could foster alignment in outcomes, if applied across an industry, instead of being differentiated. Organizational isomorphism may result from the use of similar innovation management technologies, methods and techniques. Streamlining innovation processes, as promoted by vendors of digital platforms, may limit a contextual, fluid and constructive approach to innovation. Business model design and innovation process consulting follow a systemic approach. They integrate the contextual and dynamic aspects of system models, emphasize social interactions and the build-up of design capabilities of employees.

Space-behavioral applications, such as the examples analyzed in Chapter 7, focus on the environmental conditions which shape creative and innovative interactions of people. With the exception of sociometric tools based on the theory and empirical findings of social physics, the applications have not gained acceptance in the practice of innovation management. Similar to the architectural consulting models, spatially driven applications such as Space Syntax, the tools from the LAI or parametric social functionality method, do not provide a supporting innovation process theory. Though the applications introduce a spatial dimension, they neglect the aspects, system and sequence model outline as required in an innovation process, e.g., time, budget, feasibility and project development. The spatial applications provide building design and physical spaces as frames for innovation. Applications that integrate architectural thinking and architectural tools with innovation management at a systemic and abstract level are not yet available. In consequence, the space-behavioral applications are transferred and implemented in practice through individual cases, and not as a consulting service for a broader market. Sociometric tools, based on "science-backed analytics and data-driven insights" (Humanyze, 2021a), offer features to improve the engagement, productivity and adaptability of people and teams in an organizations.

The reliance on metrics and big data de-emphasizes intuition, abduction and creative insight in its analysis and design process. Recalling that innovation management and business model design were described as an art and a craft in Chapters 3 and 4, intuition and imagination may be relevant. "Analysis does not produce synthesis" (Langley, 1999, p. 709) and requires an intuitive, imaginative and creative approach (Langley, 1999, p. 708; Staun, 2015).[101]

The applications support the functions of collaboration and modeling in different ways. While managerial applications are well suited for integration and interaction, they offer little support for the explorative and constructive side of designing innovation processes. Enterprise architecture tools excel with features to capture and assess a company and its processes, but are less suitable when used to explore and create visual constructions. The space-behavior related applications offer few possibilities for interaction and integration. Clients and users are treated as passive participants providing information or conveying knowledge. Though explorative and constructive elements are well defined in two architectural applications, they are generally accessible only to people familiar with the software and its offered features (see Table 12).

Application	**Company**		**IM Software**		**Consult**	**Space-related**			**Behavior-related**	
	EA	BMD	module structured	holistic	process focused	Space Syntax Method	Tools of LAI	Parametric Social Functionality	InnoTracing Tool	Sociometric Tools
Interactive & Integrative Collaboration	⬤	●	●	⬤	⬤	●	•	•	•	•
Explorative & Constructive Modeling	•	●	●	●	●	•	⬤	⬤	•	•

⬤ strong consideration ● consideration • neutral

Table 12: Comparison of Reviewed Application by Functions

Applications from the field of innovation management, spatial architecture and behavioral sciences support differently the function of collaboration and modeling, that are required for a new model of innovation process.

Consequently, as the applications differ in the ways they support collaboration and modeling, the features they offer differ from the features needed for an innovation process design. In order to collaborate and model innovation processes as a system, based on an integrative architectural design process, the applications should feature dynamics, multi-dimensionality, systemic views and visual work. Applications from a managerial field support multi-dimensionality, but make little use of visualizations as a medium for design. On the other hand, space-related application excel in visual representations and artifacts, but consider fewer dimensions of innovation processes.

The design process as experienced in architectural work requires vagueness and fuzziness in order to reflect-in-action and remain open or liquid to changes. Transforming a managerial decision making attitude into an architectural design attitude means moving the focus from precision and control to vagueness and flow. The applications reviewed have not fully incorporated an alternative design approach, as described and proposed in this thesis (see Table 13).

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[101] Langley (1999, p. 708) argues that theory building and process design "involves three processes: (1) induction (data-driven generalization), (2) deduction (theory-driven hypothesis testing), and (3) inspiration (driven by creativity and insight). "Inspiration" may be stimulated by empirical research, by reading, by thought experiments, and by mental exercises (Weick, 1979, 1989), but its roots are often untraceable. It draws indiscriminately on formal data, experience, a priori theory, and common sense." Against this background, the science of social physics may reach limits in synthesizing new systems when being based on data.

Application	Company		IM Software		Consult	Space-related			Behavior-related	
	EA	BMD	module structured	holistic	process focused	Space Syntax Method	Tools of LAI	Parametric Social Functionality	InnoTracing Tool	Sociometric Tools
Dynamic	●	•	•	•	●	•	•	●	•	•
Multi-dimensional	●	⬤	●	●	●	•	●	•	•	•
Non-linear/ Systemic	⬤	●	•	●	•	•	•	●	•	⬤
Visual	•	●	•	•	•	⬤	⬤	⬤	●	●

⬤ strong consideration ● consideration • neutral

Table 13: Comparison of Reviewed Application by Features

Applications from the fields of innovation management, spatial architecture and behavioral sciences offer to different extent features to model and design innovation processes holistically.

To introduce a "third culture of design" (Cross, 1982, p. 226) in innovation management requires an integrative approach between precision in verbal expressions and precision in visual means. In the case of architecture the culture of design is based "not so much on verbal, numerical and literary modes of thinking and communicating, but on nonverbal modes" (ibid.). In this respect, an important differentiation between the discipline of management and the discipline of architecture becomes apparent. While in management precision is required in verbal and numerically expressed areas, in architecture nonverbal, visual means such as drawings and models are made and communicated with precision (see Figure 42).

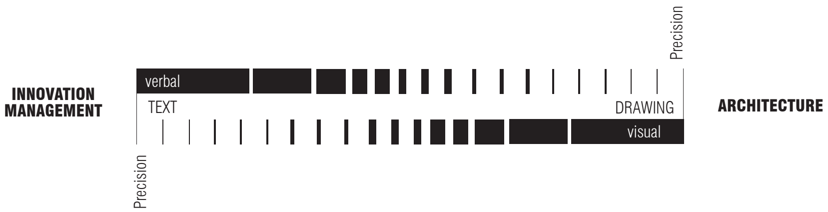

Figure 42: Precision in Means of Communication

Primary means of communication differ in the disciplines of innovation management and architecture. Innovation management uses verbal means of communication with precise terminology. In architecture visual means are foregrounded.

The different relevance of means of communications in decision making can be a source of mutual misunderstanding when management and architectural disciplines collaborate. An integrative approach, an architectural innovation design, needs therefore to be a bridge for communication. Managerial and architectural approaches to constructing an innovation process require a shared understanding. An integrative approach combines the advantages from management process models in capturing multi-level complexities with architectural consulting models that emphasizes social interactions and a design attitude. Applications to support this approach need to enable the collaboration and the construction of innovation processes as a multi-dimensional, dynamic, adaptive and visual system. Transferring design thinking principles in a sequential process to innovation management ignores the instrumental elements of a design culture. On the other hand, design driven spatial-behavioral approaches reduce the innovation process to a matter of social interactions in physical spaces. They fail to suppport broader applicability and acceptance in managerial practice. Innovation processes should be designed collaboratively with the use of non-verbal boundary objects and based on a new mental model of what innovation processes are and how they can take visual shape.

8.4 Requirements for an Integrative Approach

In management practice, innovation process models are adjusted to the characteristics of a firm and the requirements of its environment. The models themselves are abstract representations of reality and generic guides to the tasks to be performed. They convey and shape the thinking about innovation in an organization and they shape the way an organization fosters it. The selected examples of conceptualizations and models (in Chapters 3, 5, 6) as well as the selected examples of applications (in Chapters 4, 7) show that conceptualizations, models and applications are interrelated and contingent. Conceptualizations influence the mental and explicit construction of models. Models suggest, encourage and define appropriate actions and practical tools. Tools or applications, enable and guide particular activities, which in turn reinforce the underlying assumptions of theoretically or empirically based models. An alternative approach to innovation management from the field of architecture needs to provide a different way of thinking, a methodology and an corresponding application.

Firstly, it needs to address thinking and conceptualizations about innovation processes. As an emergent, dynamic, fluid and adaptive learning process, an innovation process requires the consideration of multi-level complexities and social interactions in an organization. Innovation processes are multi-dimensional systems of relational and spatial proximities between human actors and human actors, and between human actors and non-human entities: technologies, objects and physical spaces. Humans creatively interact, explore, confront each other and implement change through the creation of a different new whole. Models in innovation management are limited in their access to this multi-dimensional view of innovation processes. Since the turn of the millennium approaches have been developed to integrate design-led disciplines and to address the complexity and wickedness of innovation process. Architectural thinking and architectural design offer an additional perspective. Benefits from the discipline and practice of architecture need to be made explicit. They need to be explained in comprehensible ways to non-architects and architects alike, to access this architectural perspective. Non-architects such as management executives, employers and other stakeholders in an organization may be laypersons and unfamiliar with designerly ways of working that make use of, e.g., visual thinking and the construction of non-verbal boundary objects. An architectural perspective on innovation processes needs to be accessible, so that people are able to understand, interpret and construct the perspective themselves. On the other hand – which may sound contradictory – architects as well need to access the value of their thinking and tools for innovation management. Architectural thinking and tools provide means to understand, interpret and construct innovation processes that are not necessarily related to physical space.

Secondly, the integrated approach has to provide a methodology of how and what to analyze, understand and develop an architectural design attitude. The methodology explains the principal activities for analysis and synthesis, but refrains from prescribing a specific method. In the same way as with an architectural consulting and architectural design process, the activities are aligned to each other but combined upon need and combined depending on abilities and preferences of the architectural practice. Design as inquiry and design as form-giving synthesis require design skills and design expertise. As "[i]nnovation management is not an exact or predictable science, but a craft, a reflective practice" (Tidd & Bessant, 2013, p. 642) the methodology of an integrated approach is accordingly based on craftsmanship and reflective practitioners, trained and experienced in spatial intelligence, architectural immersion and the creation as well as use of non-verbal boundary objects.

With the methodology and expertise, the architect reframes the complexity of an organization in qualitative and visual ways; she or he considers interactions in relational and spatial proximities, and assesses their type from personal encounters face-to-face to asynchronous digital communications; she or he opens a design discourse with the subject of design (i.e. the innovation processes) and the parties involved. The methodology shows whom and what to represent and integrate; how to represent, integrate, collaborate and design. For architectural practices the methodology is a framework for how to transfer their thinking and tools to managerial challenges. It supports the architectural approach to the design of innovation processes and removes disciplinary barriers. For innovation management the methodology is an externalized design process for better understanding, engagement and active participation. In this methodology design principles are applied to visually represent, formulate, reflect, interpret, manage, to move back and forth between problem and solution spaces, as well as moving forward with conviction, to synthesize and create a meaning and theme (Lawson & Dorst, 2009, pp. 50–60; Rehn, 2020). In these principles collaborative and modeling aspects of design are subsumed. In particular, the reflection-in-action, the iterations, the creation of tangible models and prototypes offer possibilities for the involvement of non-architects and co-creation.

Thirdly, an application is necessary for the concrete collaboration, modeling and architectural design of new innovation processes in practice. The language and working processes of people from different disciplinary and professional backgrounds need to be bridged. The term 'model' is used at two levels and with two meanings. At a theoretical level, the integrated approach is a model of an architectural innovation process design. It consists of a conceptualization, a methodology and a tool. At an operational level, within the methodology and tool-set, models are non-verbal boundary objects and persuasive artifacts. The new conceptualization can be transferred to visible objects; the methodology and principles can be implemented using these tangible models. They help firms to see their organizations and processes from an architectural perspective and to immerse themselves in the practice of design. The models at the level of applications are visual expressions of thought, intent and concept. They are constructive. They emerge and take form when the company begins to build them together with the architectural practice. The models are company and context specific. The dimensions of process, social interactions and space become simultaneously visible.

The application functions as an integrative and constructive device. It needs to be easy-to-use and comprehensible for the stakeholders to participate. On the other hand, it needs to be fuzzy and open to model and design with. Its constructive function makes it possible to explore, and discover, non-verbal models and test configurations for future innovation processes. In this regard, the application requires certain features. Dynamics show the responses and adaptions to changes in parameters and to changes induced by design. Multi-dimensionality refers to the display of relational and spatial proximities, of connections between elements, their type and intensity, and the interaction processes occurring. A systemic feature ensures the level of abstraction, enabling users to see interrelations with their non-linear behaviors and details in the context of the whole organization. The application needs to be visual to simultaneously consider different elements, and to directly reflect, collaborate, model and design on a non-verbal boundary object. Through this application knowledge on the organization and its processes as well as preferred futures can be retrieved and made visible, in ways which have not been covered by the works examined in Chapter 4 and 7. Against the background of increasing digitization, the increase in data and information availability, the digital application requires interfaces to import enterprise data, data on communication, movements and behaviors, as well as information on innovation processes from a project management view. However, to foster a design attitude in methodology and tool, fuzziness and vagueness, ambiguity and uncertainty need to be kept vivid. The creation of an "unexpected outcome" (Nelson & Stolterman, 2012, p. 132) resides in the liquid state of a design discourse with interpretation, criticism and judgement (ibid, p. 139; Boland & Collopy, 2004a, pp. 17–18). To result in an synthesized new whole, a design, "judgement making is essential" (Nelson & Stolterman, 2012, p. 139):

> *"Design judgements are essentially nonmetric decisions or understandings. That is, they do not rely on science of measurement to determine an objective or subjective outcome in their deliberation. Design judgement making is the ability to gain subconscious insights that have been abstracted from experiences and reflections, informed by situations that are complex, indeterminate, indefinable, and paradoxical. This results in the emergence of meaning and value, through the creation of relationships and connections, out of apparent chaos."*
>
> *(Nelson & Stolterman, 2012, p. 145)*

Finally, the theoretical basis from innovation research and management needs to be combined with the design thinking and design creation from architecture and architectural consulting practice. The limitations of architectural consulting for innovation, described in Chapter 6 and in the space-behavior related applications in Chapter 7 are addressed by an integrative approach that will be introduced and termed 'Architectural Innovation Design.'

9

9 – Architectural Innovation Design (AID)

Architectural Innovation Design (AID) is an architectural approach for the understanding and design of innovation processes. It considers innovation processes in a firm as a multi-dimensional, socio-technical system of humans with humans, and humans with non-human entities – technologies, artifacts and spaces. With a socio-technical system humans and technologies, artifacts and spaces are regarded as mutually dependent actors in an innovation process (Bauer & Herder, 2009, p. 601; Behymer & Flach, 2016, pp. 113–114).[102] The approach closes the voids in existing architectural consulting models. Architectural innovation design

- introduces an extended conceptualization of innovation processes as a theoretical base.
- enables a collaborative, architectural design with stakeholders from different disciplinary backgrounds.
- frames design phases for innovation processes and facilitates them with the aid of architectural design tools.

A prerequisite to the approach is an alternative view of architectural work that values the particular kind of design thinking architects perform, that outlines the generation of knowledge on organizations through a design process and acknowledges the architects' capability to design systems. So far, these aspects are covered in architecture through the emphasis on physical outcomes, that is made from the perspective of management and architects alike. To introduce architectural innovation design, firstly architectural work is reframed. Secondly, the approach provides a methodology for visual and spatial understanding of innovation processes with particular aspects from architectural thinking and design for its collaborative construction. Thirdly, the approach is supported by a tool to implement the methodology in practice. The prototypical tool facilitates the creation of visual and spatial boundary objects. The boundary objects are instrumental for collaborating and modeling in an architectural innovation design process. The tool itself serves as an example of how to apply, test, refine, repeat and scale the approach in practice. It also serves as example of how to embed a spatial innovation system in an organization.

9.1 Reframing Architectural Work

To introduce architectural innovation design it is necessary to reframe architectural work. The design thinking discourse in management has facilitated the application of methodologies and tools of creative disciplines to innovation management. Though different analogies and metaphors have been used to describe the process of innovation, e.g., as journey, play or network, it has been

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[102] The concept of socio-technical systems by Behymer & Flach (2016, pp. 113–114) refers to humans and technology only: "In sum, the challenge is to move beyond an either/or attitude with respect to humans and technology—the classic "Humans are Better at/Machines are Better at" lists—that tends to focus on optimization of separate human and autonomous components as the top priority, and leaves the design of interfaces and team processes as an afterthought. The alternative is to take a holistic perspective, and to begin thinking in terms of both/and, where the goal of design is a seamless integration of human and technological capabilities into a well-functioning sociotechnical system. Success in complex domains will ultimately depend on the ability of humans AND technologies working together as well coordinated teammates—each contributing unique abilities to create a team with the potential to be greater than the sum of its parts, and thus jointly bridge the gulfs of execution and evaluation in order to address the requisite variety of complex domains, or wicked problems."

sparsely seen and modelled as space with an architectural point of view.

With architectural innovation design, the discipline of architecture offers its knowledge, expertise and skills in a similar way to innovation management, as a discipline, for example, like industrial design or mechanical engineering does. On the one hand, architectural work is in this view related explicitly to managerial challenges and can be explained in terms of its capabilities for process and system design (Bouman, 2007, p. 92; Cross, 2013, p. 6; Koolhaas & Obrist, 2004a; Lawson, 2005, p. 285). On the other hand, the conception of architecture is extended to challenge "a profession that foregrounds and celebrates practitioners who build unexpected things" (Samuel, 2018, p. 161). As a second reframing argument, a by-product of architectural work for industrial clients is brought to the fore. The design and planning processes generate knowledge about the culture and deep structures of an organization. Thirdly, the capabilities architectural practices use for a physical building design are systems thinking capabilities. Architects, ideally, read existing patterns and synthesize a new whole. Building design is system design. The architect is a "designer of systems" (Luebkeman, 2015b, p. 37) and positioned as such in an architectural innovation design.

9.1.1 Architectural Design Thinking

The production of designs and plans for the built environment are central to the architectural discipline and profession (Leatherbarrow, 2001, pp. 87–89).[103] The dominant mental model, in which architects produce drawings and plans for building structures, needs to be altered with a "(novel) standpoint" (Dorst, 2011, p. 525) in a new set of reference or in new frame (Held, 2016, p. 61). The relevance and value of architectural work can go beyond the built environment, as shown in the examples of architectural consulting in Chapter 6 and examples of "The Other Architect" (Borasi, 2015b, p. 362; Cross, 2001; 2007). Its particular form of design thinking can contribute to managerial challenges, because it does not propose an "ideal step-by-step technique" (Rowe, 1987, p. 2).

Architectural design thinking is applicable to managerial challenges and can augment the design thinking methodologies of other creative and engineering disciplines with its distinct characteristics. The characteristics differ individually among architects and architectural practices, but share commonalities, that are rooted in design expertise, design skills and design tools. Designers, including architects, "produce novel, unexpected solutions" (Cross, 1990, p. 132) in an imaginative and constructive way while tolerating "uncertainty, working with incomplete information" (ibid.) by using specific tools for problem solving. A design ability is fundamental to the design work. It applies a third mode of thinking besides induction and deduction: the abductive, productive respectively constructive thinking (Cross, 1982, pp. 225–226; 1990, pp. 134–135; Dorst, 2011, p. 524; 2015, pp. 45–50). As "a process of creative exploration" (Dorst, 2015, p. 49) design abduction in design thinking is a constant commute between problem and solution, between analysis, synthesis and evaluation, where the solution as well as the problem are defined and re-defined at the same time (Cross, 2008, p. 25; Lawson, 2005, p. 49).

Design is a "Reflective Conversation with the Situation" (Schön, 1983, pp. 76–79), a negotiation inside a complex mental process of the designer, which advances by design expertise over time (Lawson, 2005, pp. 48–49; Lawson

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[103] Carpo (2013a) notes that the conception of an "architect, as a maker of drawings" (ibid., p. 128) was constituted with the separation of planning and constructing in the 15th century and remained the dominant view since.

& Dorst, 2009; Schön, 1983, p. 77). The design attitude in architecture is distinct, as shown in the previous chapter, and relevant for managerial challenges (Boland & Collopy, 2004a, pp. 3–18; Buchanan, 2008, pp. 2–3): it generates new alternatives, maintains and sustains uncertainties and ambiguity during the design process; this liquid state also reveals its openness and adaptability to changing requirements, new insights and perspectives. Architectural design thinking is driven by optimism and believes in achieving a betterment for the parties involved; it continuously represents a problem with varying non-verbal tools for a deeper understanding; the thinking space is extended by non-verbal boundary objects and persuasive artifacts as tangible models, sketches, diagrams and interactions with others; it adds context to the actions of creativity and invention (Beucker, 2016, p. 35; Daniell, 2013, p. 115; Dator, 2016, p. 549).

Architectural thinking offers a design thinking approach to innovation management with design expertise, built on design values and design skills. It applies a long-term view to the problem resolutions beyond current user, business or market needs; it adds a third dimension with its spatial intelligence to understand and immerse itself in the socio-technical structure of an organization; it uses existing architectural design tools as non-verbal boundary objects to understand and reframe complex problems; and architectural design thinking is capable of creating novel tools, if necessary, to analyze, synthesize and transform ideas into practices, as it is “committed to concrete reality” (Gänshirt, 2012, p. 15). The architectural synthesis develops a meaning and theme in the design resolution, which exceeds the mere functionality of its combined parts. With its ethical function architecture anticipates the behaviors and structures an organization intends to shape in the future (Fisher, 2016, p. 437; Illies & Nicholas, 2009, pp. 1218–1220). Architectural design thinking offers a design thinking attitude for innovation management.

9.1.2 Organization Knowledge

Architectural work ideally challenges the obvious problem formulation and the initial brief statement. It is a point of departure for an exploration into the problem space “to give the client (…) not what he wants, but what he never dreamed he wanted. And when he gets it, he recognizes it as something he wanted all the time.” (Architect Denys Lasdun quoted in Cross, 2007, p. 52). As a second reframing argument, the designing and planning work in the architect-client relationship is considered as the generation of knowledge of interaction, of culture and of organization. Architects understand on the one hand the status quo of an organization and on the other hand create a future, desired state (Cross, 2007, pp. 51–54; 2008, p. 25; Daniell, 2013, p. 116; Gänshirt, 2012, p. 22). In the architectural designing and planning process drawings, plans, description and models are developed for the construction of a building (Cross, 2008, pp. 3–6). Throughout the different phases, architects compile, receive and gain information, which are then transformed into communicable building designs (ibid.; Gänshirt, 2012, p. 20). The formal planning process in architecture is in general structured according to several phases with increasing levels of detail. In a pre-design, programming phase or phase zero, architects raise the information level prior to the start of a building design; qualitative and quantitative requirements are researched, collected, created and developed for a design brief (see Chapter 5.2.1). Quantitative aspects are related, for instance, to numerical data, facts, floor areas, sizes, distances, energy, cost and time. Qualitative aspects capture vision, culture, strategy, organizational structures, processes, and human needs. The brief or initially stated problem by the client does not remain stable, but is defined and re-defined continuously (Cross, 2013, p. 8; Lawson, 2005, p. 182).

In distinctive designs, the client-architects relationship plays a vital role for in the success of the project (Lawson, 2005, pp. 85, 168). They are based on trust and credence in a highly intangible and integrative service (Zeithaml, 1981, p. 186). The client is a creative partner, source of inspiration and knowledge, who fosters the architect's approach to new solutions (Brookes & Poole, 2005, p. 16; Lawson, 1997, p. 168). In reality, the architect does not deal with a single person as client but with a multitude of different stakeholders (Pongratz, 2004). The architect receives information from and in interaction with users, process planners, technicians, consultants, managerial departments, municipalities and the public (Styhre & Gluch, 2009, p. 224). The form and intensity of communication between architect and stakeholders varies according to the scope and complexity of the projects. It also varies according to the architects' expertise and unique design thinking approach (Hershberger, 1999, pp. 4–6; Rowe, 1987, p. 2). Aside from the project management aspect of co-ordinating and integrating the different stakeholders, the interactions with the stakeholders generate information and knowledge on processes and systems in the organization (Cross, 2008, pp. 3–6; Pallasmaa, 2016).

As shown in the architectural consulting projects in Chapter 6, over the course of a project assignment an architectural practice develops a deep understanding and knowledge of a company's interactions, its organization and inner workings (Henn, 1998, pp. 429–430; Nilsson, 2013, p. 3; Samuel, 2018, pp. 154–157). Knowledge is the transformation of information by comparing, relating and contextualizing, reflecting and deducting implications into insights and actions (Davenport & Prusak, 1998, pp. 3–7). While data describes a "set of discrete, objective facts" (ibid., p. 3), while information is organized data for a purpose and with a meaning, knowledge comprises experience, judgement, intuition, value and beliefs as well as "the ability to deal with complexity" (ibid., p. 9) of e.g., contradictory or missing information.

In a design process, the transformation and contextualization of information depends on the architect's ability to review the requirements and the problem situation from different perspectives. She or he develops, defines and re-defines the context during the process of design and planning (Fisher, 2016, p. 437). The architect works with the available explicit knowledge and information, but also observes and accesses the intangible, tacit knowledge of different stakeholders by using design tools like sketches, diagrams, drawings, and models, which function as boundary objects, to communicate, reflect and retrieve ideas and information in the multiple interactions. When requirements and goals are in conflict, the architect tries to represent and reframe the complex challenges for the organization and reflect them internally in his or her practice and together with the client. As stated earlier, the nature of a problem unfolds in discourse and inquiry. Besides its relevance for a building design, the information and knowledge retrieved by the architect reveals the informal structure of the organization and interactions between people, processes, spaces and things. Experienced architects immerse themselves in the client's position in order to design, plan and foresee a situation which ought to be, taking into consideration the larger context of time and space, without necessarily proposing a building as the solution (Pallasmaa, 2016, p. 41).

The empathic approach, familiar in other areas of design thinking, addresses a future state beyond the primarily communicated demands (Pallasmaa, 2016, pp. 41–42; Trüby, 2012, p. 511). As "knowledge architects" (Samuel, 2018, pp. 154–165), architects focus on processes and systems; they order information and create new contexts. In this role, the architect has received limited consideration in architectural research, in education and in practice. The organizational analysis conducted by the architect is descriptive and constructive at the same time. Its value for designing and re-designing innovation processes resides in the knowledge about who interacts with whom, with what, when, where and why, in the relational and the spatial dimension. This knowledge may also reveal defects in the organization and uncover the resistances of people to change, which are grounded in patterns of organizational behaviors and structures (Gharajedaghi, 2011, p. 31).

An organization is, according to Galbraith (1977, p. 3), a composition of people, who interact through time for the achievement of a "shared purpose" (ibid.); the people in this "social entity" (ibid.) divide the labor and are "integrated by information-based processes" (ibid.). How they interact, and will interact in future, is a question of synthesis, integrating the parts into a coherent new whole (Boland & Collopy, 2004b, p. 48; Buchanan, 2015, p. 13; Lawson, 2005, p. 37). In management discourse "the search for coherence or a fit" (Galbraith, 1977, p. 5) between strategy, the mode of organizing and the integration of individuals is seen as organization design. The resulting organizational structure of a firm is in turn intertwined with its innovativeness and innovation processes and reflecting them (Lam, 2005, 2010; Pisano, 2019; Trott, 2012, pp. 91–103). As architectural design process works in a similar way as organization design towards a synthesis of vision, culture and processes – based on its knowledge on the organization's deeper structures and interactions – it provides valuable support for innovation management and design.

9.1.3 System Design

The third reframing argument concerns the commonly perceived output of architectural work, the building design. Building design is a system design, in which different elements are synthesized into a coherent whole with the creation of a new meaning (Ackoff in Brant, 2010; Bachman, 2012, p. 42). A building design is a complex system, in which spaces, materials, people and flows are brought together, in a functional and purposeful way which is greater than the sum of its parts (Hillier, 2007, pp. 32–33; Meadows, 2009, p. 12). If this system is transformative, it turns surroundings into environments and creates dialectic relations between the existing and the new (Buchanan, 1992, pp. 10–11, 2017; Hillier, 2007, pp. 32–33). By offering possibilities of interactions, architecture evolves from the purpose of protecting (giving shelter) and nurturing (providing ease) to the purpose of transforming the behaviors of users in a building positively (Hershberger, 1999, pp. 41–53). Through an interdisciplinary and co-creative process, the architect creates the physical frames in which behavior unfolds (Pendleton-Jullian & Brown, 2018, pp. 59–61). What constitutes the final building design is a result of a system thinking and system design approach. In management theory, system thinking has been framed a "fifth discipline" (Senge, 2006, p. 69) to develop learning organizations. System thinking is "a discipline for seeing the "structures" that underlie complex situations" (ibid.) like transformations, shifts and challenges in markets, industries or regions.

System thinking in this conception is a critique of the reliance on mathematical models to describe and predict behaviors and performances, analytical tools and strategic plans. It is interdisciplinary, holistic, purpose-driven and radical (Gharajedaghi, 2011, xiii–xv; Senge, 2006, pp. 71–73). The design of a house is not the optimal planning of the single elements and rooms, but the design of a unity of all the rooms and requirements, which achieves more than the sum of its parts. An architect does not focus on the quality of the parts, but on the quality and performance of the system as a whole (Ackoff in Brant, 2010, min 07:03). For a building to be an open, a "dynamic and adaptable system intended to accommodate change" (Franck, 2016, p. 17) it needs to be designed as such. This capability of sytem thinking as well as the capability to design a system resides in architectural practice and work (Ackoff in Brant, 2010; Luebkeman, 2015b, p. 37). Designing a building means designing a complex system.[104] In the context of organizations and their innovation processes, the architect blends the information of clients and further stakeholders in a deep understanding of the elements, the interconnections and the purpose of a complex system (Checkland, 1981, pp. 3–4; Meadows, 2009, p. 12; Pendleton-Jullian & Brown, 2018, pp. 59–61). Designing a complex system means considering the system's properties of feedback loops, non-linearity, emergence and leverage points. With simple organizing rules a multitude of interactions and behaviors are possible, leading to the dynamic property of self-organization, which is important in the context of the social entity of the firm (Galbraith, 1977, pp. 3–5; Meadows, 2009, pp. 80–81, 159). Complex systems "can't be controlled, but they can be designed and redesigned" (Meadows, 2009, p. 169).

Architecture has served other disciplines as a metaphor for an organizational structure, which is intentionally built, combines stability and the capability for adaptation (Budds, 2016; Duschlbauer, 2007, p. 128; Shamiyeh, 2007b, p. 8).[105] Thinking in buildings, in a metaphorical sense, is thinking in systems. As Koolhaas & McGetrick (2004b, p. 20) put it:

> *"Liberated from the obligation to construct, it [architecture; author] can become a way of thinking about anything—a discipline that represents relationships, proportions, connections, effects, the diagram of everything."*
>
> *(Koolhaas & McGetrick, 2004b, p. 20).*[106]

Reframing architecture and the work of architects at the level of thought, process and output provides an alternative conception of architecture for management and architectural scholars. Architecture is framed as a structuring, ordering and organizing intelligence that goes beyond built space (Bouman, 2007, p. 96; Shamiyeh, 2007b; Solà-Morales, 2012, p. 12). By underlining

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[104] Bachman (2012, pp. 42–57) describes building as system outlining structural, infrastructural, energy, climate and material related aspects. Buildings as complex systems entail the metaphors of buildings as flow, phenomena, system, program and robot. Wilhelm ((2012, pp. 33–41) extends the system metaphor to building as achievement of an inter- and transdisciplinary network, with a dynamic lifecycle, an ethical impact to the inside and the society, a meaning giving, acting, adapting and interacting function. The concept of convergence in Deutsch (2017, pp. 8–19) also refers to the material, technological, structural, computational and multidisciplinary aspects in the workflow of designing, planning and constructing a physical building.

[105] Fjeldstad et al. (2012, p. 735) summarize: "The term 'architecture' is frequently used in the characterization of structures, such as buildings or cities, but increasingly the concept of architecture is being applied to other domains, including products (Sanchez and Mahoney, 2003), industries (Jacobides, 2005), and organizations (Ethiraj and Levinthal, 2004; Gulati and Singh, 1998; Lepak and Snell, 1999; Miller, 1993; Nadler and Tushman, 1998; Worren, Moore, and Cardona, 2002). Architecture is the synthesis of form in response to function (Alexander, 1964; Sullivan, 1896). Extended to complex systems and organizations, architecture can be defined as the 'fundamental organization of a system embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution' (Maier, Emery, and Hilliard, 2001: 108). Contained in this definition is the layman's understanding that structure should be consistent with purpose ('form must follow function'). Over time, the concept of architecture across a variety of domains has shifted from a focus on the design of specific structures to a focus on principles that foster coherence, growth, and change (Avermaete, 2005)."

[106] Rem Koolhaas (1944), Dutch architect and theorist, is reviewing and extending architecture as discipline and profession. With his architectural practice OMA (Office for Metropolitan Architecture) he has been creating and building in unconventional ways. In 2000 he was awarded The Pritzker Architecture Prize (The Hyatt Foundation, 2022b). As a subsidiary to OMA he established AMO as a "research studio and think-tank […] which 'applies architectural thinking in its pure form to questions of organization, identity, culture and program'." (Hyde, 2013, p. 57). For the publication 'Content: Triumph of Realization' (Koolhaas & McGetrick, 2004b) he acted as Editor-in-Chief.

the architectural kind of design thinking, by delineating the architectural knowledge generated in relation to organizations, and by stating the system design as the outcome of architectural work, innovation management can relate architecture to its challenges. Architectural practices can get closer to the field of management and the design of innovation processes. With the methodology of architectural innovation design these practices make the different approach explicit and relate themselves to innovation management. The capabilities needed for its conduct depend on design expertise, skills, tools that are present in the architectural practice. It requires an awareness and understanding on the part of the practice to reframe and communicate its architectural work as innovation process design.

9.2 The Methodology of AID

The methodology of architectural innovation design (AID) formulates an architectural design and consulting process for innovation management. It focuses on the analysis of context, the construction of the organization as a 3-dimensional model of interacting parts and the design of its innovation processes as a multi-dimensional, dynamic and emergent system. It provides an explorative and constructive process of design which uses the different capabilities of architectural practice for interdependent and collaborative design phases. The methodology transfers the unpredictable constructive nature of a design process to the management of innovation, considering that "the emergence of design ideas cannot be constrained to a particular place or sequence in a design methodology" (Designer David Radcliffe quoted in Cross, 2013, p. 126).[107]

Consequently the phases of an AID methodology are interdependent and contribute equally to the design of an innovation process for a firm. Architectural practices can incorporate their individual design approaches in this methodology. They can accentuate and structure phases that meets a challenge's requirements on the basis of their design judgement. They can create and apply case-specific methods and tools, to address the characteristics of the unique characteristics of a firm. Linear and system process models in innovation management (Chapter 3), as well as digital applications and developed methods (Chapter 4), are prescriptive. They offer generic approximations, which require adjustments in practice to the respective organization and context. If companies adopt these prescriptive approaches and methods, they follow a prescribed path. This may result in a structural similarity or an organizational isomorphism among different companies. The methodology of AID is constructive. It enables the development of an innovation system that is reflecting and embodying the envisioned, unique corporate structure, its culture and purpose for innovation, without prescribing a sequence of steps to follow and a particular form to take. The organizational demands of a particular organization and the design preferences, capabilities and expertise of the architectural practice shape the methodology and the design outcome. The methodology does not shape the organizational demands and process design.

With this methodology architectural practices are enabled to engage with organizations on the subject of innovation processes, and to apply their particular design expertise. The practices are guided to model and design the

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[107] "It is clear that design ideas emerge where they will in the continuum of the design conversation … Ideation cannot be constrained to occur only during the prescribed time for this activity as dictated by notions of due process and proper sequence of phases in design." (Designer David Radcliffe quoted in Cross, 2013, p. 126).

innovation processes of a firm spatially as a tangible transformable system of elements and interactions. The resulting model facilitates the implementation of an innovation process in a firm and serves as a reference for evaluation and adjustments. For the methodology distinct capabilities and design phases are instrumental as represented in Figure 43.

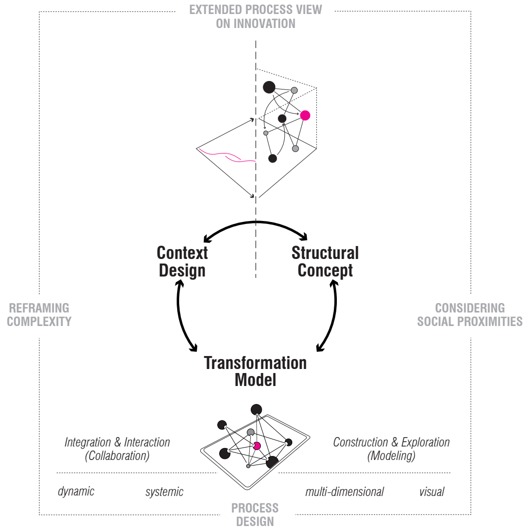

Figure 43: Methodology of Architectural Innovation Design

The capabilities reside in architectural practice and expertise. The phases of context design, structural concept construction and transformation model design are developed from architectural design processes and architectural consulting with the demands of an extended process view of innovation. The phases constitute a design process that incorporates at a conceptual level aspects from the system models of innovation processes, as context, fluidity, network and design (Chapter 3), in dynamic, systemic, multi-dimensional and visual ways.

9.2.1 Capabilities

The methodology is built upon specific capabilities that result from the analysis conducted in the Chapters 2, 3 and 5. With the term 'capabilities' the individual capacity to perform an activity with a distinct ability, skill, attitude or mind-set is subsumed. The extended process view on innovation in Chapter 2 and the system models examined in Chapter 3 argue for capabilities which are similarly propagated and developed in architectural practice. These capabilities exist in the design expertise, skills and tools of architects, though they are not referred to in the same terms. They are developed through training, education, design exercises and experiences in practice. They differ among design professionals and across architectural practices, but share a basic commonality that in principle and ideally a trained architect is able to provide and perform.[108]

As displayed in Figure 44, five capabilities are central to the methodology: visual thinking, spatial intelligence, the ability to create and use non-verbal

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[108] The line of argumentation in this Chapter is based on capabilities architects posses in principle. Architectural practices and architects may in practice not be able, qualified or interested to provide the capabilities described. The critical reflection in Chapter 10 will address this issue.

boundary objects, holistic and long-term thinking, and the ability for design synthesis. These capabilities make it possible to analyze and represent complex environments of an organization. They make it possible to reflect and integrate social interaction and organizational processes. They make it possible to design innovation processes as multi-dimensional systems in explorative and constructive ways.

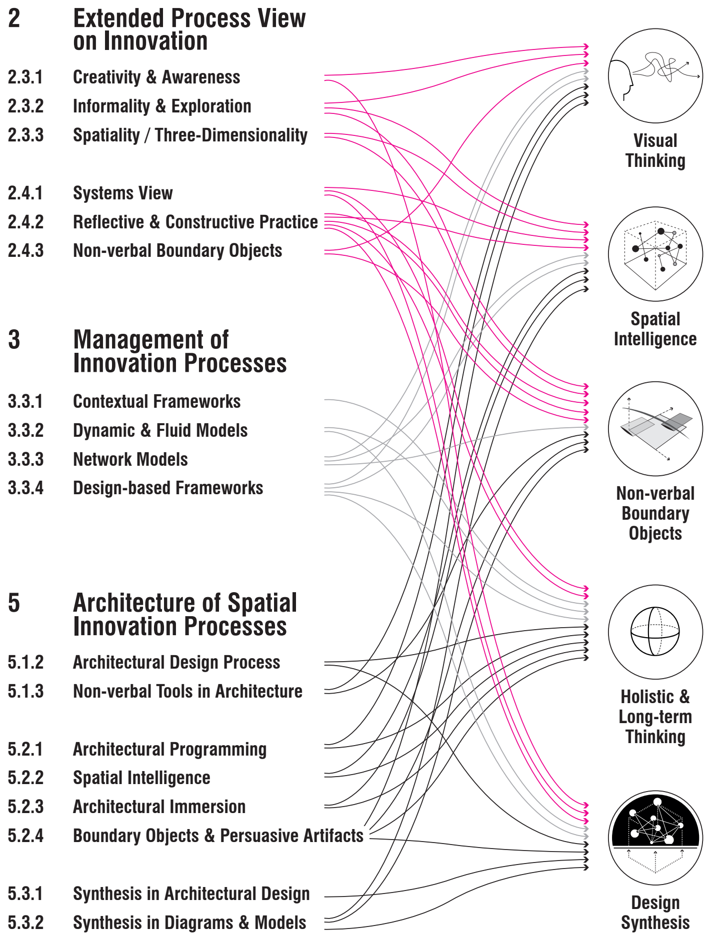

Figure 44: Capabilities for Architectural Innovation Design

The capabilities comprise elements of an extended process view (Chapter 2), of system models form innovation management (Chapter 3) and of architectural approaches for spatial innovation processes (Chapter 5).

Visual Thinking. Firstly, the capability to think and work visually supports comprehension, clarification and awareness of complex context by externalizing thoughts, ideas, information and knowledge with non-verbal means (Förster, 2014, p. 21; Russell et al., 2016). Visualizations extend the thinking outside an individual's head and function as external storage for information, knowledge, thoughts and ideas (Cross, 2013, p. 12; Fischer, 2014, p. 147). Visualizations are communicative bridges between the different stakeholders to retrieve, discuss, align information and knowledge. Sketching, diagramming, drawing and modeling – described in Chapter 5.1.3 – are tools for thinking and working abductively. The tools enable architects and stakeholders to commute between problem and solution space with "informed guesses" (Clarke, 2016, p. 91). They switch flexibly between different subjects and between different levels of abstraction; they focus simultaneously on the details of a situation and the situation as a whole. The different degrees of vagueness, indeterminacy and fuzziness in sketches, diagrams, drawings and models make it possible to explore elements of context from different perspectives and keep several aspects in sight (Cross, 2007, pp. 54–58).

Visual thinking and visual work facilitate the structuring of complex problems (in terms of, e.g., vision, goals, processes, needs, requirements); they make it possible to maintain parallel lines of thought, to relate and cross-reference externalized ideas, information and knowledge (ibid.). Through structuring, maintaining, relating and referencing, collaborative discourses are facilitated, alternative interpretations fostered, new insights gained and eventually new knowledge generated. Visual thinking and visual work can be conducted digitally and in analog ways. In the latter case, further senses are addressed. People activate their tactile or haptic senses. They perceive the represented information spatially. They experience intuitive and unconscious movements across different visualizations as well as they experience engagement and dynamics of direct collaboration with other people. Visual thinking addresses creativity and awareness (Chapter 2.3.1), informality and exploration (Chapter 2.3.2). It aids the creation and use of non-verbal boundary objects (Chapter 2.4.3). Network models (Chapter 3.3.3) and design-based frameworks (Chapter 3.3.4) in innovation management outline the importance of visual thinking for understanding and developing innovation processes in a firm. Visual thinking is essential in the architectural design process, to use non-verbal tools (Chapter 5.1.3) and create boundary objects (Chapter 5.2.4). It is a main principle in the architectural programming method (Chapter 5.2.1).

Spatial Intelligence. In relation to visual thinking spatial intelligence is the second instrumental capability. It adds a third dimension to the analysis, to the exploration and to the design of relations and interactions occurring in innovation processes. The proximities of actors, facilities and processes can be depicted in spatial ways, and reveal vital connections as well as the informal structure of an organization, based on how people actually behave, communicate and interact with other people or with technologies, artifacts and spaces. As social network models in innovation management suggest (Chapter 3.3.3), the interaction patterns, the connections and locations of elements influence the innovative performance of a firm or system. Who interacts with whom and how is aligned to the question of where. Spill-over effects, the exchange of tacit knowledge, the emergence of flow and dynamics in collaboration, the possibility of chance encounters outline the importance of spatial proximities and spatial awareness. Their visual depiction makes it possible to access complex and previously invisible structures and retrieve new insights, e.g., where important activities occur or the main actors in innovation processes reside. A third dimension extends the two-dimensional visualizations of a network analysis and integrates a spatial intelligence. Nodes and connections can be related and placed in relation to each other in new ways and viewed from different angles. Distances can be displayed more accurately as they exist in reality. This may reveal new possibilities for reconfiguring existing or establishing new connections by configuring the distances through the movement of nodes. The spatial intelligence introduces a systems view of an organization as a 3-dimensional structure of interrelated parts. In contrast to a social network analysis it reflects and interprets the current configuration in a process of design. The spatial intelligence integrates qualitative information and knowledge about an organization and its processes in the arrangement of its elements to each other. Based on interaction patterns gained from data and information about the organization, the capability of spatial intelligence supports the visualization of how people think, imagine and talk about their innovation processes. With spatial intelligence the informality of innovation processes and the relevance of exploration is addressed (Chapter 2.3.2). It introduces a 3-dimensionality to understand innovation processes as multidimensional, social processes (Chapter 2.3.3) and to develop a systems view (Chapter 2.4.1). It further support the reflective and constructive practice of design in innovation management (Chapter 2.4.2). Network models (Chapter 3.3.3) outline the relevance of spatial proximities and visualize them with network structures. Design-based frameworks (Chapter 3.3.4) emphasize the spatial awareness for colleagues and processes, but do not represent spatial configurations visually. The spatial intelligence of architectural practices (Chapter 5.2.2) allows a different understanding of organization and processes, and an immersion into their challenges (Chapter 5.2.3). It is a fundamental capability for achieving a design synthesis (Chapter 5.3.2) in the moment different and conflicting elements are integrated into a new whole. With a third dimension, non-linear and simultaneously occurring processes can be displayed, conveyed and understood more clearly.

Boundary Objects. Visual thinking and spatial intelligence support the capability to create and to use non-verbal boundary objects. Representing and reflecting information, knowledge and ideas in tangible objects (virtual and physical) is essential for a design discourse and collaborative design with stakeholders from different disciplinary backgrounds. Boundary objects enable a reflective and constructive practice (Chapter 2.4.2). Boundary objects address the senses of sight and touch, invite people to discuss and transform the structure they represent. The construction and deconstruction of non-verbal boundary objects stimulate immersion, creative participation, exploration, confrontation and co-creation (Samuel, 2018, pp. 67–68). The boundary objects differ depending on case and use in type and level of abstraction, in materiality and scale. They function as tools to reframe existing and create new mental models of an organization. They can be commonly shared and support the development of a mutual understanding. Diagrams as "architecture's best means to engage the complexity of the real" (Allen, 1998, p. 17) function as boundary objects as well. Thoughtfully developed and ordered, a diagram suppresses the quantity of details to emphasize relevant information, convey a narrative and remain open to discourse and interpretation. Architectural models as virtual or physical artifacts represent the complexity of spatial and relational proximities in abstract and comprehensible ways. They represent "knowledge in the making" (Nilsson, 2013, p. 1) and approximations to reality and to the final design of a new whole. Organizational structures and processes can be literally prototyped as 3-dimensional models, explored, communicated, discussed and transformed. The appropriate level of abstraction needs to be developed throughout the processes. Models can be detailed to show processes, requirements for proximities and demands for interaction. At the same time they remain fuzzy to allow interpretive flexibility and novel transformations of the relations and placements. With the capability to create non-verbal boundary objects, informality and exploration (Chapter 2.3.2) are again addressed, which is necessary to create a liquid design process (Boland & Collopy, 2004b, p. 273).

Depending on the kind of boundary object, a systems view of the organization (Chapter 2.4.1) can be displayed in 3-dimensional ways (Chapter 2.3.3). Network models already provide these kinds of boundary objects for innovation management (Chapter 3.3.3). The non-verbal tools architects use allow them to create similar objects to convey in comprehensible ways locations, proximities, connections and interactions between people, departments, functions and facilities, which are of relevance for an innovation processes and can be visually traced. Network models are generated from quantifiable data and objective information retrieved from different enterprise data sources, interviews and observations. Boundary objects created as persuasive artifacts differ from an objective database. Persuasive artifacts interpret the information and knowledge acquired; they offer management executives and employees alternative configurations and suggestions, e.g., to re-locate, merge or exclude elements of the organization as shown in the examples of the case studies (Chapter 6.2.3 and 6.3.3). They also confront the people involved with novel design ideas that are discussed and criticized. Eventually persuasive artifacts lead to a design synthesis for a new visual system of innovation processes (Chapter 5.3.2). In comparison, the boundary objects the selected system models offer are simplified, descriptive or normative devices. Contextual frameworks (Chapter 3.3.1), dynamic and fluid conceptualizations (Chapter 3.3.2), design- and people-based frameworks (Chapter 3.3.4) provide verbal check-lists, tables, two-dimensional charts and diagrams.

Holistic and long-term thinking. The capability for holistic and long-term thinking is necessary to challenge simplistic, superficial or apparent solutions for the design of an innovation processes. Multiple and diverse elements in an innovation process – people, interactions, knowledge, technology, artifacts, spaces, creativity, culture, values, purposes, time and resource constraints – need to be considered, especially in the context of radical, revolutionary or disruptive approaches. Holistic and long-term thinking as capability incorporates the human perspective over the course of time. It studies what behaviors are relevant and important at present, and what behaviors should be nurtured and promoted in an organization in the future. It addresses the values an organization possesses and the values it intends to maintain, to strengthen or to build in the future. Long-term thinking is essential to practice an art of critique and lead the design discourse beyond the stated short-term needs of the stakeholders. The development of new mental models and appropriate mental models depends on the capability to anticipate and imagine a preferred future state. As with the capabilities discussed earlier, holistic and long-term thinking is practiced throughout the entire design process (Chapter 2.4.1 and 2.4.2).

The future vision of an organization for how innovation processes should be understood and performed unfolds itself during the design process. It cannot be defined at the beginning of the design process and inquiry, when the informal organization has not been uncovered. System models in innovation management already consider this thinking in their dynamic models and design-based frameworks. In the dynamic model, the innovation system of a firm is a journey through an unchartered landscape or an act of strategic use of innovation technologies and play (Chapter 3.3.2). In the design-based frameworks the innovation system is constructed by strategies, systems and cultures. It is framed as a design discourse between interpreters. It is reduced to design thinking attitudes (Chapter 3.3.4). System models provide a frame, in which innovation processes can evolve and adapt to changing contexts. A holistic and long-term thinking foresees possible transformation of the processes and allows adaptation to unknown situations. It deals with uncertainties in the system design. Especially in approaching wicked problems, an innovation process system requires areas of freedom and experiment. Ideally, the long-term and holistic thinking is trained and observable in the architectural design processes and architectural programming (Chapter 5.1.2. and 5.2.1). Concepts for a complex buildings are usually developed for longer time spans than the initial use may cover.

Design Synthesis. As a fifth capability, design synthesis is the repeated activity during the design process. It creates preliminary solutions in phases of convergence, which are iterated and revised (Clarke, 2016, p. 91). Practiced in engineering and design disciplines, design synthesis adds to the sum of the parts further inspirational elements whose "roots are often untraceable"

(Langley, 1999, p. 708). It binds different elements together with a new theme and meaning that the organization intends to follow. This meaning or design theme represents the art of configuration of the tangible and intangible assets. It comprises formal and informal elements of organizational structure through a "visual sensemaking" (Beucker, 2016, p. 39). The ethical function of architecture together with a long-term and holistic thinking contributes to a sustainable design resolution (Düchs, 2012, p. 424; 2017, p. 187). Further, a good design synthesis includes aesthetics as features of clarity and usability (Kolko, 2010, p. 15; Norman, 2005, p. 17 et seqq.). The outcome is reduced to its essential form and "confusion and clutter" (Tufte, 1998, p. 53) is expelled from the information it visualizes (Shamiyeh & Duschlbauer, 2007, p. 104). The capability for design synthesis integrates qualitative and quantitative information. Design synthesis becomes visible and tangible in non-verbal boundary objects as diagrams or models. It communicates a new reality for innovation processes, constructed during the design discourses of the stakeholders. The visual and explicit outcome of a design synthesis may evoke behavioral change, as it becomes accessible and tangible to the viewer.

9.2.2 Design Phases

The methodology is a process of inquiry into a firm's innovation structure. At its core are three interdependent phases of design: context design, structure concept construction and transformation model design. The phases follow the extended process view of innovation elaborated in Chapter 2. They capture multi-level complexities, social proximities and process design activities. The phases take into consideration the perspectives of system models in innovation research and management as explained in Chapter 3. During the phases, the focus is on context, fluidity and dynamics, social networks, design discourses and people-centerdness. The methodology transfers particular thinking and tools of architecture to the design of innovation processes in business environments. The activities for the methodology are distilled from architectural design processes, form architectural programming and architectural consulting cases, as examined in Chapter 5 and 6, and share similarities to activities in innovation management. The methodology combines the visual analytical phases and working principles of architectural programming and consulting with the constructive synthesis phases of architectural design. It dissolves the strict separation of programming and design of the architectural programming method, avoids a prescription of how design sequences need to be performed and how the information needs to be structured.

The activities of the architectural consulting cases in Chapter 6 – to collect information, map processes, model the organization, create and refine the sections, and extrude a 3-dimensional model – are reinterpreted and subsumed in three design phases for context, structure and transformation. The three phases enable the analysis and synthesis of spatial organizational systems for innovation in a concise, yet designerly way that emphasizes structure, people, social interactions and possibilities for adaptation with the aid of non-verbal boundary objects. The term 'model' is used from an architectural perspective, as visual, foremost 3-dimensional representation of thoughts, ideas, design concepts and design resolutions with analog or digital means. The methodology integrates different stakeholders through active participation and co-creation. It further supports the implementation and evaluation of the designed innovation system in organizations, which have remained unconsidered in the examples of architectural consulting cases. The methodology is open to adjustments in its design phases and in the use of existing design tools or design tools, that need to be developed first by the conducting practice. Context design, concept construction and transformation model design can be conducted with a diverse range of methods and tools, which depend on the skills and expertise of the architectural practice. Figure 45 shows how the different areas of analysis and findings in the previous chapters are incorporated in the methodology of architectural innovation design.

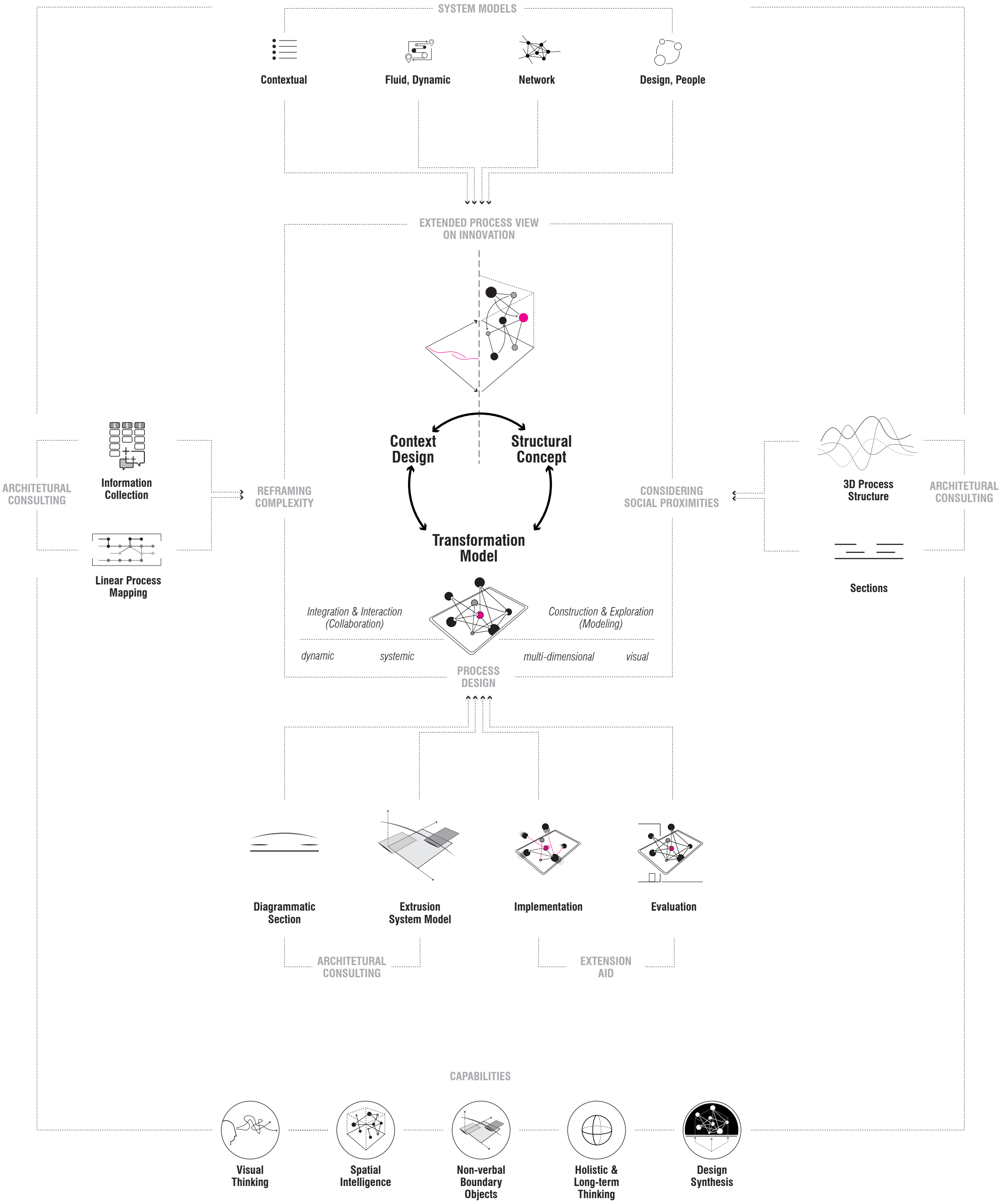

Figure 45: Theoretical Construction of the AID Methodology

Context Design. In the context design phase information and knowledge about the environment of an organization, its industry, technology and its unique structure is retrieved and created. Context is regarded on the one hand as a given constraint, and as subject to design on the other. In contrast to a contextual innovation management (Chapter 3.3.1), the context of an organization can be influenced and changed. Novice thinking in architectural work, the quest for the new, allows architects to explore different design directions that otherwise would be excluded in an expert's assessment (Lockwood & Papke, 2018, p. 21; Pendleton-Jullian & Brown, 2018, p. 106).[109] Novice thinking paired with design expertise and paired with the capabilities for long-term and holistic reasoning facilitate the search and discovery of information and knowledge, and to build on the organization's culture of innovation in the subsequent design phases.

The context design phase addresses at a qualitative-organizational level vision, culture, values, challenges, strategy, capabilities, and structure; at a quantitative and operational level functions, departments, processes, technologies, resources, facilities and spaces are analyzed. In the beginning of the context design phase, the practice obtains information from representatives of different hierarchical levels and functions through direct interaction in the form of, e.g., dialogues, interviews and workshops. It retrieves information and knowledge regarding the social interactions and regarding the physical space, through mapping techniques, organizational charts, analysis of available enterprise data on communication and work processes. It observes and examines facilities and the spatial structures. It analyses the digital architectures of the company that are related to the innovation process.

As outlined in the examples of system models (e.g., social network analysis, design-based frameworks) people and social interactions are vital for innovation processes. The exchange of implicit or tacit knowledge, the emergence of an innovative idea through discourse or by chance encounters, depend on relational and spatial proximities. In addition, the dynamics within an organization need to be captured. Proximities are considered in a relational and spatial structure. A node in the visualizations represents an actor (department, function, group of employees, team or individual) and his or her location. The connections between the different nodes represent the type and intensity of interaction. Interactions are grouped in direct and synchronous face-to-face encounters or by voice-to-voice exchange. Virtual asynchronous interactions are captured through e-mail traffic and messaging or social media activities.

The information is made visually explicit, to be discussed and reframed with the participating people. With the use of analog and digital design tools such as sketching, mapping and diagramming, complexities are represented in abstract ways. The visual record and visual collaboration evokes an active participation of the involved parties and retrieves tacit knowledge through their reflective or intuitive contributions. It enables the creation of new knowledge and insights on the organization by a collaborative reflection-in-action process. The paths an idea and project covers through an organization are represented as tangible and intangible flows. Intangible flows relate to data, information, knowledge and inspiration; tangible flows relate to embodied knowledge in objects like samples or prototypes, and the movements of people for knowledge exchange within an organization. Similar to the "schreck models" (Gehry, 2004, p. 20) preliminary visualizations in the context phase are also used to confront the participants with alternative interpretations of information and knowledge, in order to provoke reactions and generate deeper insights.

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[109] Lockwood & Papke (2018, p. 21) refer to a quote by a Zen-master, Shunryu Suzuki: "In the beginner's mind there are many possibilities, but in an expert's mind there are few."

Essential to the context design phase is the process of uncovering the informal structure of an organization regarding its innovation processes, interactions, relational and spatial proximities. The phase seeks to visualize the mental models the different stakeholders possess in relation to the organization's innovation processes. Though innovation process diagrams and organizational charts are used to externalize and codify the structure, they often describe a formal and prevailing conceptualization. They are descriptive or normative (Verworn & Herstatt, 2000, p. 11). The mental model – how individuals think and talk about their processes and organization – may differ from the codified and existing externalized diagram. To retrieve the mental image of the organization an individual holds, it is important to reflect on the organizational challenges regarding innovation and develop a shared understanding. It builds the basis to eventually create a shared vision for the future system of innovation processes. As problem and solution co-evolve throughout the entire design process of the methodology the developed shared vision during this phase is preliminary. The emergence of a design idea that frames the vision is not "constrained" (Cross, 2013, p. 126) to a particular phase. Understanding and vision are reflected, interpreted, transformed and constructed throughout the three phases, visually and spatially.

The spatial dimension matters insofar as the location of nodes of an innovation process needs to be visualized in their proximities to each other, in order to discover patterns in flows, areas of intense interaction, structural holes or possible shortcuts, which are used informally but have remained invisible to the management, or which it would be advantageous to install. The spatial dimension makes it possible to leave the linearity of processes and interactions, and to represent the complexity of the simultaneous processes in comprehensive ways. The spatial dimension allows the construction of a structural concept.

Structural Concept Construction. In the structural concept the information and knowledge of context is transferred to different visual boundary objects. The structural concept represents the existing innovation processes of an organization as 3-dimensionsal structure. It outlines the nodes an innovation process passes through or shall pass through. By adding a third dimension, the architectural practice can display proximities of nodes and processes simultaneously which would remain covered or untraceable in plain view representations or two-dimensional graphs. In the structural concept the human related entities, e.g., departments, teams, individuals, are viewed in their dependence on non-human entities like spaces, facilities, artifacts, equipment and technologies. These relations and dependencies need to be considered to construct the existing structural concept and explore new configurations. The spatial representations offer a visual frame to analyze the feasibility of the existing structure for innovation processes. This aids to reveal deficiencies in the placement and arrangement of distinct areas regarding their existing and non-existing interaction patterns and embeddedness in the firm. Departments, teams and individuals may be placed in relational and spatial distances which impede awareness for innovative initiatives, informal communication and chance encounters for idea and knowledge exchange, for critical discourse, inspiration and creative disruption. The mental models and verbal means used to communicate the culture of innovation and process of innovation by management executives and employees may differ from its factual, visually externalized structure. The transfer of the data acquired, information and knowledge from the context design phase into a structural concept is a constructive process. The configuration is developed in a dialectic discourse with the stakeholders. Communication and interaction processes as well as the informal organization are relationally and spatially mapped and recomposed.

Qualitative aspects of informal interactions, that are observed by the architects or reported by the people involved, can be integrated. In the collaborative design process intuitive gestures and unconscious moves by the participants can reveal new insights on former hidden patterns, connections and configurations. Through the spatial-visual representation of the organization and its processes, new perspectives on the social interactions and the culture of a company can become visible (e.g., a siloed structure, an isolated entity, or a center of knowledge). Locations, distances, relations and connections are visualized, reflected and revised until the structural concept of the firm is appropriately (to the judgement of client and architect) represented. The resulting structural concept shows spatially where interactions happen that support innovative initiatives and where these interactions are absent.

In contrast to automatically generated social network analyses or graphs, the spatial network in the AID methodology is created by design discourse. This reflection-in-action process makes it possible to directly discuss the feasibility of configurations, to alter and manipulate the placements, to include, exclude, merge and divide nodes. It may lead to a visual representation of the organization which may not be covered by existing organizational charts, default templates or generated graphs. The freedom to visualize, to experiment and explore, to alter or adjust the configuration is instrumental in the design process. The visual collaboration on non-verbal boundary objects invites to explore the organizational structure of innovation processes in a firm. It enables client and architects to take intuitive action to reconfigure, play with, adapt and change. The constructive process may lead to alternative placements of nodes and formulations of connections that run counter to or disrupt the existing structure of innovation processes in a firm. The confrontational design discourse is a prerequisite for an idea of a preferred model to evolve.

Transformation Model Design. The design of a transformation model turns the structural model in a preferred system of innovation, which the organization intends to follow, to externalize and to implement. Design is modeling with conviction. For the creation of a transformation model the emergence of a design idea is necessary. It synthesizes the different parts of analysis from context design and structural concept under a new theme and meaning. The design idea is the art of arrangement and placement of the different elements. To develop the transformation model preliminary configurations are designed, viewed from different perspectives, intersected and discussed. Its different elements are rearranged and aligned with the context and vision of the organization. In a similar way to the concept construction, the development of the transformation model encourages intuitive actions, creativity and play while thinking, reasoning and reflecting on the preliminary outcomes.

The transformational model is a visual, multi-dimensional innovation system consisting of the nodes and connections innovation processes may pass through. It shows a configuration of nodes in relational and spatial proximities, which also transfers the culture of innovation, e.g., by centering distinct departments, co-locating functions or teams in close proximity to each other or digitizing processes for broader transparency and accessibility across the organization. The transformation model represents the structure an organization seeks to test or implement. It is a non-verbal boundary object that integrates the representatives of different decision-making levels and disciplines. It creates a common understanding of the company's innovation culture and innovation capabilities. It communicates the system of innovation to further stakeholders and actors. It is a virtual 3-dimensional proposal that represents the different elements of an innovation processes – people, interactions and things – simultaneously. It frames the in-between in the socio-technical system of innovation, the probability and possibility of innovation processes to occur. It comprises fuzziness and form, order and chaos. It visualizes the complexity of the processes in tangible ways and displays areas for free action at the same time. It serves as a prototype to test alternative configurations and to implement them after approval through digital or analog tools. Existing software application for innovation management can be adjusted or new application can be developed according to the transformation model. Analog solutions can result in new spatial configurations and routes of movement.

The transformation model further serves as a reference model. An organization can evaluate the extent to which the changes have fostered the innovation culture and facilitated the innovation processes by collecting data on the performance and engagement of its employees, based on the proposed model. As organizations work in changing environments, adaptation in connections and arrangements of departments, teams or individuals may be necessary. The model can help to anticipate the necessary adaptation, or be adapted according to the new demands. From the employees' perspective the model is also an aid for the implementation and testing of a new innovation system in a firm. Employees can use the model to become aware of ideas, inventions and implementations occurring in the system. Through the model, they can localize themselves in relation to peers and to innovation processes. They can interact with the model, engage and immerse in the various processes and phases of innovation. They can self-organize in teams or explore other fields.

In contrast to a sequence model for innovation management, the transformation model outlines the innovation culture, the structure and possibilities for innovative actions of the organization as a whole. It supports a different understanding of innovation processes and individual behavior towards innovation. For instance, innovative performance over time is conveyed as flow in space. But project management aspects of innovation processes, as portrayed in the examples of sequence models (Chapter 3.2), need to be integrated as an additional layer of information. Innovation management has developed different applications to address challenges of innovation processes and support practitioners. As outlined in Chapter 4, these selected applications transfer different conceptualization of innovation processes into methods and analog or digital tools. Similarly, in architectural design processes, analog and digital tools have been created to support, facilitate or constitute the design process. For the methodology of architectural innovation design the use of a digital tool makes the abstract phases of design and their outcomes tangible and concrete. It facilitates and accelerates the application of the methodology. A digital tool supports collaboration and modeling in order to develop a dynamic, systemic, multi-dimensional and visual boundary object of innovation processes.

The phases of context design, structural concept construction and transformation model design constitute a design process which incorporates aspects of context, fluidity, network and design. It represents the thinking model, in which the methodology is emebedded in and defined by. Methodology and resulting models have two functions. At first they function as interactive and integrative means to establish a collaboration between architects and management professionals. As a second function, which ensures a design attitude, the methodology is explorative and constructive. Architects and management professionals cooperate and co-create in modeling. The methodology requires a tool to aid this process of collaboration and modeling. At an operational level it needs to feature dynamics, systemic perspectives, multi-dimensional levels and visualizations. In return, the tool in use shapes the thinking model of an extended process view, as shown in Figure 46.

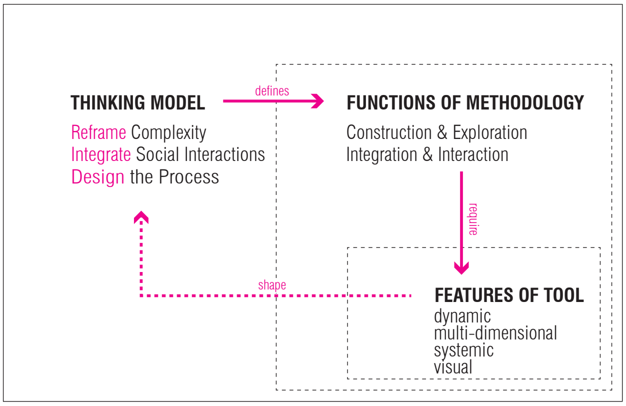


Figure 46: Relation of Extended Process View, Function and Features

The thinking model of an extended process view on innovation defines the functions of the AID methodology, which requires particular features in a supporting tool. The tool in use eventually shapes the thinking model.

9.3 Tool Concept

A design tool for the development of innovation processes needs to meet particular requirements. In first place, it is a tool to design. It should support its users to conduct activities of an architectural design process for particular challenges of innovation management, i.e., to explore and construct innovation processes for an organization as a whole. Its main focus is the designerly way of capturing, structuring and configuring data, information and knowledge about elements, interactions and relations in innovation processes. To enable this design approach the tool facilitates application of the capabilities needed for the methodology: visual thinking, spatial intelligence, the creation of non-verbal boundary objects, systemic thinking and synthesizing. The tool supports the stakeholders in design judgement and design decisions, when they develop a multi-dimensional innovation system. The final design for a new structure results from the collaboration of architects with management professionals and users of the system. Their course of action, their co-creation and discourse, and especially their imaginative capacity to develop a design idea with the guidance of an architectural practice leads to a transformation model. The tool itself is a supportive mean for design.

The particular requirements for the tool will be outlined first. Secondly, the corresponding properties of a software application will be explained. Thirdly, the basic features and actions the tool offers will be described. Fourthly, a system concept will be drafted, indicating how the digital tool could be technologically set up and structured. The section closes with additional considerations for the broader implementation of the tool. It can be progressed from a supportive design device to an individual innovation management device.

9.3.1 Requirements: Collect, Structure, Construct

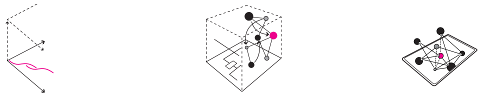
The tool needs to meet interdisciplinary requirements, the requirements of diverse user groups and the requirements of an architectural design approach. In the architectural consulting cases and the space-behavioral applications (Chapter 6 and 7), visualization tools, graphical programs and CAD programs were used to retrieve, represent and analyze information and knowledge on innovation processes. The programs supported the re-design of organizational structures in a two-dimensional or a 3-dimensional space. The 3-dimensional models conveyed relational and spatial proximities with different kind of interactions. However, several aspects limit their use for an architectural innovation design. The tools were not developed for innovation process analysis and synthesis. They were not built on a comprehensive theoretical basis of innovation processes as multi-dimensional, dynamically changing and emergent systems. They neglected quantifiable information regarding innovation project management. They required a computing infrastructure to operate and advanced knowledge in usage. Their user interface did not allow or enable anyone other than experienced architects or designers to actively interact with the program, with the model or with other users. The interface did not offer diverse user groups opportunities to model, to add information, to visualize and explore different types of configurations for innovation processes. Consequently, their accessibility and acceptance from the field of innovation management remained restricted. In contrast, examples of related applications from the field of innovation management (Chapter 4) are based on theoretical models of innovation processes as sequences of events or actions which need to be performed during a specific period. They emphasize quantifiable aspects and defined phases to develop innovations. The primary goal in these applications is to generate ideas, facilitate initiatives and foster developments on particular topics. They outline collaborative features at an operative project level and provide information for the management of innovation processes, while the examples from the field of architecture foreground modeling features for a strategic and holistic perspective (see Chapter 8.3).

A digital tool to support the methodology of architectural innovation design needs to include aspects from the field of architecture and the field of management. It needs to combine a creative approach of architectural thinking and design that outlines the structure of a whole firm regarding innovations, with an analytical approach of innovation management that focuses on the project performance of innovation. The tool for an architectural innovation design serves as a common playground for different actors with architectural and managerial backgrounds. With the tool, architectural practices can make their design work for innovation management visual and comprehensible. They can familiarize themselves with a theoretical conception of innovation processes. The tool facilitates the application of an architectural innovation design methodology, and the integration of different stakeholders in co-creative and collaborative design process. In addition, the tool enables innovation management to convey visually its comprehension of innovation processes and the relevant information. Management executives and stakeholders involved in innovation topics are enabled to participate, collaborate, model, explore, experiment and test alternative configurations of innovation processes in a designerly way. The digital tool embodies a theoretical access to innovation for architects and it offers a creative approach to innovation managers.

To account for diverse users, the tool is easy-to-use and comprehensive. Collaboration and modeling are central functions in the methodology. The tool enables this collaboration and modeling for users who have different disciplinary background, skills, levels of expertise in design and the use of technical infrastructure. Architects, though trained in digital design tools, are introduced to innovation process theory conveyed in the tool; management executives and employees are encouraged to use form-giving design features to externalize their information and knowledge in visual ways. An intuitive, easy-to-use tool for the methodology keeps requirements for external introductions and advanced digital skills at a minimum. The learnability of the tool corresponds with the design process. While gradually analyzing and designing the innovation process, the use of the tool advances.

Concretely, the tool supports its users to collect and structure data, information and knowledge and construct 3-dimensional boundary objects with an architectural design approach. Data, information and knowledge on the innovation processes that reside in an organization and in the stakeholder's mind are made visually explicit, shared and become subject to reflection, interpretation and design. Organizational knowledge, knowledge of innovation processes and innovation culture are only partially codified. They are socially embedded, partially implicit and tacit, and comprise formal and informal relationships. The tool supports the visualization of formal and informal relationships, and their transformation into non-verbal boundary objects during the three phases of the methodology. For an architectural design approach, the tool enables visual thinking and spatial intelligence. It thus provides a 3-dimensional Euclidian space. In this 3-dimensional space the data, information and knowledge of all phases need to be displayed instantly and provide a visual feedback for the reflection-in-action and reflection-in-discourse process. Abductive reasoning, and a non-linear and gradual approximation to a design solution need to work in vague and fuzzy ways as well as with precise data and information. The tool needs to offer possibilities to work with different degrees of accuracy and different degrees of autonomy. Users need to interact, collaborate and model, reflect on and discuss the individually performed design actions without being required to enter precise information. At the same time, the users can enter precise information regarding the innovation processes.

The tool is used across the three phases and addresses different foci, areas of information, activities and design outcomes. Table 14 examplary describes the primary focus and design outcome in each phase.



	Context Design	**Structural Concept**	**Transformation Model**
Focus	Status Quo Organization	Informal Organization	Future Organization
Design Outcome	Vision Culture	Structure Form Diagram	Synthesis Configuration Model

Table 14: Scope of Design Phases in the AID Methodology

In the content design phase, data, information and knowledge regarding organization, actors, and environment is collected, imported and visualized in a visual working space. The tool enables interaction. Users can visually map, structure and model the information on the organization with nodes, interactions, connections, proximities and processes flows. In the structural concept phase, nodes, interaction, connections, proximities and processes need to be reflected, discussed, interpreted and manipulated. The tool enables the user to collaborate with other users, to navigate through the visualizations for deeper analysis and to manipulate the structures displayed. In the transformation model design phase, the tool supports the users in manipulating and modeling the 3-dimensional boundary object. The tool supports collaboration between the users, the interaction between users, and the interaction between users and the model in the visual working space. If the users or co-designers agree upon a configuration the transformation model is finalized or saved as a preliminary version. The constructed transformation model serves as a digital model to conduct simulations, test and implement an innovation system in a firm.

In the architectural design process intuitive and unconscious gestures are instrumental, which unfold during reflection-in-action states, states of exploration, test, and play and states of flow. Accordingly, the tool needs to foreground the explorative design process, while reducing the input of quantifiable and precise information. Further, a design challenge – such as the design of innovation processes – is unique to each company. The features required to analyze the organization and visualize its structure may not be available in the tool. A design attitude seeks to develop new features for the tool or adjust the tool. The tool offers therefore possibilities for customization and extension of its features. As an open application, the tool provides a basic modular structure, design and user interface that can be further developed, extended by other features and applications or integrated in other applications.

9.3.2 Properties

The tool addresses the different requirements with distinct properties for functionality, usability, performance and adaptability (BSI, 2011, p. 4; Carvalho, de Castro Andrade, Marçal de Oliveira, de Sousa Santos, & Moreira Bezerra, 2016, p. 774). In its further development, especially for broader implementation and use across an organization, the properties of security, adoption and scalability increase in importance. The properties follow the categorizations used in international standards for software quality models, which "provide consistent terminology for specifying, measuring and evaluating system and software product quality" (BSI, 2011, p. 1). The characteristics or properties are refined by further quality characteristics of human–computer interaction evaluation according to their relevance for the tool in consideration here, and selectively renamed (Carvalho et al., 2016, p. 774; Szopinski et al., 2020, p. 475).

Functionality describes the extent (degree) to which the tool meets its intended purpose and requirements (BSI, 2011, pp. 10–11). As a digital design tool for the development of innovation processes, design environments and design features are central. The tool is functionally suitable if it provides a design environment to display visually and spatially the data, information and knowledge regarding an organization. A 3-dimensional Euclidian space is the central workspace the user can interact with to collect, and structure data information and knowledge, and to construct 3-dimensional boundary objects. The design environment further allows between different users to interact for collaboration.

Usability refers to the extent to which the specified users can actually apply and use the tool (BSI, 2011, p. 12). The primary users are the architectural practices that work in the design environment and introduce and guide other users (e.g., from management practice) in the design environment – and the methodology. As diverse users may exist within architectural practices and among involved stakeholders, the tool is easy-to-use, understandable and learnable without requiring prior knowledge, expertise and skills in design. As the design activity is foregrounded, the tool follows simplicity, "user interface aesthetics" (ibid.) and aesthetics in the user experience of design so as not to impede the design process. Related to this, the user interface and experience provides the features needed to operate and control the tool. For a rewarding design process features of play are integrated. Related to this, the reversibility of performed actions and repositories of different versions of work are important. They allow users to pursue radical design directions without fear of failure and in a risk-free fashion; they allow them to compare parallel lines of thought and to iterate between different design attempts (BSI, 2011, p. 9; Carvalho et al., 2016, p. 761).

The property of **performance** is essential for a digital design tool. Sketching, drawing and modeling by hand allow seamless movements, provide instant feedback and offer the possibility for intuitive gestures and reflection-in-action. The tool addresses these aspects with real-time visualizations and visual feedback on the inputs by the users. The design actions, as well as the collaboration features require different degrees of computing resources. To perform the different design and collaboration actions provided by the tool, and to remain independent of constraints in computing infrastructures, operating systems and devices at the user's end, the tool is developed as web- or cloud-based application. This offers further advantages in the tool's adaptability.

The handling and use of design tools depend on the expertise of its user and the subject of design. The design of innovation systems is unique to each organization and therefore case-specific. It may require features that have not been foreseen in the basic configuration of the tool. The tool therefore is developed with a modular structure, which allows the extension by new features as software or hardware plug-ins. Considering its interdisciplinary use, architectural practices and innovation management may need to customize and extend the tool according their requirements, their expertise and the technological infrastructures they use. Especially for broader acceptance and use among architectural practices, the tool provides possibilities for adding particular design features to fit the individual design approach.[110] To ease the exchange with the existing data sources of an organization, the tool supports corresponding interfaces. The tool is conceptualized as a stand-alone application. To ensure its relevance for other software applications, the tool provides programming interfaces for integration e.g., in existing management software or CAD software. With an integration in existing innovation software the tool adds a visual design environment for the existing data sources. With an integration in CAD software, existing or future spatial configurations can be assessed with the transformation models created in the tool.[111]

The expansion of the tool regarding scope and new use cases increases the importance of properties relating to security, adoption, scalability and robustness (Carvalho et al., 2016, p. 774). Data, information and knowledge regarding innovation processes in a firm are sensitive. In competitive and fast-paced business environments the way a company innovates, as well as the subject of innovation, are vital for its future existence. Accordingly, the content displayed in and developed with the tool, as well as the user's access, actions and contributions need to be secured. With users from executive levels and from confidential projects, as well as with a growing number of people participating, authorization, confidentiality, accountability and authenticity is managed in the tool (BSI, 2011, p. 14). Users' involvement and participation is securely authorized and traceable (ibid.). The security issues are also building blocks to create trust and user satisfaction (ibid.). For acceptance and adoption in larger use-cases with multiple users the tool strengthens its properties in usability, performance and reliability. Finally, the tool is designed for scalability and robustness. A web- or cloud-based solution in this perspective is again advantageous for the entire tool development.

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[110] Reasons explaining the limited acceptance and use of architectural programming among architectural practices may reside in the rigid structure of the method to collect and process information and knowledge, and in the recommended separation of activities for analysis from activities of design (see Chapter 5.2.1 and 6.1.1).

[111] A prototypical tool has been developed in the master thesis by Konstantin Flöhl at the Technical University of Munich. He proposes In his concept of "Building Innovation Modelling" (Flöhl, 2021, pp. 15–17) an actor-based simulation to design buildings in alignment with innovation processes (see Appendix II.2).

9.3.3 Features & Actions

The tool offers a virtual 3-dimensional Euclidian space as its central workspace. The digital design environment consists of controls displayed in the workspace for settings, inputs, design actions, collaboration and navigation. Virtual space and user interfaces provide a playful user experience to direct the attention and time of users to visual analysis and design. A playful and intuitive handling in using the controls is important to support the experience of learning. The tool with its core controls defines the visual language for the design of additional software plug-ins that conduct operations depending upon needs and expertise of the users, e.g., for calculation, analysis or simulation (Schubert, 2021, p. 115).

Similarly to CAD programs, the settings of the workspace need to be defined as an initial step before entering. The workspace is supposed to display elements with relational, spatial proximities to each other, with different strength of connections, and proportional ways if required. Therefore, the scale and units need to be set. The scale of the workspace can consider individual actors, team and department perspective, or different organizations. The units relate to figures regarding the number of employees, the generated revenues, the number of square meters, and physical, relational and communicational distances. Setting up the scale and units is important, that a user can make inputs by design, distinct entry and data import.[112]

As the users input data, they can work vaguely as well as precisely. For design activities and the design process this vagueness and fuzziness in entering and manipulating elements visually is important. The user can enter graphical elements directly in the workspace without the need to further specify them. The manual construction of 3-dimensional visualization is instrumental to the design process. With mouse, touch pad, keyboard commands or further input options the users are enabled to work by hand and manipulate the elements in size, connection and location directly in the virtual space. The users develop through the designerly mapping and the inserted information an alternative representation of the organization's structure and innovation processes. The tool offers an openness and interpretive flexibility to the users, allowing them to add and specify where to place particular actors of innovation processes.

On the other hand, the tool offers options to enter or import precise data and information, which are relevant from an innovation management point of view. Representations of individuals, teams or departments involved in an innovation project, their work scope, their team or department size, the resources and time they spent or the interactions they have with other entities can be inserted and displayed at an additional layer of information. Parameters, which are subject to change, as team sizes, type and intensity of interactions, content of communication, flow directions of knowledge or idea exchange, can be specified by the user through selection, slide bars or direct input. Value constraints of the slide bars can be defined in the settings as mentioned before. If data is imported, the categories represented in the tool need to be retrievable from the available data sets. The direct interaction in the visual workspace enables users to map elements immediately, i.e., to add them via mouse, touch pad or keyboard controls and to move or to manipulate them with the design actions offered. During the discourse with a firm in the context design phase the

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[112] For example: If the scale is set for teams and departments, the team and department sizes are displayed by number of employees. For proportional visualization a node represents a single individual, and rises in size by the number of employees in a team or department. The maximum number of employees can be infinite or limited to a maximum value retrieved from organizational information.

architectural practice can visually record and map thoughts on innovation processes and the language used in talking about innovation processes in a firm. The depicted map of who is interacting with whom on innovation, at what stage of the process and on what kind of content may differ from prevailing prescriptive or normative innovation process models in the form of charts and diagrams.

Nodes and connections are added and placed in the 3-dimensional space manually. They can also be automatically generated from an enterprise data source, which provides information on people, functions, departments, facilities, their proximities and interactions. Nodes represent either individual actors, teams, departments, functions, facilities or capabilities and technologies that contribute to an innovation process in a firm. Connections represent the interactions between the different nodes. As the type and intensity of interaction is relevant in innovation processes, the connections are proportionally represented (e.g., by thickness) and distinguished by type (e.g., face-to-face interaction, digital interaction via e-mail or messenger tools, exchange of data, information, knowledge and tangibles). For example, the following information can be inserted through the control panel:[113]

- name of element;
- size of element displayed as diameter of the nodes: by number of individuals or team members, by area in square meters occupied or required, by financial resources used or required, by other resources, measurable and with relevance to the users;
- location of element by organizational structure, by geographical coordinates;
- interactions between element by type (face-to-face/ synchronous, virtual/ synchronous, virtual/ asynchronous, matter-related/ physical) and intensity (frequency of interactions);
- content of communication by type (idea-related, development-related, implementation-related, engagement-related, explorative);
- time duration of interactions, movements, logistics;
- innovation project figures as resource constraints, deadlines and development level.

If existing data is imported, the automatically generated configuration needs to be checked against the information from a context design. Informal interactions, which may not be represented in the data sources, need to be considered and integrated. The automatically retrieved visualization is then adjusted by relocating nodes or revising their connections. As introduced with fluid and dynamic models (Chapter 3.3.2), innovation is a spatio-temporal process. The nodes the process passes are not linearly aligned or systematically followed. Particular nodes may be involved repeatedly during the process, while others may be passed once or not be integrated.

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[113] A prototypical tool has been developed on basis of this thesis during an interdisciplinary project by Semin & Shohina (2019) at the Technical University of Munich (see Appendix II.1).

The constructive functions in the tool enable user to model and manipulate the inserted elements and information. The user can move, blend, separate, connect nodes, to alter connections or revise the configuration, as well as they can add further elements. The representation in a Euclidian space makes it possible to build a 3-dimensional boundary object, which conveys qualitative and quantitative data. Qualitative, implicit information can be represented by the art of configuration. The configuration of process paths can convey narratives about how an organization innovates. For example, a hierarchical structure with one central node can be transformed into a network structure with multiple centers. The creation of this object facilitates an architectural understanding of innovation processes as a multi-dimensional system.

To address the changing interconnections of innovation processes, the tool offers a dynamic feature. If nodes are modified or manipulated, primary and secondary impacted connections and nodes are re-arranged. Moving a node, transforming its properties and connections, removing it or adding a new node changes the configuration of environment of the node and eventually the model. Architectural practice, management executives and employees can explore and test the consequences on the system's structure by merging departments (combining nodes), externalizing functions (removing nodes) or relocating teams or facilities (moving nodes).

For understanding and modeling the user can navigate with mouse, touch panel or keyboard commands through the virtual 3-dimensional space and view the inserted elements and developed structures from different perspectives. Navigation addresses the spatial intelligence of the users allowing them to perceive relations, connections and proximities with an architectural view and immerse themselves in different locations within the system of innovation. To maintain orientation, a view panel in the user interface displays the current viewpoint of the user. Similar to 3-dimensional modeling software (e.g., Rhinocerus) used in architectural practice, the simultaneous consideration of top and side views aids the analysis and design of a 3-dimensional structure. The user can further zoom out to receive a holistic view on the entire structure. The displayed elements aggregate into larger clusters to keep legibility (e.g., individuals to teams, teams to departments, departments to business units). Of general importance in a digital design tool are the possibilities to save and store the developed structure in the workspace. For comparison between alternative design directions, different statuses of workspaces can be imported and displayed. The workspace is a collaborative space. It allows multiple users to participate in the constructive processes, insert data and conduct design actions. This collaboration can occur synchronized when users interact at the same time or asynchronous, when users can individually join the workspace (Szopinski et al., 2020, p. 476).

To foster a design approach, especially in the early phase of the methodology, the synchronous collaboration is favored. It emphasizes a direct design discourse between architectural practices and client. Listening, understanding, criticizing and interpreting depend on the synchronous dialogue, as proposed also in design-driven innovation (Chapter 3.3.4). Involved stakeholders, active in the workspace, are members of the workspace and represented with an according mark (e.g., icon, avatar, portrait picture). Their authorization to modify and model within the workspace is defined and controlled by administrative rights in the settings. Communication features, as messaging and video are embedded.[114]

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[114] Online collaboration tools for whiteboards, mind mapping and idea generation integrate features for synchronous remote interaction. As outlined in Chapter 4, collaborative aspects are emphasized in existing applications, while modeling features for design (e.g., working with scale, units, proportions, spatial proximities and dynamics) remain limited.

A digital prototype application developed during an interdisciplinary project for this thesis at the Technical University of Munich displays a 3-dimensional configuration of functions as nodes of a fictitious organization (Figure 47).

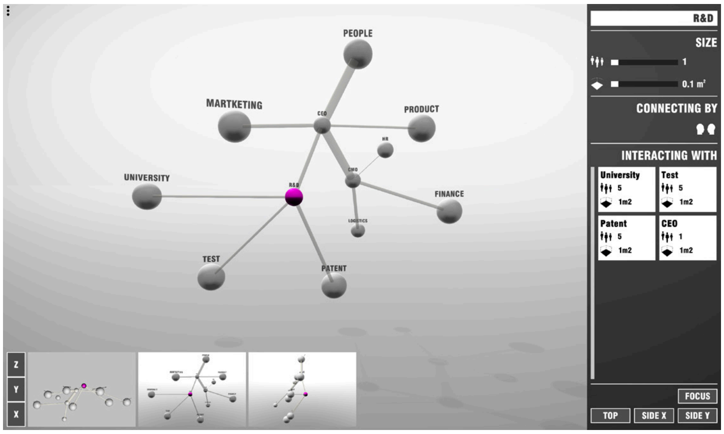

Figure 47: Prototype Interactive Design Tool (Semin & Shohina, 2019)

The digital prototype application developed in an interdisciplinary project for this thesis at the Technical University of Munich displays a 3-dimensional configuration of a fictitious organization. Controls allow the input of e.g., size of departments, or of type and intensity of interaction between two nodes. Additional windows show the configuration from different viewpoints. Visualization by the author using the prototype application by Semin & Shohina (2019).

Innovation processes are defined as multi-dimensional systems. The 3-dimensional Euclidian workspace provides a visual space for spatial analysis and design, which focuses on structure. Time as important dimension for innovation management is integrated upon this structure. The users add information regarding the movements of ideas and knowledge between nodes, and weigh their contribution to an innovation process. As the emergence of an innovative idea cannot be restricted to particular phases and interactions, the movements represent a principal itinerary through an organization on which the innovative contributions occur. With a timeline and motion path the tool can represent the path an innovation process takes. "[T]he often precarious route a selected idea can take into a firm's innovation funnel" (Van den Ende, Frederiksen, & Prencipe, 2015, p. 486) could be visualized with the model in entirely new ways and contribute to a deeper understanding. Changes in the connections, as well as changes in the location of nodes can alter the innovation process. To maintain visual legibility and secure the design process, form, color and size of node and connections in the workspace can be used to convey another layer of information that is needed in describing and understanding innovation processes (e.g., financial and other resources, legal requirements, associated external partners).

To assist future design processes, the tool is developed as an expandable platform. Design actions, collaboration and navigation are basic features. Further features as plug-ins, can extend the functionality of the tool according the requirements of the architectural practice and users. As examples, plug-ins for automated calculation, analysis and simulation can be possible (Schubert, 2021, pp. 116–118).

Regarding the first category, **calculation** plug-ins can provide information on people involved in particular innovation areas that are visible in the spatial structure. They can quantify the time people spent commuting for direct interactions face-to-face. As the connections are weighted by their value for and contribution to innovative outcomes, a calculation can show the intensity or overall weight of innovative discourses in certain clusters, which are manually selected in the visualization by the user. The plug-ins help to calculate past or present innovation processes by the time they need and the path they take.

Plug-ins for deeper **analysis** – beyond the design inquiry during the methodology – can locate many things including centers of gravity, structural holes and the shortest paths. The centers of gravity in this context represent an accumulation of inspiration, ideas or knowledge, which drive the course of action for an innovation. As they may not be formally assigned to innovation projects or officially positioned at a decision-making level, these centers can still be vital for informal assessment, criticism and valuable interpretations of innovative initiatives, which are not documented. With an analytical feature, organizations could see where centers of gravity reside and where they are likely to emerge. In the opposite direction, an analysis plug-in can detect structural holes rather than centers of gravity. In these areas, interactions are sparse or nonexistent. Siloed nodes do not contribute to or benefit from innovation processes and paths in an organization. The analysis could further reveal whether particular nodes and connections are constrained or shadowed by other nodes and their connections. With a visual analysis of the spatial structure, the participation of represented nodes in innovation can be assessed. Lines of visibility between nodes and accessibility to particular areas - familiar from space syntax analysis - can be investigated. Also, a path can be traced to see which nodes an innovative endeavor frequently passes through. Awareness and exploration among employees of a firm are important drivers of innovation processes. With a 3-dimensional model displayed in the workspace of the tool, these aspects become subject to analysis. The insights gained by analysis plug-ins require interpretation by the architectural practice and the involved stakeholders to reflect other possible causes unmatched by the tool. As co-designers they can re-configure the structure to strengthen one center of gravity or distribute it into several centers. They can bridge structural holes or remove siloed areas, shorten successful innovation paths or expand them for the whole organization to connect with other areas better.

In the third category, **simulation** plug-ins can process the 3-dimensional model and its embedded data. The plug-in can simulate the overall changes and impacts if nodes and their connections are moved, removed, added or merged. Different routes of innovation through the structure can be tested and discussed. Regarding the challenges to retrieve relevant and sufficient data and program appropriate algorithms, simulations are not a core feature of the tool.

The tool is intended to actively design a new configuration for innovation systems. Design solutions may result from unconventional, or disruptive proposals, which evolve during design discourse, exploration, play and experiment with the visualized and modelled information. Design synthesis combines the different and sometimes conflicting parts of innovation processes with a design theme and meaning which exceeds a functional arrangement of individuals, teams, departments or facilities. An organization's culture and values regarding innovation can be supported by a structure designed accordingly. For example, if an organization intends to encourage all its employees to be innovative, the tool can assist them to visualize, rethink and redesign hierarchical structures with a central node. If an organization intends to redirect the purpose and field of their innovations, they can use the tool nodes to visually locate connections and areas which contribute to this purpose and field, and may require strengthened connections or/and higher visibility. The visual collaborative design tool with its plug-ins supports architectural practices to apply the methodology. It supports its users from management practice to build a different view on innovation processes, collaborate visually and model spatio-visual structures. It promotes creative, constructive and collaborative thinking.

9.3.4 System Concept

To meet the explained properties and features, a system concept with four parts is suggested: a core application, software plug-ins, hardware plug-ins and exchange interfaces for integration into further software applications as shown in Figure 48.

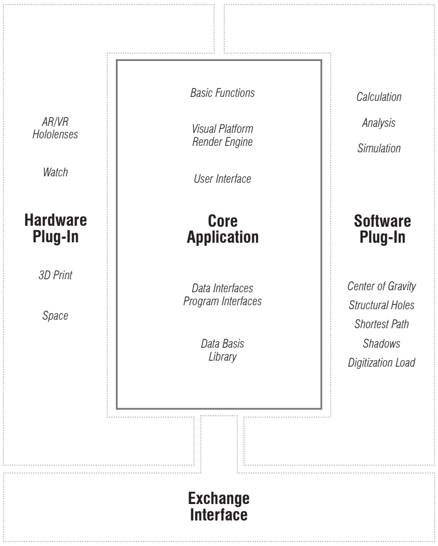

Figure 48: System Concept of a Digital Tool

The core application is a cloud-based platform. It functions independently from the particular device and operating system. Computing capacity and infrastructure are separated from the user's hardware. A cloud-based solution offers possibilities for customization needs upon user demands and the extension by additional features and plug-ins. In its core, the platform provides the central user interface and the virtual 3-dimensional workspace created by a render and game engine. It displays the basic features required by a user to insert information, to model, place, move, manipulate elements, to collaborate with other users, and to navigate through the workspace and constructed configurations. For real-time visualizations, instant representation of dynamic changes and seamless navigation, a game engine (incl. a render engine) is used.

Plug-in software as the second component processes the data and the developed 3-dimensional model. They are integrated into the core application and follow its user interface design and programming language. Software plug-ins represent actions, which are developed according to the needs and individual preferences of an architectural practice and innovation management. They are not restricted in number and functionality. As mentioned, they can conduct calculations, analysis and simulations in the context of innovation processes.

Hardware plug-ins are the third component in the system concept. They offer the possibilities of extending the visual collaboration workspace into other digital environments and of producing tangible artifacts. The diversity and functionality of hardware plug-ins are not limited. Their development and integration depend on the user's expertise, resources and objectives. For example, virtual and augmented realities or hologram functions can become useful extensions of the tool for an immersive experience and design process. The 3-dimensional workspace of the core application, its control panels and views can be displayed on devices for virtual or augmented realities. Users who collaborate with an immersive experience of space can craft (e.g., with handheld devices) the structure of a spatial innovation system and move virtually with body movements through the system. Augmented reality plug-ins can map the workspace area onto physical artifacts and real-life settings. The constructed 3-dimensional model could, for example, blend the virtually developed structures with existing or projected areas of a company (e.g., firm campuses, research and development areas), buildings (e.g., headquarters, innovation centers, research and development facilities) or floorplans (e.g., research labs, innovation labs, workshops, office spaces). Technological developments in workspaces and designed structure could appear as holograms and substitute for VR- or AR-devices at the user's end.

Another hardware plug-in could support the design process. The data of the virtual model with its spatial scale can be used for 3-d printed prototypes. A plug-in allows the users to print the virtual boundary object and alternative versions thereof as tangible artifacts. The design process could then be transferred to a real-life setting with discussion, collaboration and modeling on physical models. The shift from digital to physical models offers possibilities for new insights, as physical models address a broader number of senses and evoke direct, analog actions different to the actions triggered or conducted digitally. The physical objects can be reflected on, discussed and modified differently. If several alternative configurations exist, they can be compared simultaneously and evaluated. With tangible models, the "knowledge-in-the-making" (Nilsson, 2013, p. 1) of models from architectural design processes with its discussion on aesthetics can be introduced into innovation management.

Exchange interfaces are the fourth component in the system concept. The tool can be developed in a way which integrates it into separate applications or software, which benefit from the 3-dimensional structure of innovation processes and the related data. In the field of building architecture, an integration (or exchange) with building information modeling software can support the assessment of building designs. Planned space configurations for buildings can be evaluated by the extent they fit with the developed transformational model of the tool (see Appendix II.1 and II.2). In the field of innovation management software, the tool could provide spatial visualizations of the ongoing innovation processes. It could support acceptance and usage of the tool by the employees, as they could localize themselves in an organizational innovation system, become immersed and collaborate differently. The tool itself is then transformed from a strategic design device, as described in this thesis, into an individual innovation management application. The transformation model, which had been developed and visualized with the tool, serves in individual applications as a guidance model for constant assessment.[115] The transformation model can be shared with a larger group of users to either request feedback and iteration or promote the realization of the new configuration. As innovation processes are dynamic and continuously changing, the model itself is transformed and adjusted based on the collected data by the individual actors. In the visualizations of movements and interactions, social load, flow and emergence of innovative activities could be observed. With social load, the intensity of social interactions is described, which promotes idea and knowledge exchange. Possible further directions for development, which exceed the scope of the thesis, could integrate gamification elements to foster, track and reward innovative initiatives in a firm.

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[115] Pentland (2015, pp. 108–111) explains the development of the "Meeting Mediator:" A sociometric badge collects the interaction between different people, which is then visualized on a mobile phone, as a ball with strings to the different members of a group. When the ball has a central position, group interaction is supposed to be "healthy" (ibid., p. 109). When one person dominates interaction or one person does not engage sufficiently, team health is supposed to decrease and action is required.

9.4 Understand, Model, Architect

Innovation process design is itself a process of innovation. The methodology of AID provides a process of design to analyze, understand and develop an organizational structure that fosters innovation. The AID offers with the process and the tool a dynamic, multi-dimensional and visual model of innovation processes in a firm. As dynamics increase in economic environments, static, normative and descriptive models may fail to assist management executives in developing new structures. An architectural innovation design introduces two aspects into innovation management. Firstly, it introduces a design attitude based on diagrammatic and visual thinking. It gives management professionals an understanding of abduction, which allows new ideas to enter the discourse and evolve. Secondly, AID introduces a meaning into the construction of innovation processes and innovation systems. As design synthesis can only be achieved through the creation of a design theme and meaning, innovation management is challenged in the methodology to answer why and how the organization innovates. The methodology seeks a unity (or fit) of organization, culture, process and people, as it applies the design logic of designing a building to the design of innovation processes. Design judgements, intuition and design expertise are made accessible to innovation management to synthesize a new whole, a system that exceeds the sum of its parts. Architecture and building-related terms have been used as metaphors in management disciplines and innovation management. With AID, architecture itself can actively propose terms for the discourse of innovation processes in a firm, such as center of gravity, social load, visibility, accessibility, shape and shadow.

The constructed 3-dimensional model is an aid to innovation management and management executives. Once introduced and having become familiar, the model and the tool enable them to track performances, adapt the configuration or create a new configuration for changing environments. At an employee's level the model and the tool are aids to locate oneself, to explore and engage with innovation initiatives in a playful and design-orientated way. The employee himself or herself becomes a co-designer and architect of the innovation system. The system concept of the tool allows for extensions in this direction.

However, the AID is an architecturally driven methodology that may not be a substitute for established approaches in innovation management. A critical reflection from managerial and architectural practice will help to put the concept into perspective, and reveal the implications for refinement and future research directions.

10

10 – Critical Reflection with Expert Interviews

The methodology and the tool are developed from the perspective of architectural design on innovation theory and practice. The extended process view on innovation is based on an analysis of challenges and new demands in innovation research and management. The study of selected innovation process models and application for its management reveals a relevance of contextual, fluid, network and design aspects. These aspects are contrasted with the architectural design process and its suitability to be applied to strategic issues of innovation management. From practice, two project examples illustrate an architectural consulting process for innovation that serves as an ingredient for the development of an architectural innovation design methodology. The methodology is, on the one hand, enabling architects to work on organizational challenges of innovation. On the other hand, it offers innovation management a design-centered approach to configure an innovative system.

Yet, the question arises how this architectural innovation design would be perceived in practice. Would organizations actually use architectural thinking and tools to create new perspectives on understanding innovation processes, as the initial hypothesis states? Would practitioners welcome a non-linear and multi-dimensional approach, originating from the discipline of architecture that is based on an alternative model of innovation processes? Would the visualization of the organizational structure with a spatial dimension help deepen understanding and the future design of innovation processes?

To gain the first answers to these questions, the external perspective from possible users (or clients) is needed. Although architectural practices are addressed with this thesis, assessing the approach requires professionals who are dealing with innovation processes for and in organizations and who are distant to the field of building architecture. This distance from the field is relevant to reduce a disciplinary bias caused by a positive self-affirmation on the potential residing in architectural practices. The distance also allows an alternative perspective on the challenges of innovation processes. For the critical reflection, firstly the qualitative approach when conducting expert interviews will be described. Subsequently, interviews conducted with experts from knowledge-intense enterprises, from innovation consultancies and from architectural consultancies will be paraphrased. The chapter closes with an evaluation, conclusion and a discussion of limitations.

10.1 Interviews with Experts – A Qualitative Analysis

Qualitative interviews with experts offer a viable way to access particular knowledge and interpretations in a specific field (Bogner, Littig, & Menz, 2014, pp. 2, 22). Qualitative interviews seek to retrieve interpretative, tacit knowledge and reflective thoughts of the interview partners, raise open questions and are flexible or adaptable to changes in the turns an interview takes (Lamnek, 2010, p. 320). Furthermore, a qualitative interview relates to design dialogues and design discourses, which have been mentioned earlier as essential approaches in an architectural design process in order to access and retrieve knowledge from different stakeholders, and establish a collaborative environment.

Expert interviews are suited to retrieving a particular knowledge and interpretation from practice, regarding the changing and complex topic of innovation management (Bogner et al., 2014). In the context of this study, experts were searched for and chosen from practice to firstly, test the developed hypothesis and theoretical underpinning, and secondly, draft a first evaluation of the methodology and the tool. Against this background, experts are defined as professionals with successful approaches to innovation management and design, who receive broad attention and acceptance, and who create and shape with their approaches the behaviors of others and organizational innovations systems (Bogner et al., 2014, p. 13). Experts have a distinct knowledge in a field plus an influence on the acting of their surroundings. They shape thinking and doing in practices, and are socially accepted (ibid.). Additionally, experts are able to develop, apply and follow, value, evaluate and rate novel approaches. Their subjective interpretations are relevant, as they are often shared among colleagues and peers (Bogner et al., 2014, p. 19). Possible experts were searched and sampled in consideration of the referenced approaches and applications in Chapter 4 and Chapter 7. Regarding the number of qualitative interviews, recommendations in academic literature vary or are indeterminate (Dworkin, 2012, p. 1319; Sim, Saunders, Waterfield, & Kingstone, 2019, p. 621). The recommended range is between 5 to 50 interviews, with in-depth interviews to provide saturation between six to twelve (Boddy, 2016, p. 429; Dworkin, 2012, p. 1319; Mason, 2010, p. 3). The sample size is influenced by the focus of research, the type of interviews, the level of response of the interviewee, and the possibilities of approaching the intended groups. In the present study, the interviews are conducted to receive a first evaluation of the methodology and the tool, and show possible avenues for further research. Lee, Mitchell, and Sablynski (1999, p. 164) provide a further argument for this approach:

> *"Qualitative research is well suited for the purposes of description, interpretation, and explanation. In particular, it can effectively address questions such as "What is occurring?" and "How is it occurring?""*
>
> *(Lee et al., 1999, p. 164)*

Experts with years of professional experience and leading positions in their respective organizations were interviewed. This made it possible to focus on the relevant aspects of the study.[116] In total, eight interviews were conducted, as summarized in Table 15. In expert interviews, the subjective views of pre-selected experts from a particular field are of relevance, which on the other hand, limits the – negligible – representativeness (Lamnek, 2010, pp. 350–352). In this study, the perspective from leading innovation consultancies, architectural practices and knowledge-intensive, producing enterprises are considered. Diversity regarding gender, age and socio-economic background has been addressed in the selection of experts from different groups of entrepreneurs, managing directors and senior professionals, but could not be reached equally. From the perspective of innovation management consulting with novel approaches, two managing directors of Boston Consulting Group

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[116] The interviewees were approached through direct contact, existing personal and academic network.

Digital Ventures were interviewed, one managing director of Accenture technology innovation and one creative director of the consulting agency Futurice. The architectural perspective has been considered by interviewing one managing director of the international architectural practice Gensler and one co-head of Zaha Hadid Architects workplace strategies who additionally holds a chair for digital design in higher education in the field of architecture. The enterprise perspective is considered by experts in knowledge-intense industries with a dedicated focus on innovation processes. The senior director from SAP responsible for the global lead of Next-Gen Ecosystems at SAP was interviewed and the Head of Digital Office from Ottobock.

	Interview Partner	**Company**	**Position**	**Focus**	**Duration** (Transcript)
Innovation Consultancy	Alison Rushworth (01)	BCG Digital Ventures (BCG DV)	Partner and Vice President, Design	Consultancy as subsidiary of Boston Consulting Group for innovation, incubation and investment bcgdv.com	34:14 min 03.03.2021
	Jürgen Eckel (02)	BCG Digital Ventures (BCG DV)	Partner and Managing Director	Consultancy as subsidiary of Boston Consulting Group for innovation, incubation and investment bcgdv.com	35:58 10.03.2021
	Matthias Ziegler (03)	accenture technology innovation	Managing Director	Consulting unit for technology innovation in Germany, technology incubation in Europe, developing and applying technology innovation for and with clients accenture.com (>services >technology innovation)	43:59 20.04.2021
	Sven Bibi (04)	Futurice	Principal Design, Principal Strategy & Culture	Consultancy for digital product design and build, agile software development and lean organizational change futurice.com	49:21 min 16.03.2021
Architecture	Philip Tidd (05)	Gensler	Managing Director, Principal	Design practice for holistic improvements in human experience in urban environments, buildings and workplaces gensler.com	57:22 min 17.03.2021
	Uli Blum (06)	Zaha Hadid Architects (ZHA); Münster School of Architecture	Co-head ZHA workplace strategies department; Professorship for Digital Design	Global architectural studio for projects with transformational approaches zaha-hadid.com	61:55 min 12.03.2021
Enterprise	Konstantin Heckmann (07)	Ottobock	Head of Digital Office	Unit for digital innovation at Ottobock, a global leader in technology for wearable human bionics. ottobock.com	41:46 28.04.2021
	Deepa Gautam-Nigge (08)	SAP	Senior Director, Global Lead SAP Next-Gen	Software company with an innovation network for the next generation of decision makers and young entrepreneurs sap.com (>about >innovation >SAP Next-Gen)	44:00 12.03.2021

Table 15: Overview of Interviewed Experts

10.2 Methodology

The aim of the interviews is to access and retrieve the interpretive knowledge of experts ("Deutungswissen" acc. Bogner et al., 2014, p. 19) regarding innovation process design and the applicability of an architectural-based methodology. The methodological approach in this qualitative analysis comprises the interview design, the development of a sequence of questions, the conduct of the interviews and the analysis of the transcripts with a code system.

The interviews were designed as semi-structured expert interviews with open questions. The semi-structured approach assures to remain within the time frame the experts were available and to cover the relevant aspects for evaluation. For reasons of comparability between the experts, the questions and sequence have been kept similar. To access the interpretive and tacit knowledge of the interviewees, the semi-structure offers the freedom to adapt the course of the interview and revise, add or remove questions according to situational demands (e.g., if a novel and valuable topic arises during the answers). Through this kind of interview, the expert is not considered a provider of information and the interviewer is positioned as a cooperative partner or familiar expert in the field (Bogner et al., 2014, p. 52; Lamnek, 2010, p. 320). The questions were not shared with the interviewees prior to the interviews to maintain spontaneity and a "free-flowing speech" (Lee et al., 1999, p. 178; and Bogner et al., 2014, p. 30). The language in the interviews was either English or German, based on the preferences of the interviewees. Accordingly, questions and transcripts followed the agreed language. The formulations of questions were bilingual, as shown in Table 16. Due to the restrictions caused by the Covid-19-Pandemic, the interviews were conducted by the author via video-conferencing in a one-on-one situation (Zoom and MS Teams) in March and April 2021. The interviews were recorded as audio files with the consent of the interview partners and transcribed for evaluation acc. Dresing & Pehl (2018) transcription rules. The interview recordings were supplemented with post-interview memos. For reasons of comprehension and clarity, repetitions of words and fillers of words were removed or smoothed out in the transcripts if content of statement and answer was not affected. The interviews were not conducted anonymously in order to outline the professional environment of the interview partners and consider it in the qualitative analysis.

The questions were developed to assess the theoretical work of this thesis on two levels. The sequence of questions from number 1 to 9 directly address theoretical arguments developed in this thesis in Chapters 2, 3, 5, 8 and 9. The questions were grouped into four themes. Questions in the first theme address the relation of the interviewees' work to innovation processes and how they would characterize the process. They serve as introductory questions and provide first insights into whether the process view of innovation needs to consider new aspects. The second theme emphasizes the problem space of innovation processes. In this theme, problems or challenges in innovation processes were considered, extended process views investigated and conceptualizations or methods for innovation management and problem resolution were researched. Questions in the third theme address the capabilities needed to successfully deal with the problem space and manage or design innovation processes. Within this third theme, the interviewees were asked to consider particular capabilities such as visual thinking, relevance of visualizations, spatial intelligence and systemic thinking. In the fourth theme, the methodology and tools of an architectural innovation design are central. The AID methodology is described with words and then visually explained by the demonstration of a 90- second video of a prototypical tool.

Across the eight interviews, the order of questions and formulation were adjusted if answers by the interviewees led to other topics or if particular aspects of interest were stated. The semi-structured approach allowed the interviewer to adjust the interview and to maintain a fluent conversation. Questions which were not answered directly were reframed. Also, questions that were answered indirectly at another time during the interview were removed. Particular questions that evolved during the interviews were posed additionally. The principle sequence of questions and their formulation are shown in Table 16. It served as a guide for the interviews. The precise formulation and order of questions, as well as additional questions are documented in the transcripts of

Appendix III. The interview structure of questions enabled the interviewer to guide the experts from abstract and general themes of innovation processes to the concrete considerations of the AID methodology and its supporting digital tool.

At the second level, the questions are addressing a hypothesis and its sub-hypotheses of this thesis. As marked in Table 16, the questions support to assess the hypothesis and sub-hypotheses.

			Hypothesis	**Sub-hypothesis 1**	**Sub-hypothesis 2**
		Guide of Questions (Questions may differ across expert interviews)	Architectural thinking and tools of architecture are appropriate to create new and needed perspectives on the understanding and design of innovation processes.	Architectural thinking offers a non-linear, multi-dimensional approach to analyze and design innovation processes as dynamic systems, for which existing managerial approaches have reached their limits.	Architectural thinking and tools uncover a company´s informal process of innovation and add a third, a spatial dimension for its understanding and future organization.
Innovation Process	**1a**	How is your work related to innovation processes? Wie haben Sie in Ihrer Tätigkeit mit Innovationsprozessen zu tun?			
	1b	In a few words, what characterizes an innovation process? In wenigen Worten, was macht einen Innovationsprozess aus?		**x**	
Problem Space & Conceptualizations	**2**	Which challenges have you encountered in making enterprises (or your organization) more innovative? Auf welche Herausforderungen treffen Sie, um Unternehmen (oder Ihre eigene Organisation) innovativer zu machen?		**x**	
	3a	What is your approach to solving these challenges? Wie gehen Sie vor, diese Herausforderungen zu lösen?	**x**	**x**	
	3b	To what extent has your approach changed over the past years? Inwieweit hat sich ihre Herangehensweise über die vergangenen Jahre verändert?	**x**	**x**	
Capabilities	**4**	What capabilities does someone need for this task? Welche Fähigkeiten braucht jemand für diese Aufgabe?	**x**		
	5	What role do visualizations play in capturing relations & interactions spatially? Welche Rolle spielen Visualisierungen und die Fähigkeit, Relationen und Interaktionen räumlich zu erfassen?	**x**		**x**
	6	How could a spatial design discipline, for example an architect in architecture, help you in your work? (or: How could visualizations and spatial proximities play a role?) Wie könnte Ihnen eine räumliche Designdisziplin, bspw. ein/e Architekt/in bei Ihrer Arbeit helfen? (Oder: Wie könnten Visualisierungen und räumliche Nähen eine Rolle spielen?)	**x**		**x**
Methodology & Tool	**7**	Imagine an architecture firm offers a new service. It captures challenges, requirements and interactions of innovation processes in a company visually, with sketches, diagrams, models. Together with the company, the practice develops a 3-dimensional structure showing people and departments with their relational and spatial proximities to each other. What benefits do you see in this? Angenommen, ein Architekturbüro bietet eine neue Dienstleistung an. Es erfasst Herausforderungen, Anforderungen und Interaktionen von Innovationsprozessen in einem Unternehmen visuell, mit Skizzen, Diagrammen, Modellen. Das Büro entwickelt zusammen mit dem Unternehmen eine 3-dimensionale Struktur, die Personen und Bereiche mit ihren relationalen und räumlichen Nähen zueinander zeigt. Welchen Nutzen sehen Sie darin?	**x**		**x**
	8	You can actively participate in this design process. You can change and model the structure until you have developed an organizational structure that enables better innovation processes. To what extent and in what way is interacting (i.e. collaborating on and modeling with the structure) relevant for you? Sie können aktiv diesen Entwurfsprozess mitgestalten. Sie können die Struktur verändern und modellieren, bis Sie eine Organisationsstruktur entwickelt haben, die bessere Innovationsprozesse ermöglicht. Inwieweit und in welcher Art ist interagieren (d.h. kollaborieren an und modellieren der Struktur) für Sie relevant?	**x**	**x**	**x**
	9	To make the structural model more tangible, I demonstrate a digital application for 90 seconds. What possible use cases could you think of? Um das Strukturmodell greifbar zu machen, führe ich ihnen eine digitale Applikation für 90 Sekunden vor. Welche Anwendungsmöglichkeiten sehen Sie?	**x**	**x**	**x**

Table 16: Guide of Questions

The questions incorporate aspects regarding methodologies and methods used by the experts to address innovation processes; they comprise aspects regarding capabilities; and they address aspects regarding the AID methodology and its tool. For example, questions regarding problem space, conceptualizations and practiced approaches indirectly consider agility in process refinement, systems view, the use of non-verbal tools, empathy and deep understanding. Questions regarding capabilities indirectly address whether non-linear and multi-dimensional thinking was regarded as beneficial to innovation management. In asking about the relevance of visual and spatial thinking, the questions are directly aimed at the sub hypotheses, without stating them. In the subsequent evaluation, the answers to the following questions could be related to the hypothesis and sub hypotheses:

> *Questions 3-9 relate to:*
>
> *H1: Architectural thinking and tools of architecture are appropriate to create new and needed perspectives on the understanding and design of innovation processes.*
>
> *Questions 1b-3; 8,9 relate to:*
>
> *SH1: Architectural thinking offers a non-linear, multi-dimensional (3-dimensional plus) approach to analyze and design innovation processes as dynamic systems, for which existing managerial approaches have reached their limits.*
>
> *Questions 5-9 relate to:*
>
> *SH2: Architectural thinking and tools uncover a company's informal process of innovation and add a third, a spatial dimension for its understanding and future organization.*

Additional questions and answers occurring during the interview were considered and evaluated accordingly.

The transcripts were evaluated with a coding approach and the use of a qualitative data analysis (QDA) software (Kuckartz, 2010).[117] The codes mirror the terms introduced in Chapter 2, 3, 5, 6, 8 and 9. Additional codes were built during the analysis phase and supplemented. The codes were categorized and related to the theoretical underpinnings of this study (see Table 17):

- **Innovation process and extended process view on innovation:** Codes are built according to the categories of complexity, social proximities and process design, introduced in Chapter 2.
- **Conceptualization & Model:** Categories and codes consider thinking about innovation and innovation processes (i.e. conceptualizations), applied methodologies, methods, approaches and aspects of a design process. They render the theoretical arguments of Chapter 3, 5, 6.
- **Architectural Innovation Design Methodology (AID):** The categories and codes cover the different elements of the AID methodology. They address the capabilities and mindsets considered relevant to manage and design innovation processes. They outline the frames (i.e. conception) the experts possess regarding architecture and space. They consider the perception of the AID methodology and they capture the perception of the prototypical tool. Additional codes were built to consider the practicability of the methodology and the tool, viewpoints and particular terms used by the interviewees.

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[117] In this study the software MaxQDA Plus 2020, Release 20.4.0, was used.

The codes were also assigned to one or more questions which underline the cross-references between the answers (see Table 18). To evaluate the hypothesis and sub hypotheses, the answers of the interviewees were coded by their rate of support or refusal. If the number of coded supporting and refuting answers differed by 8-10 codes, strong support or refusal was stated. If the number of coded supporting and refuting answers differed by 5-7 codes, tend to support or tend to refuse was stated. If the number of coded supporting and refuting answers differed by 2-4 codes, interest was stated. If the number of coded supporting answers equals coded refuting answers or differed only by 1, a neutral or indifferent position was concluded.

Cluster	Codes by Categories	Single Codes	Frequency (of 1163)	In %
Extended Process View on Innovation Chapter 2 27,2%	**Complexity**	Complexity	21	1,8%
	6,3%	Change	20	1,7%
		Ambiguity	1	0,1%
		Dimensions	17	1,5%
		Organizational Structure	14	1,2%
	Social Proximity	Human / People	32	2,8%
	15,6%	Awareness	3	0,3%
		Connectivity / Crossing / Network	22	1,9%
		Diversity / Multidisciplinarity	19	1,6%
		Communication	9	0,8%
		Culture / Mindset	7	0,6%
		Relationship	8	0,7%
		Creativity	16	1,4%
		Tacit / Implicit Knowledge	8	0,7%
		Informality	10	0,9%
		Spatiality / 3D	47	4,0%
	Process Design	Process Design	0	0,0%
	5,3%	Short- / Long-term View	10	0,9%
		Systems Thinking / Holistic Thinking	17	1,5%
		Artifacts / Boundary Objects	25	2,1%
		Indirect Design / Learning by Seeing, Doing	10	0,9%
Conceptualizations & Models Chapter 3,5,6 26,8%	**Model, Conceptualization**	Model Thinking / Conceptualization	33	2,8%
	10,1%	Work Relation to Innovation	17	1,5%
		Innovation Process	52	4,5%
		Challenge Mental Model	11	0,9%
		Challenge Incentives	4	0,3%
		Challenge User Centerdness & Test	1	0,1%
	Methodology, Method	Methodology, Method	54	4,6%
	8,1%	Expertise / Experience	7	0,6%
		Understanding	33	2,8%
	Design Process	Design / Design Process	53	4,6%
	8,6%	Speculative Design	4	0,3%
		Sketchy / Conceptual	5	0,4%
		Play	14	1,2%
		Synthesis	7	0,6%
		Tool	17	1,5%
Architectural Innovation Design Methodology (AID) Chapter 2,5,6,8,9 46,0%	**Capabilities / Mindset**	Capabilities / Mindset	38	3,3%
	11,4%	Guiding / Moderating	12	1,0%
		Translating	14	1,2%
		Visual Thinking	9	0,8%
		Visualization	60	5,2%
	Frame	Frame	2	0,2%
	8,8%	Frame Architecture	62	5,3%
		Frame Space	38	3,3%
	Perception AID	Perception AID Methodology	40	3,4%
	17,5%	Increased Understanding	26	2,2%
		Interaction	23	2,0%
		Communication	18	1,5%
		Collaboration	28	2,4%
		Engagement / Immersion	22	1,9%
		Modeling	24	2,1%
		Construction	15	1,3%
		Exploration	8	0,7%
	Perception Tool	Perception Tool	33	2,8%
	8,3%	Practicability	33	2,8%
		Simulation	13	1,1%
		Dynamics	6	0,5%
		View Points / Perspectives	7	0,6%
		Text	2	0,2%
		Gravity	1	0,1%
		Scale	1	0,1%

Table 17: Codes by Addressed Category

Table 18: Codes by Addressed Questions

		Guide of Questions (Questions may differ across expert interviews)	Codes by Questions (for qualitative analysis)
Innovation Process	1a	How is your work related to innovation processes?	**Consulting** **Design**
	1b	In a few words, what characterizes an innovation process?	**Complexity** **Change** **Interaction** **Innovation Process**
Problem Space & Conceptualizations	2	Which challenges have you encountered in making enterprises (or your organization) more innovative?	Complexity Interaction **Organizational Structure** **Creativity** **Informality** **Communication** **Engagement** **Exploration** **Learning** **Short- / Long-term View**
	3a	What is your approach to solving these challenges?	**Model** **Methodology** **Method** **Multidisciplinarity**
	3b	To what extent has your approach changed over the past years?	**Expertise / Experience** Learning
Capabilities	4	What capabilities does someone need for this task?	**Capabilities** **Mind-Set** **Speculation** **Construction** **Guidance** **Synthesis**
	5	What role do visualizations play in capturing relations & interactions spatially?	**Visual Thinking** **Visualization** **Spatiality / 3D** **Artifacts / Boundary Objects** **Text**
	6	How could a spatial design discipline, for example an architect in architecture, help you in your work? (or: How could visualizations and spatial proximities play a role?)	**Architecture** **Architectural Thinking** **Systems Thinking** **Holistic Thinking**
Methodology & Tool	7	Imagine an architecture firm offers a new service. It captures challenges, requirements and interactions of innovation processes in a company visually, with sketches, diagrams, models. Together with the company, the practice develops a 3-dimensional structure showing people and departments with their relational and spatial proximities to each other. What benefits do you see in this?	**Conceptual** **Ambiguity** Boundary Object Spatiality Architectural Thinking
	8	You can actively participate in this design process. You can change and model the structure until you have developed an organizational structure that enables better innovation processes. To what extent and in what way is interacting (i.e. collaborating on and modeling with the structure) relevant for you?	**Modelling** **Collaborating** **Immersion** **Perspective** **Simulation** **Practicability** Engagement Exploration Informality
	9	To make the structural model more tangible, I demonstrate a digital application for 90 seconds. What possible use cases could you think of?	**Tool** **Dynamics** **Gravity** **Scale** Practicability Short- / Long-term View Exploration Informality

10.3 Evaluation of Themes

Eight interviews were conducted with experts from different professional groups. As the thesis is located at the interface of the discipline of management and architecture, representatives from both fields were approached. For the management perspective, experts from innovation consultancies and experts from knowledge-intense enterprises were interviewed. For the architectural perspective, experts from design practices took part. Innovation consultancies are regarded in this thesis as service providers that consult organizations from different fields in topics of innovation, e.g., in new business and venture creation, in innovation development, innovation management and the build-up of innovation capabilities. The selected experts belong to globally acting and leading large-sized consultancies in that field with more than 500 people employed. From BCG Digital Ventures (BCG DV), a partner and vice president of Design, Alison Rushworth and a partner and managing director, Jürgen Eckel were interviewed separately. From Futurice, Sven Bibi, a principal of design, strategy and culture was interviewed. From accenture technology innovation, Matthias Ziegler, a managing director for technology innovation in Germany and technology incubation in Europe was interviewed. To consider an internal organizational perspective, experts from knowledge-intense enterprises were approached. These enterprises are characterized by a high level of knowledge work for innovation and development of their services and products. In contrast to innovation consultancies and architectural practices, these companies would apply an AID methodology directly to their internal innovation process management. Representatives of a large-sized enterprise software company and a large-sized manufacturing company for advanced wearable human bionics were interviewed. Deepa Gautam-Nigge, senior director and global lead of SAP Next-Gen from SAP participated, and Konstantin Heckmann, head of digital office from Ottobock. With their answers an organizational perspective was integrated. Experts from the field of architecture were selected for their visibility, their interdisciplinary approaches and activities in areas besides traditional building design. Gensler, globally one of the largest architectural design practices, offers a wide range of consulting services in the built environment. Its workplace and early-stage consultancy addresses issues of innovation for organizations. For this study, Philip Tidd, managing director and principal with years of experience in workplace consulting, was interviewed. A further architectural design perspective was brought in by Zaha Hadid Architects. Besides its leading role and expertise in parametric design and advanced building design the practice has developed a unit for analytics and insights that addresses workplace strategies. Its co-head, Uli Blum was interviewed for this study. He also contributes an academic perspective with his professorship for digital design at the Münster School of Architecture.

The interview partners participated voluntarily and expressed a positive attitude towards the study and questions. Their answers were evaluated by the codes listed in Table 17 and by codes supporting or refuting the hypothesis and sub hypotheses. The codes were summarized according to the themes that the questions addressed: innovation process, problem space & conceptualizations, capabilities, AID methodology & tool.

10.3.1 Innovation Process

The professional work of the interviewees relates differently to innovation processes. On the one hand, the innovation itself is core to their scope of work. The experts (01, 02, 03, 05, 06, 08) search for new ideas and develop them for implementation in collaboration with the client or organization. This includes also the architectural practices. They describe their work in the following way; "always push the boundaries in thinking of what is possible (App. IIII.6, Blum, 2021, Pos. 30-31) in designing a new artifact or by fostering a "never happy, never comfortable mindset" (App. III.5, Tidd, 2021, Pos. 399). On the other hand, the innovation consultancies and architectural practices (01, 03, 04, 05, 06) support, help and enable clients and organizations to meet their challenges in innovation, to find and solve frictions in order to reach or maintain a leading position in existing or new markets. The experts from innovation consultancies meet the demands by applying developed methodologies and approaches. The architects interviewed answer the challenges posed by their clients by understanding behaviors in spatial configurations, by analyzing connectivity and human interactions. The experts from knowledge-intense enterprises distinguish between internal and external innovation processes. In external innovation processes they focus on improving the interactions of different stakeholders and how the concrete outcome of innovative initiatives can be defined and pursued. Internal innovation processes are more structured to optimize existing operational processes in the respective company. Two experts from innovation consultancies (02, 03) pointed out that an innovation as outcome is difficult to separate from the innovation process itself. In their experience, focusing on an innovation necessarily entails dealing with the innovation process in an organization for its development and implementation.

Innovation processes are described with aspects of friction, change and risk that cause misunderstandings, concerns and resistances among employees. The interaction of a larger number of people is essential for innovative projects, as the need for different areas of knowledge, different skills and expertise has risen. An innovation process integrates diverse views and skills from different disciplines and a cross-functional exchange between different management levels. Though the relevance of collaboration is mentioned, the "quiet headspace" (App. III.1, Rushworth, 2021, Pos. 212) and developmental aspects which turn ideas into tangible outcomes and results is emphasized (01, 02). Result-orientation is also highlighted in the enterprise view (08).

An innovation process is a particular structure that offers, on the one hand, a freedom of action; on the other hand, it guides us through different phases to implementation. It is a long-term process, whose impact on the organization is "not going to be immediate" (App. III.1, Rushworth, 2021, Pos. 93-94). From one architect's perspective, the process "needs to be learned" meaning to "actually train our innovative mind further." (App. III.6, Blum, 2021, Pos. 20-22). The experts share an understanding of innovation processes as driven by human interaction, interdisciplinary work, cross-functional exchange and commitment. Innovation needs to be understood on multiple levels, which are referred to as dimensions by the interviewees, e.g., the incentive structure to promote innovation, the result-orientation, the different roles people have in an organization, the informal relationships and communication between people, the frictions between different people, teams or departments, and the frictions between hierarchies (01, 02, 04, 06, 08). The experts' views differ regarding the problems and challenges they face in innovation processes, and how to address them.

10.3.2 Problem Space & Conceptualizations

Employees' behaviors, organizational structures as well as the cultural and technological capabilities of the firm are seen as recurring challenges in innovation processes. The experts point out that employees often resist questioning the status quo, miscommunicate or misunderstand each other and remain in their "thought cages" (App. III.1, Rushworth, 2021, Pos. 72-81). These thought cages prevent employees from trying out new processes, or imagining a different kind of organization and collaboration with others. A similar view is shared by the experts from architectural practices. In their experience, organizations (respectively clients) tend to stress the complexity of their established structures, which they consider difficult to understand or change. But when the architectural practices conduct a deeper analysis, they manage to develop simplified views on the organization, which supports the client to reflect its complex structures and leave its mental frames. The moment a company "is actually thinking about themselves," is "usually when they start to build a building. When they think of buildings" (App. III.6, Blum, 2021, Pos. 380-382). In this reflection, when a building design is intended, a "process of engagement" (App. III.5, Tidd, 2021, Pos. 138) with the client begins. The sometimes distorted self-image of an organization and its processes becomes visible.

From an enterprise perspective these deep understandings of relations, interactions and structures which hinder innovation processes require time to be discovered and uncovered (08). A 360°-degree view ("360-Grad-Blick", App. III.8, Gautam-Nigge, 2021, Pos. 60), mainly conducted by verbal communication, helps to discuss and clarify the expected outcomes of an innovation initiative, to define performance indices and their measurement. In this expert's interview, resistances are not necessarily considered as impediments to an innovation process. They may be rooted in an aversion to risk, but also be an expression of a critical position to the proposed innovation process: a feeling that important aspects have been overlooked or not integrated. In an example mentioned during the interview, the deeper understanding of resistances uncovered a situation the involved departments and the executive levels were not aware of (App. III.8, Gautam-Nigge, D., 2021, March 09, Pos. 355-378). With the demand for a holistic view to understand a situation, an organization should also develop a long-term perspective and align its structure to this perspective, which in practice is difficult to do.

The lack in organizations of a futuristic and speculative way of thinking as well as a positive attitude is outlined by three experts from innovation consultancies (02, 03, 04). Making progress with innovations requires an open, multi-disciplinary and cross-functional collaboration, and according to one expert, appropriate incentive structures (02). In his view, especially in large corporations, employees do not feel encouraged to innovate if the benefits are not clearly visible or communicated. Innovation needs to be supported and initiated by the executive level, top-down. This view is underlined by another expert from innovation consultancies and indirectly by one expert from architectural practice. In the experience of the latter, the executive level needs to be approached and addressed first in questions of innovation and change. In contrast, the two other experts from innovation consultancies argue that challenges of innovation need to be welcomed by everyone and understood across an organization. The culture and mindset to promote innovation, which was phrased by one expert in this way, needs to be combined with the right infrastructure and technological capabilities within an organization to actually realize novel ideas (App. III.3, Bibi, S., 2021, March 16, Pos. 26-30). Innovation, in his words, cannot be carried out and decided on top down, and then driven, but is actually something that needs to be present in the entire organization with the understanding that it makes sense, that it serves and addresses the sustained existence of the enterprise and the organization (translated by author; App. III.3, Bibi, S., 2021, March 16, Pos. 30-34).[118] Similarly, a second expert from innovation consultancies describes innovation as a task for all employees across an organization, and not, as he observes in practices, a work of innovation specialists (App. III.3, Ziegler, M., 2021, April 20, Pos. 100-103). Indirectly, one expert with an architectural perspective supports this aspect by outlining the relevance of an organization's social network and the level of connectivity it creates for its employees (06). With connectivity he relates the distances between office desks and the walking ranges of employees to the probability of direct communication face-to-face (App. III.6, Blum, U., 2021, March 12,

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[118] „Und die Herausforderungen bestehen da drin, dass Innovation nichts ist, was top down durchgeführt und entschieden und dann getrieben werden kann, sondern eigentlich was ist, was in der gesamten Organisation vorhanden sein muss als Verständnis dafür, dass es einen Sinn ergibt, dass es dem nachhaltigen Bestehen oder Bestand des Unternehmens und der Organisation dient und gilt." (App. III.3, Bibi, S., 2021, March 16, Pos. 30-34).

Pos. 66-71). An organization needs to see and understand the ties between its employees also in spatial dimensions.

Methodologies and approaches differ among the experts. Three experts foreground a methodology and method which they have developed over the years. A double-diamond methodology of diverging and converging phases and advanced versions of design thinking methods were described by two experts from innovation consultancies and one expert from the field of architecture. The methodologies are adjustable in their duration, depending on the time given by the clients and the core goal of the assignment. In one interview, a general design thinking methodology got incorporated into the consulting services by acquiring a design firm. The particular and generic design thinking process had been implemented across the organization and adjusted to the needs of different consulting and development areas for e.g., strategy, technology or software architecture. (App. III.3, Ziegler, M., 2021, April 20, Pos. 61). Collaboration in the methodologies was highlighted in two respects, the collaboration within the team and the collaboration with the client. Multidisciplinary and diverse teams are assembled in accordance with the needs of the client and the nature of the challenge. The collaboration with the client, its employees and further stakeholders is crucial. The innovation consultancies seek to embed themselves in the client's organization, or to "embed as many of their team as we can into the process so they become part of that innovation hub, effectively" (App. III.1, Rushworth, 2021, Pos. 114-116). In the architect's practice, this is addressed by a "process of engagement" (App. III.5, Tidd, 2021, Pos. 138). It shows a similar rate of embeddedness. Phases of the analysis work - what the architects understand by applying their thinking and tools - and synthesis work – what the architects design as a solution - are conducted through their digital tools in a co-operative way (App. III.5, Tidd, P., 2021, March 17, Pos. 495-500).

Three experts described their way of working as a freely developed approach, based on their experiences and learning over the years. The 360-degree view, mentioned earlier, evolved from experiences in working in a start-up and being challenged to understand and integrate the different and diverse perspectives of customers and their processes. In one interview, the individual approach is explained as a combination of disrupting creativity and structured stability (02). Creativity from the interviewee's perspective is considered to mean a willingness to question and transform the status quo; stability is considered to mean having the structure and discipline to develop and deliver an outcome of the initiated idea (App. III.2, Eckel, J., 2021, March 10, Pos. 171-176). One expert of innovation consultancies frames his approach as a moderating role between different stakeholders (04). With his disciplinary background in industrial design, he is experienced in transforming ideas and concepts into tangible outcomes. Accordingly, he supports the client in translating the different languages of its employees and stakeholders into a visual form that everyone understands (App. III.3, Bibi, S., 2021, March 16, Pos. 85-89). Additionally, with this operational level of moderation, he emphasizes the need for interdisciplinary discourses to reflect perspectives, goals and problem-solving approaches in other fields. In his practice, he achieves this by a "sounding board" (App. III.3, Bibi, S., 2021, March 16, Pos. 196-218), a group of experts from different fields who openly discuss a problem in the context of the respective field and possible solutions.

In two interviews, the experts described the indirect effect of their work on innovation processes for the consulted organization (01, 04). Though not directly assigned to transform the innovation processes of a firm, their work induces a learning process on the client's side. The way the innovation consultancies work, from a method and spatial perspective, demonstrates to the employees of the client a different innovation process. By seeing and experiencing the methods of consultancies and by working with them in joint teams, the organizations adopt and internalize new processes.

Physical space was addressed by the experts as relevant for "cross pollination of ideas (…) as serendipitous collisions" (App. III.1, Rushworth, A., 2021, March 03, Pos. 179-180), for creative exchange, for connectivity, for awareness, for engagement, for the manifestation of working rituals, and for learning processes. In their physical designs, the spaces can also decipher the modes of collaboration prevailing in an organization (08). The increased need for agile working had also transformed physical space. "Agility becomes lived in space," as one expert from architecture explains, "And having walls between people means also having walls between thinking of people" (App. III.6, Blum, U., 2021, March 12, Pos. 400-404). But people and their relationships remain more important to the innovation process itself, as the architect added. Two experts from innovation consultancies and one expert representing the enterprise view state this similarly. Physical space can be supportive, but relational aspects, incentive structures and the composition of teams with different skill-sets and capabilities are considered more relevant. The increase in remote and virtual collaboration, especially in response to the Covid-19 pandemic, may support these views further.

To sum up, successful innovation processes rely on social interactions and the commitment to innovation by the employees and the executive management levels. Understanding is central in two respects: firstly, people need to develop a common understanding among each other about why to pursue innovations, what problem to address, and how to proceed; secondly, the consulting party needs to develop a substantial understanding of the different stakeholders, the people in an organization, their behaviors and their motivations to accept and pursue an innovation. The prevailing mental models, or thought cages, as well as the self-image of an organization need to be addressed in collaboration with the client. Methodologies and methods exist, but are not evenly applied by the experts, as some have developed their own approaches over the years. Methodologies and approaches help to engage and embed the people in the redesign of their innovation process. This is achieved by moderating the development of a mutual understanding or by translating verbally communicated information and knowledge into visual forms. Methodologies and approaches combine a creative element of disruption, of speculative and futuristic thinking, with a structured element of disciplined work. The disciplined work implies a critical and holistic consideration of stakeholder perspectives and the development of an expected outcome, e.g., an innovation itself or the development of cultural and technological capabilities in an organization to innovate. Incentive structures and the sense-making of innovation are subsumed under the cultural capabilities. The question of whether innovation processes need to be initiated top-down or bottom-up marks two extreme positions.

10.3.3 Capabilities

The questions regarding capabilities were addressing what characteristics professionals need to manage and design an innovation process. This broad frame offered the experts an interpretive margin of discretion to emphasize particular aspects and suggest further terms used in their respective field. The relevance of visual thinking and visualization was directly asked about in order to guide the interview towards the field of architectural practice. Asking how architects could contribute to innovation management was intended to reveal the prevailing conceptions of the interviewees regarding architectural discipline and the architectural profession. Its aim was to investigate the kind of capabilities the experts regard as valuable in architectural practices. The answers show a broad range of capabilities and skills, but also question whether the terms are appropriate to describe the individual qualifications needed to deal with innovation processes. Two experts from innovation consultancy and architecture (01, 05), foregrounded multidisciplinary teams which combine different skill-sets of individuals depending on the nature of the questions posed by the client. From an innovation consultancy view, the mind-set is more important than a particular skill. It is described as; "to have a sort of fail-first, fail early approach", of "(…) being willing to break stuff" and knowing how to do what needs to be done in the particular situation (App. III.1, Rushworth, A., 2021, March 03, Pos. 161-169). From an architectural practice view, the "never happy, never comfortable mindset will always drive you to do better" (App. III.5, Tidd, 2021, Pos. 399). The practice seeks and combines people with different skill-sets to best meet the task at hand. Individual skills are of less importance then the skill-set provided by a team.

The capability for systematic and holistic thinking is considered by the mentions of a 360°-degree view and the deep understanding of behaviors and interactions. Long-term thinking is covered by the interviewees through terms such as futuristic or speculative design, strategic thinking, through the creative disruption and the mind-set of pushing the boundaries and continuously seeking a better solution (02, 03, 04, 05, 06). This requires, on the one hand, an openness to collaboration in diverse teams, to being critical, curious and willing to learn, to being optimistic and to being disciplined in the conduct of the work. On the other hand, resilience and patience is important in order to proceed and to address recurring difficulties and adapt the process to new circumstances and requirements with agility. One expert outlined the importance of developing a narrative and of being a storyteller, an influencer and a person able to engage with other people and win them over for the purpose and successful implementation of the project (App. III.3, Ziegler, M., 2021, April 20, Pos. 113-115; 140-142). This guiding role is also underpinned by an enterprise perspective. For the analysis of an innovation process and its development, it is important to provide orientation and set a frame ("Bezugsrahmen"; App. III.8, Gautam-Nigge, 2021, Pos. 438-441) the people involved can relate to. The experts from enterprises, innovation consultancies and one architectural practice agree that the process of innovation needs to be moderated. One expert (04) highlighted the capability to moderate and translate verbal language into tangible forms in order to create a common understanding between the different stakeholders and their respective views on a problem and process. Similarly, a second expert (03) from innovation consultancies explains the benefit of integrating colleagues as illustrators or graphic recorders. (App. III.3, Ziegler, M., 2021, April 20, Pos. 149-151; 281-282). They translate communications during meetings or workshops in visual representations. Furthermore, colleagues experienced in design thinking methods show others how to set-up, moderate and conduct these workshops (ibid, 104-106).

The relevance of visual thinking and spatial visualizations has been addressed in the interviews. It makes it possible to investigate particular models for analysis and understanding in the context of this study. For innovation consultancies, visualizations are considered important for several reasons. They make it easier to structure thoughts and to reflect thoughts by externalizing them, for example, on a white board or wall (App. III.2, Eckel, J., 2021, March 10, Pos. 190-207). The physical presence of visualizations in a room is supportive for reflection, especially in its simultaneity as digital devices with a screen show only a limited section of information. Visualizing is seen to discipline the work, especially for attaining an overview on a topic. Value stream mapping, process or stakeholder mapping and the visualization of ecosystems through charts and diagrams were mentioned (App. III.2, Eckel, J., 2021, March 10, Pos. 287-291; App. III.1, Rushworth, A., 2021, March 03, Pos. 249-250). One expert (04) described visualizing as part of his daily routine when consulting processes. The mapping of different perspectives of users, their activities, movements and systems they work in offers him a deeper understanding. In his view, it is very helpful to transform thoughts that are often expressed in words into tangible, visual forms. As a visual thinker you are well suited to moderate innovation processes, define interfaces and bridge communication between different stakeholders (App. III.3, Bibi, S., 2021, March 16, Pos. 85-101). Visualizations make it possible to capture complexity, especially in topics of digitization, and describe both abstractly and concretely the dependencies of different fields (App. III.3, Bibi, S., 2021, March 16, Pos. 97-101).[119] From an architect's perspective, "using a lot of different kind of visualization tools or diagrams or things to try to communicate" (App. III.5, Tidd, P., 2021, March 17, Pos. 352-353) with the client, supports the process of engagement with the client, to simplify and understand his or her complexity. The information they receive is compared to "usual tropes that come out from clients about the complexity" (App. III.5, Tidd, P., 2021, March 17, Pos. 364-365) in their organization and processes. In their architectural practice they metaphorically "cut through" and "chop down" (App. III.5, Tidd, P., 2021, March 17, Pos. 365-368) these tropes and reassemble the elements to fit with the way they have understood the client's wishes. Visualizations are "incredibly important" (ibid., Pos. 317) to synthesize and communicate understandings, ideas and concepts and to engage with the client (ibid., Pos. 351-352). This aspect is also stressed by innovation consultancies. Visualizations are incredibly helpful ("unfassbar hilfreich", App. III.2, Eckel, J., 2021, March 10, Pos. 217) to communicate with users and with decision makers and explain the task at hand. Visual thinking is considered by two experts as important to understand relationships, integrate perspectives and reflect on the structure of systems and activities. In one example, the use of tangible objects as in LEGO Serious Play[120] transfers discussions and perceptions onto systems and processes in a spatial dimension. The spatial experience fosters an immersion and a deeper understanding of complex structures, an innovative product or service (App. III.3, Ziegler, M., 2021, April 20, Pos. 154-164). The spatial experience invites users to apply creative reasoning or play, and addresses the senses and encourages intuitive collaboration, which, on digital applications or in a 2-dimensional mode are rarely activated. The spatial dimension was differently described in the interviews. On the one hand, the experts related the spatial dimension to physical spaces for creative collaboration. On the other hand, the space was regarded as a frame for the display of relationships or systemic configurations. In its physical meaning, the space allocation of people is regarded as "fundamental" (App. III.1, Rushworth, A., 2021, March 03, Pos. 177), when considering the importance of collaboration, serendipitous encounters, informal thought exchange and non-verbal communication for

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[119] "Visualisierung spielt immer wieder eine besondere Rolle, weil ich glaube, auf der Ebene der Komplexität von Themen, mit denen ich mich beschäftige im Kontext Digitalisierung zum Beispiel, man nicht umherkommt, von der reinen verbalen Ebene sich zu verabschieden, hinein in eine Ebene, wo wir vielleicht abstrakter, aber trotzdem auch konkreter die Abhängigkeiten von unterschiedlichen Themen zueinander beschreiben können." (App. III.3, Bibi, S., 2021, March 16, Pos. 97-101).

[120] Lego Serious Play is described as „methodology [...] designed to enhance innovation and business performance" by following a guide of questions and building a „3D LEGO model [...] using specially selected LEGO elements. These 3D models serve as a basis for group discussion, knowledge sharing, problem solving and decision making." (LEGO, 2022).

innovative work (01, 03, 07, 08). In its meaning as a frame for visualization, the spatial dimension allows the display of further information, such as distances, proximities, relationships and interdependencies, which may not become visible in a 2-dimensional way (01, 03, 04, 06, 07). Three experts consider spatial visualizations to be closer to human cognition and as a means to simplify and communicate complexity. One expert from architectural practice outlined the importance of analyzing and visualizing the social network of an organization. With the digital tools in their architectural practice, they focus for example on measuring the overview a location provides in a building to see other people or activities, and on measuring the connectivity of places (App. III.6, Blum, U., 2021, March 12, Pos. 60-71).

> *"We measure with an algorithm the distances between every desk to every other desk. And we can calculate how many people are within your walking range of eight, 16, 24, 48 meter. And we correlate that with the Allen-Curve that says that this is kind of inverse exponential"*
>
> *(App. III.6, Blum, U., 2021, March 12, Pos. 68-71).*

In his practice, the complexity of a social network can be broken down and developed further: "A skills analysis or knowledge analysis" for example could reveal "where (…) the knowledge hotspots of a certain topic in a company" reside or silos between people exist (ibid., 198-200). Designers and users can develop more insights when being confronted with or embedded in a spatial representation or 3-dimensional model. A virtual or augmented reality can create a new kind of experience and perception of systems, relationships and ideas (App. III.3, Ziegler, M., 2021, April 20, Pos. 221-242). Digital twins, as one expert from innovation consultancies explained further, offer a great potential to interact in a digital environment while being simultaneously connected to real-life processes and receiving immediate feedback on the effects of virtually performed actions (ibid.). In contrast, two experts question the practicability of spatial visualizations (02, 08). In their view, a third, Euclidian dimension would confuse users when obtaining information and impede their navigation through the proposed space. For creative tasks, graphical or visual work is considered suitable, whereas for decision-making, written communication is favored as it provides an appropriate level of clarity. From an architect's perspective, a visualization, despite its importance, "can sometimes work against you. You do something which is so visually enticing, visually kind of compelling that the client sometimes feels that they haven't really had an involvement in that." (App. III.5, Tidd, P., 2021, March 17, Pos. 330-332). The use of visualizations "needs to be more conceptual, more sketchy, not necessarily the finished product, which is what architects often rush to that." (App. III.5, Tidd, P., 2021, March 17, Pos. 335-336). In the work of this architect, engaging and involving client and users in the process of design is central for a successful outcome.

The design thinking methods and design processes in innovation consultancies also emphasize the importance of integrating the client, its employees and further stakeholders, and ensuring that they collaborate (01, 03). The 360°-degree view, highlighted by one enterprise expert, relates to oral communication with colleagues and stakeholders. Despite using terms like view point, perspectives and dimensions, the 360°-degree view is not referring to externalized visualizations and visual spatial frames. As visual cues, common organizational charts or organigrams are sufficient for the understanding of formal dependencies. They make it easier to select and contact people to support or foster a process. In the view of the interviewee, strategic dependencies are more important than spatial configurations or visualizations showing where people are actually located. In her context, work with teams is usually distributed. A spatial dimension would be relevant to communicate spaces colleagues can visit in order to work creatively and collaborate with each other. In general, visualizations of the organizational structure need to be aligned to the formal organization of responsibilities and authorities for decision-making. Visualization can, in the interviewee's words, hardly convey frictions in an organization and the soft factors among people (App. III.8, Gautam-Nigge, D., 2021, March 09, Pos. 385-397). The informal organization becomes apparent through dialogues and conversations.

10.3.4 Architectural Practice

Posing the question how architects could contribute to innovation management with their capabilities and the visualizations they create, two experts from innovation consultancies, two experts from enterprises and one expert from architectural practices referred first to building designs for collaboration spaces (01, 03, 05, 07, 08). Purposeful designed physical environments enhance creative work and multidisciplinary collaboration. They increase the probability for chance or serendipitous encounters and informal communication, which are considered essential elements for developing innovative ideas. In this respect, architects contribute to the management of innovation processes by designing a spatial environment.

In two interviews with experts from innovation consultancy and enterprise, the transfer of architectural thinking in order to analyze and reorganize a client's structure and processes was valued as an interesting novel approach that the interviewees had not been drawn to before (01, 08). In the first case, the innovation consultant integrates architects "to design our own space" or "to recommend spaces for our clients" (App. III.1, Rushworth, A., 2021, March 03, Pos. 223-224). The architects also worked as "strategic designers (…) leveraging the ethnographic and the problem-solving capabilities they have as designers to help clients to solve other problems. But so far, we've not looked at using architecture as a discipline and pivoting that discipline to, you know, solve a different problem set" (App. III.1, Rushworth, A., 2021, March 03, Pos. 237-239). In three interviews, experts from architecture, innovation consultancy and enterprise explained possible benefits of architectural thinking and work separated from building design (03, 05, 07). The analogy to architecture and the use of architectural terms are applied to software development internally (03); also, a reference is drawn to the influence architectural thinking had on information technology with the works of Christopher Alexander and his co-authored concept of pattern language[121] (App. III.3, Ziegler, M., 2021, April 20,

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[121] With 'A Pattern Language' Alexander, Ishikawa & Silverstein (1977, p. x) suggested a system of architectural elements termed patterns, that describe particular architectural problems and their resolution. Patterns were composed for a needed design outcome. Scheurer (2009, p. 41) summarizes: „It was based on the fundamental idea that the problem pattern, meaning recurring problems in the architectural design and planning process, should be abstracted situationally and functionally and assigned the appropriate solution patterns. Since these individual patterns relate to one another, a complex hierarchical network is formed of 253 interrelated patterns that should collectively present a formal, practical guideline for the architectural design process. Alexander's pattern language caused quite a stir back then, but it was not integrated into architectural practice. Yet ten years after Alexander's publication, the American computer scientists Kent Beck and Ward Cunningham applied his theory to problems in software engineering. That is how the pattern language, originally conceived as a system for architectural design, was eventually applied to the world of computer science – which at that point was experiencing a paradigm shift caused by what are known as object-oriented programming languages."

Pos. 178). In the expert's view, experienced architects could help to visually record, to translate information into visual representations and to moderate the working process with clients. The expert cited the concept of digital twins and the implementation of virtual and augmented realities as examples of the increasing importance of spatial and immersive visualizations. These can be considered further fields architects could contribute to (ibid., Pos. 221-242). A further expert from innovation consultancy values the capability of translating innovative work processes into a physical representation and manifestation (07). Creating visual and physical artifacts, which invite to collaborate and explore playfully new innovation processes can increase in his view the quality of the process development. From an architectural perspective, the two experts interviewed outline the innovative attitude approach in architecture, which they pursue with their respective design processes and new digital tools to deal with the complexity of social systems (of the organization) and visualize it.

> *"But I think, where architects and designers are naturally, or let's call it genetically programmed, if you like, is architects and designers are well suited to dealing with ambiguity (…) because, as a designer, that's what you do, right? You're trained to, you know, sit in a room with a piece of paper in front of you and create something. And so, we're used to sort of dealing - unlike, say, engineering or mathematicians, whatever - we deal in ambiguity. We deal in things which are not straight in front of us."*
>
> *(App. III.5, Tidd, P., 2021, March 17, Pos. 280-286).*

Three experts, one from architecture and two from innovation consultancies, answered the questions detached from building design. They related architectural thinking and work to systemic thinking (02, 04, 06). One of the innovation consultancy experts emphasized that architecture as a discipline thoroughly reflects how artifacts relate and interact with their context. The discipline is used to integrate different perspectives in its design processes and develop a systemic view in its design processes (04). Architects, as mentioned before, can translate communicated thoughts, information and knowledge into a visual representation which supports the analysis of complex relations and the building of an understanding of a shared problem. The second expert from innovation consultancy compared his own approach of creative disruption and a process discipline to architectural work (02). During the interview, he uncovered similarities to his approach in dealing with innovation projects. Architects in his comparison combine the creation of novel ideas with a commitment to their implementation. He sees this as a valuable capability to question the status quo, to develop a possible solution and, if necessary abandon it (App. III.2, Eckel, J., 2021, March 10, Pos. 176-188).[122] He would also take into consideration the idea of employing more architects as they combine a visual-creative attitude

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[122] „Interessanterweise, dieses Architektenbild finde ich ganz spannend. Du hast das ja auch bei der Architektur - wir haben gerade gebaut. Da hast du eine ähnliche merkwürdige Kombination. Auf der einen Seite möchtest du, dass ein Architekt irgendwie Wünsche von Bauherren kreativ in irgendein Konstrukt übersetzt. Auf der anderen Seite hast du eine UNGLAUBLICHE Menge an Prozess- und Strukturtreue. (...) Also du hast schon auch so eine Kombination aus Prozessstruktur, strukturieren, amorphe Wünsche nehmen und in Struktur packen. Auf der anderen Seite aber auch irgendwie, also glaube ich, wenn du ein guter Architekt bist, so eine gewisse Bereitschaft, auch Bestehendes zu hinterfragen und nochmal durchzuwühlen und durchzuwürfeln. Und auch zu sagen, „weißt du, ja, wir haben da jetzt viel Zeit reingesteckt und das funktioniert nicht, dann müssen wir es halt wegwerfen. Dann machen wir es neu." (App. III.2, Eckel, J., 2021, March 10, Pos. 176-188).

and a project management approach for processes (ibid., Pos. 229-223).[123] From the second interview with an architect, architects could contribute with their particular understanding and visualization of social networks. In his experience, companies begin to rethink their processes and organizations "usually when they start to build a building. When they think of buildings." (App. III.6, Blum, U., 2021, March 12, Pos. 381-383). Architects could accordingly "influence" the future configurations (ibid., Pos. 385). Before being capable of designing a building, they need to understand the social network of the organization and discuss questions like "where are we placing which kind of departments" (App. III.6, Blum, U., 2021, March 12, Pos. 182). This approach, for example, is pursued by the expert in his practice.

In contrast, there are several limitations regarding the contribution of architects to the design of innovation processes. The architectural expert, who outlines the capability of architects to analyze, visualize and design social networks, would consider a data scientist more suited to becoming a social network manager and monitor the network, its relationships and its constant changes (App. III.6, Blum, U., 2021, March 12, Pos. 188-204). Architects are "not drawn to that" he points out (App. III.6, Blum, U., 2021, March 12, Pos. 350). They keep focusing on the architectural design aspects of buildings instead of investing time in developing spatial innovation processes. In his view, there are several reasons for this. Architects remain distant from digital technologies for retrieving, analyzing and visualizing data on organizational processes and social interactions (ibid., 130-133). They avoid the "effort to have this conversation with the clients, and to invest into creating algorithms that measure these factors." (ibid., 134-136). And lastly, architects do not communicate their knowledge on organizational challenges and competence by addressing it in a way that could be acknowledged for the service in a similar way to management consultants:

> *"And you know, if a big organizations thinks of, "Oh I need to be innovative". They're not turning to architects, they're turning to management consultants, or to all sorts of consultants. But they don't think ever of architects to have this knowledge. Because architects don't advertise themselves. Even if they do it, they do not advertise themselves. Or in society they're not known for that."*
>
> *(App. III.6, Blum, U., 2021, March 12, Pos. 124-141)*

He sees an increased interest among enterprises in the work of his practice on floor plates analytics and workplace strategies resulting from attendance at conferences, where the practice presents and explains its approaches and insights. As one exception in the industry, the architectural practice of Gensler has developed dedicated consulting and real estate services. It explicitly addresses the challenges of strategy and innovation. As the architectural expert from Gensler describes in the interview, "we are often these day (…) invited to make a proposal from a client (…). If it involves, I would say, change and innovation, we are regularly competing with the management consultancies, whether that's Boston Consulting, Accenture, Deloitte, you know, even McKinsey. (App. III.5, Tidd, P., 2021, March 17, Pos. 220-224). He perceives it

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[123] „[W]ir müssen eigentlich mehr Architekten einstellen, finde die Kombination eigentlich gerade ganz interessant. So ein grafisch kreatives Element mit einem eigentlich sehr Prozessprojektmanagement orientierten Ansatz. Mal überlegen. Das wäre eigentlich ganz spannend." (App. III.2, Eckel, J., 2021, March 10, Pos. 229-232).

as a “kind of blurring of boundary” between the field of organizational design, physical design, technology, innovation, change management and culture (ibid., 555-560). Their core competence however, remains in the physical realm, in the development of a strategic brief and the translation of vision, culture and processes into a physical space:

> *“But at the same time, we are not experts in that field. I think, where we’ve done very well is we’ve been helping clients to rethink some of their processes and how those processes would then actually be translated into a physical layout. Let’s put it that way. It’s kind of blurring the boundary, I would say, between sort of, let’s call it, organizational design and physical design. (…) You know, what’s interesting about what we do in consulting in Gensler is a lot of what we do has very blurry boundaries. So often, we are slightly going off the, out of orbit, if you like, into technology or into innovation or into change or into brand or into culture. And we sort of play in those sandboxes quite often. But we don’t necessarily have deep expertise in that. But I think that also creates opportunities because, sometimes, clients will come to us, and they say, “Okay. I’ve gone to IDEO or to Fjord, and as an innovation company they’ve done amazing things. But they’re not actually tackling the part that I really need, which is about thinking, well, what does that mean physically?” (…) They have deep expertise there, but they’re not expert in the physical, the translation of the ideas into the physical space. And so that’s where we often will be brought in actually because that’s (…) what we do.”*
>
> *(App. III.5, Tidd, P., 2021, March 17, Pos. 552-568)*

With respect to the different expertise and skills needed to deal with complex organizational problems, the expert questions whether a single discipline could cover the subject in its entirety. In his view formed by his professional work, architectural skills and architectural perspective are only one part of a multi-disciplinary approach. In a similar fashion to the answers from experts in innovation consultancies, the combination of different skill-sets in relation and dependence to the posed task by the client is foregrounded (App. III.5, Tidd, P., 2021, March 17, Pos. 259-266). He notices that for instance in Germany, the architectural profession is still concentrated on a prevailing professional profile. In his opinion, “we’re still a little bit too kind of silo thinking” (App. III.5, Tidd, P., 2021, March 17, Pos. 286-291). The different approach he and his practice take to provide services to the client reveals indirectly the limited suitability of architects in general. By not involving the client in the development process and presenting a finished concept or product, the necessary engagement and iterations may be missed, and more profoundly the results weakened (ibid., 335-336; 496-499). One expert from innovation consultancy shares these concerns about architects presenting persuasive models and visualizations of office buildings without considering their functional requirements (App. III.2, Eckel, J., 2021, March 10, Pos. 265-272). In the further course of the interview, he challenges the idea that in the broader spectrum of architectural offices, architects would be interested and willing to contribute to innovation management:

> *"(G)roße Frage. Findest du im Architekturbüro die richtigen Leute, um das zu tun? Also nicht, um das aufzumalen (...). Aber findest du in der Breite, also sind das eigentlich die Menschen, die Interesse daran haben, so zwischenmenschliche oder prozessorientierte Dinge zu visualisieren versus (...) Großbau (planen; Anm. d. Verf.). Oder Bürobau."*
>
> *(App. III.2, Eckel, J., 2021, March 10, Pos. 295-299)*

The experts from architectural practices communicate the same concern. One expert directly states that "architects usually don't care" (App. III.6, Blum, U., 2021, March 12, Pos. 126) about spatial innovation processes, that they "keep their fingers off technology" (ibid., Pos. 132-133) to analyze social networks, that they "are not drawn" (ibid., Pos. 350) to this kind of work. Indirectly, the second expert from the field of architecture stresses how their practice is different and an exception to the traditional architectural studio by bringing different disciplines together and working iteratively with the client (App. III.5, Tidd, P., 2021, March 17, Pos. 242-250; 431-437; 496-501).

10.4 Evaluation of AID methodology & tool

The fourth part of the questions addressed the methodology of the architectural innovation design. The interviewees were first asked orally to value an architectural service that analyzes and develops innovation processes. At the end of the interview, they were presented with a 90-second demo video of a digital tool prototype. Prior to this part, the experts stated notes that can be considered as indirect support of an architectural innovation design.

In the following pages, first the indirect supportive notes during the interviews are summarized. Second, direct supportive and refuting answers to an architectural innovation design are retrieved and evaluated. Thirdly, the answers regarding the tool are summarized.

10.4.1 Indirect Evaluation

Collaboration, in-depth understanding, visual thinking and visual work, learning and guiding were important principles of an innovation design process, expressed by at least three experts. They are considered to be principles here, as they are uncodified rules for practice applied by the experts throughout their innovation processes.[124] Two experts from innovation consultancies and one expert from architecture emphasized the importance of collaboration, of engagement and of embeddedness in their design approaches (01, 04, 05). Clients and users need to participate actively in the design process and share their respective point of views. Intense communication and explanation by verbal or non-verbal means were highlighted by four experts across innovation consultancy, architecture and enterprise (03, 04, 06, 08). Similarly, four experts mentioned the relevance of a profound understanding of a situation

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[124] Peña & Parshall (2012, pp. 74–75) list twelve principles to be applied throughout their proposed architectural programming method. The principles retrieved from the expert interviews (collaboration, in-depth understanding, visual thinking and visual work, learning and guiding) are traceable in Peña & Parshall (ibid.) as principles of client involvement, effective communication, comprehensive analysis, abstract thinking, efficient operation and definite closure. See also Chapter 5.2.1.

by integrating the different stakeholders, by discovering the root causes of a problem and by attaining different perspectives (03, 05, 06, 08). Visual thinking and visual work was important to six experts (02, 03, 04, 05, 06, 07). The experts are using different means to apply visual reasoning and do visual work in order to gain understanding, to communicate, to interact, to become immersed in a project, and to engage in modeling or simulating processes, relationships and services. Three experts emphasized a principle of learning and curiosity (01, 04, 07). When clients and users become involved in their respective design processes for innovation, they learn by taking different perspectives on a subject and by experiencing new ways of creatively collaborating. In successful cases, self-reinforcing growth processes emerge („sich selbst verstärkende Wachstumsprozesse“; App. III.7, Heckmann, K., 2021, April 28, Pos. 118), through which the introduced way of innovating becomes disseminated in an organization. Five experts stated that their role was to moderate and to guide the people involved through a design process (01, 03, 04, 05, 07). They perform this role in alignment with the developed methods in their firm or with methods adjusted to particular demands of a project. Two experts guide the process based on their individual expertise and capabilities.

Further principles that address aspects present in an architectural innovation design were mentioned by one or two experts: the principle of scale, of ephemerality, of dedication and of synthesis. The principle of scale was mentioned by one expert from the architectural field (06). He relates the innovation capacity of companies to the scale they are able to organize and manage people and social networks. An increase in scale - the number of people on a single floor plate and size of this floor plate – can positively influence innovation processes if it is thoughtfully created and designed (App. III.6, Blum, U., 2021, March 12, Pos. 118-123). In his practical work, he sees building designs evolving from 2.500 square meters per floor plate to 30.000 or 50.000 square meters and beyond (ibid.; 72-86). Ephemerality describes the constant change of team compositions and networks. People are coming together or are assembled temporarily for a project while remaining physically located at different places and then disperse again (06, 08). In this respect, the configuration of teams in the network changes frequently. For one enterprise expert (08), the organizational structure is orally or verbally communicated, while for the architectural expert it is a visual representation (06). Both experts note that it demands an effort to uncover the social network of people, teams or departments. Insightful communication and discourse require time. The principle of synthesis was mentioned explicitly only by one expert from architectural practice (05). The different parts of an analysis need to be brought together into something new that clients “will recognize and that they will understand.” (App. III.5, Tidd, P., 2021, March 17, Pos. 352-353).

10.4.2 AID Methodology

Answers supporting and refuting the AID methodology were retrieved by hypothetically describing a novel architectural service. The experts were asked to value and explain possible benefits and concerns, when a 3-dimensional organizational structure is created with non-verbal means to understand and design innovation processes. The answers of the eight experts were analyzed by codes capturing the perception of AID and the perception of the prototypical tool as listed in Table 17. The coded answers were aggregated to identify the most frequent aspects raised in the expert perspectives (see Table 19). Aside from these aspects, one expert from innovation consultancy and one from architectural practice saw close similarities to their own approaches (03, 05). Six experts valued the approach as a novel direction to integrate architectural thinking in innovation management (01, 02, 04, 06, 07, 08).

Eight supporting and three refuting aspects were derived, which had three or more expert answers as shown in Table 19). Regarding the supporting aspects, six experts considered in each case visual transparency and extended possibilities for interaction as valuable contributions. Involvement and collaboration, the introduction of new dimensions, and the possibilities modeling a process structure were positively emphasized in each case by five experts. Four experts highlighted the importance for simulation in the proposed methodology, while three experts valued the aspect of play and the integration of virtual and physical elements of innovation processes in one single approach. Regarding the negative aspects, three experts were concerned about the risk of increased complexity, especially when acting with a spatial dimension. Also three experts questioned the reliability of the visually displayed data and information. Three experts challenged the focus of the approach. In their view, the approach could be more beneficial if it is applied to supporting the understanding and development of complex challenges and ideas to their resolution, than being restricted to organizational structures and processes. Supporting and refuting aspects will be explained in the following pages in more detail.

Aspects regarding AID		01	02	03	04	05	06	07	08
		Alison Rushworth	Jürgen Eckel	Matthias Ziegler	Sven Bibi	Philip Tidd	Uli Blum	Konstantin Heckmann	Deepa Gautam-Nigge
		BCGDV	BCGDV	accenture	Futurice	Gensler	ZHA	Ottobock	SAP
Supporting									
Visual Transparency	**6**	■	■	■	■	■	■		
Interacting Elements	**6**			■	■	■	■	■	■
Involvement, Collaboration	**5**	■		■	■	■	■	■	
New dimensions	**5**	■			■		■	■	■
Modelling	**5**	■		■	■	■			■
Simulation	**4**		■	■	■		■		
Play	**3**			■	■			■	
Migration	**3**			■				■	■
Refuting									
Risk of complexity	**3**		■	■				■	
Reliability	**3**		■	■					■
Focus	**3**			■				■	■

Table 19: Evaluation of Aspects Raised by Experts Regarding AID

Visual transparency. A 3-dimensional structure of people and departments was seen by six experts as being a beneficial way of capturing the complexity of an organization. It can reduce the complexity for better transparency and understanding. The experts from the field of architecture regarded visual models as an important medium to represent complex social interactions and the social network spatially (05, 06). By analyzing and interviewing people in an organization, a model makes behaviors in an enterprise transparent and reveals how the client's employees actually work (05). The four experts from innovation consultancies outlined the benefits of an additional layer of information "by understanding space and time as an extra dimension" (App. III.1, Rushworth, A., 2021, March 03, Pos. 265). In two interviews, this visual transparency was related to the understanding of complex structures and topics in general (03, 04). It was partly related to people and operational processes, their relationships and dependencies (01, 02). The experts from an enterprise did not refer to this extra layer in their answers.

Interacting Elements. Six experts considered interacting elements as crucial in their approach. Based on their own practice and experience, one architectural expert and two experts from enterprises highlighted the importance of interacting with people while analyzing and developing an innovation process (05, 07, 08). Two experts from innovation consultancy and one expert from architecture centered the interaction with the developed model itself (03, 04, 06). In one particular view, the display of complex systems and relationships through non-verbal artifacts fosters an identification of the people acting with the artifact: they can locate and position themselves within the structure of an organization or within the structure of a challenge. They are able to move from their defined role and position in an organization, and literally take a different perspective, e.g., from another department or function (paraphrased by author after App. III.4, Bibi, S., 2021, March 16, Pos. 309-326).[125] Introducing a spatial dimension was considered beneficial by five experts. As noted in the answers regarding the importance of visualizations, the third dimension provides an additional dimension to display and understand complex situations. With this extra dimension, relationships and dependencies in an organization could be better understood. Collaborations between teams and departments could be screened. Different viewpoints could be taken by the people involved to increase mutual understanding, develop new insights, or to become immersed in another role.

Involvement and collaboration. Five experts valued the possibilities of involving the client through interaction and with the use of non-verbal boundary objects. They partially referred the proposed architectural approach to their own methodologies and methods in innovation consultancy and architecture (03, 04, 05). Client and users can become immersed in a spatial model, virtual or analog, and take an active part in its construction, its analysis and refinement. Also, a multidisciplinary collaboration is enabled and fostered through the use of modelled structures.

New Dimensions. Five experts addressed the introduction of new dimensions to understand and explain complex structures and processes. The spatial dimension on the one hand offers an access to complexity which is familiar to human cognition, perception and behavior. People can work differently. They can perceive more details regarding subject and experience information in a multi-sensory way ("auf multisensorischer Ebene Informationen wahrnehmen", App. III.4, Bibi, S., 2021, March 16, Pos. 255-256). On the other hand, 3-dimensionality offers possibilities of displaying more parameters and information in different layers. The model for examples becomes a "kind of spatial representation of the network" (App. III.6, Blum, U., 2021, March 12, Pos. 242). It offers a frame of reference "Bezugsrahmen", App. III.8, Gautam-Nigge, D., 2021, March 09, Pos. 296-300) to relate processes to and understand them spatially (where people work) or as collaborative models (how people work).

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[125] „Absolut. Da sind wir jetzt noch mal am Anfang unserer Unterhaltung, wo nämlich die Frage der Beschreibung von komplexen Zusammenhängen und davon müssen wir ja immer dann sprechen in so einem Zusammenhang von komplexen Systemen oder Zusammenhängen, in dem Moment, wo sie aufgebrochen werden und über Artefakte innerhalb eines Modells sichtbar gemacht werden, führen sie dazu, dass es A zu einer hohen Identifikation der einzelnen Beteiligten mit diesem Modell kommt. (...). Egal, ob das ein Schaum-Modell ist oder ein A4-Modell oder aus Pappe gebaut oder was auch immer, es gibt mir die Gelegenheit mit einem dreidimensionalen Shape in irgendeiner Form zu interagieren. Und das hätte eben dein Modell auch so an sich mit der Möglichkeit, dass man in Abhängigkeit davon jetzt aber wirkliches PHYSISCHES 3D-Modell sprechen oder virtuelles oder digitales 3D-Modell ich da drin natürlich viel komplexere Abhängigkeiten moderieren, abbilden, beschreiben kann, die aus den verschiedenen Betrachtungsperspektiven/ das hat das Modell ja auch an sich in sich, dass ich nämlich von vorne draufgucken kann oder aus der Vogelperspektive oder ich lege mich mal drunter und schaue von unten rein. Und das sind Themen, die natürlich für das Grundverständnis von Organisationen fundamental wichtig sind, weil, dort bin ich als Teil der Organisation ja eigentlich immer in einer Rolle drin." (App. III.4, Bibi, S., 2021, March 16, Pos. 309-326).

Modeling and construction. The modeling and constructive aspect, to transform the 3-dimensional structure, was similarly stressed as relevant by five experts. From an enterprise view this aspect supports communication and collaborative interaction with others, the understanding of the processes in question, and suggestions towards their optimization (08). From an innovation consulting view, modeling makes it possible to play and to discuss changes in an organization or teams (04). Furthermore, enterprises may be "able to demonstrate blockages within their physical infrastructure" (App. III.1, Rushworth, A., 2021, March 03, Pos. 295).

Simulation. For the evaluation of interventions in the structure, simulations would be very useful. Four experts, three from innovation consultancy and one from architecture, suggested simulating changes and constructing alternative scenarios of configurations of processes and organizations (02. 03, 04, 05). In this way, the consequences of moving parts or relating them differently could be visualized and discussed. One innovation consulting expert related simulation to the concept of digital twins, a virtual representation of a physically embodied process or object (03). Changes in the digital representation could offer a real-time simulation of changes in the process or configuration of the object, or directly induce the changes in reality and feedback its results to the digital model (App. III.3, Ziegler, M., 2021, April 20, Pos. 221-242; 365-371).

Play. The aspect of play during collaboration, modeling and simulation was highlighted by two experts from innovation consultancy and one expert from enterprise (03, 04, 07). It makes it possible to observe the behavior of the participants, to foster creativity or to gain new perspectives on a problem. In an indirect comment, one expert explained the benefits of prepared 'kits': if people in the processes are provided pre-defined elements, templates and principle guidelines on how to use elements and templates, they can model and simulate processes without being an expert in that particular field (paraphrased after App. III.4, Bibi, S., 2021, March 16, Pos. 104-118). The use of playbooks and toolkits was highlighted further by one expert from an enterprise perspective. In his work, it is important to act with the playfulness of a child and through this, anchor the experience in the memories of the participants (paraphrased after App. III.7, Heckmann, K., 2021, April 28, Pos. 472-485).

Migration. Three experts valued the migration of the analog and the virtual reality of an organization to develop innovation processes. One expert named three intertwined "Key Success Factors" which needed to be built in order to become innovative (App. III.7, Heckmann, K., 2021, April 28, Pos. 299-310):[126] a physical space for people to live innovatively; a virtual space to connect people and ideas; a process space to provide and embed methods and tools people can use, which preferably are also available, present and embodied in the physical space (ibid.). In this regard, the proposed methodology of AID could provide a 3-dimensional model to simultaneously represent a network of physical spaces, of people and ideas, and of methods and tools.

Three refuting aspects could be derived, which were addressed in each case by three experts. These aspects are partially opposed to the supporting aspects mentioned above.

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[126] "Also, wenn du mich fragst, was sind die drei Key Success Factors, oder die drei Dinge, die du bauen musst, um innovativ zu sein. Du brauchst einen physischen, du brauchst einen virtuellen Raum. Also quasi so eine Art Innovationsplattform, Connecting People and Ideas, ist da der Slogan. Du brauchst einen physischen Raum, weil du musst auch im Prinzip die physischen Räume schaffen, um Innovation zu leben. Das geht von Kreativräume, Fab Labs. Projekträume, weil du musst ja eigentlich auch die einzelnen PHASEN eines Innovationsprozesses räumlich begleiten. Das ist Key. (...) Und die dritte Dimension ist das Methodische, und auch DA spielt wieder das räumliche rein, weil, wenn ich die Leute methodisch, also über Templates et cetera mit an die Hand nehme, sollten diese natürlich auch im RAUM nutzbar sein, im Raum verfügbar sein, eventuell sogar direkt mit in die Wand integriert sein." (App. III.7, Heckmann, K., 2021, April 28, Pos. 299-310).

Risk of Complexity. The expert, who positively values the migration of analog and virtual realities, also points out the risk of too much complexity by adding a spatial dimension to analyze and model innovation processes (ibid., 287-290). People unfamiliar to the field of innovation may have difficulties in comprehending the model and becoming active. Similarly, two experts from innovation consultancy question whether a spatial dimension is necessary (02, 03). For one expert from this field, 3-dimensional representations and models are complicating things, as people are used to perceiving and sharing information with their 2-dimensional devices, and are not used to interacting with 3-dimensional models (App. III.2, Eckel, J., 2021, March 10, Pos. 347-351). For the other expert, difficulties arose for interaction. (App. III.3, Ziegler, M., 2021, April 20, Pos. 323-336). Though he states that humans can perceive information spatially, the interaction in a 3-dimensional model requires guidance and training. (ibid., 245-247; 323-395). The need for guidance during the process was mentioned in total by three experts (03, 07, 08).

Reliability. A major concern was mentioned by two experts from innovation consulting and one from enterprise regarding the represented information in a model, which results from a process of collaborative interaction (02, 03, 08). Data and information are incomplete or interpreted differently by the person visualizing them in a model. Therefore, analytics of the organizational process should be directly integrated into the development of the model. In the view of two experts, the spatial dimension is not sufficient to display soft factors in an organization, e.g., personal relations, conflicts, misunderstandings, and the different roles one person has (02, 08). The same experts also raised concerns regarding the usefulness of a spatial representation.

Focus. Lastly, three experts raised questions about the focus of the approach (03, 06, 07). One expert from consulting and one from enterprise would apply the methodology to visualize and analyze ideas and improve the innovation processes for a particular service or product (03, 07). Visualizing the interdependencies between different stakeholders and responsibilities regarding an idea, its development or its concrete production could also be interesting or preferable as innovation processes include content issues that cannot easily be represented. In the view of the expert, business models could be represented as dynamic systems through the approach (App. III.7, Heckmann, K., 2021, April 28, Pos. 373-390).[127]

To sum up, the methodology was positively valued. It could convey the arguments for an extended view on innovation and the benefits of an architectural approach to process design. Interestingly, experts from innovation consultancies were more drawn to the methodology and its possible use than experts from the field of architecture. While the innovation experts would begin to consider more architectural expertise in their work, the methodology seemed to be too generic and broad.

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[127] „Ja, wie gesagt, da sehe ich ganz klar halt jetzt gar nicht unbedingt nur auf der Prozessseite eine Thematik, also das könnte prozessseitig auch spannend sein, wobei ich halt gesagt habe, beim Prozess habe ich auch immer diese Inhaltslayer-Kriterien und Verantwortlichkeiten. Ich glaube, da muss man sehen, wie komplex dann so ein Modell wird, oder wie unübersichtlich. Die andere Ebene ist natürlich wirklich auf dieser, dass ich sage, ich habe eine Idee, ich habe gewisse Abhängigkeiten zwischen Stakeholdern, und dass ich sage, was sind die Abhängigkeiten, was sind die Flüsse. Da fließt was von A nach B und wieder auch zurück. Der eine kriegt ein Produkt, dafür wird bezahlt, jetzt mal ganz basic. Aber teilweise können diese Verbindungen auch sehr indirekt sein. Oder auch/ manchmal sind die nicht ganz so einfach. Also, gerade wenn du vielleicht so B-to-B-to-C unterwegs bist, dann wird das relativ schnell komplex, und bei vielen Themen kommt man immer so an einen Punkt, dass man sagt, okay, was ist jetzt eigentlich die Value Proposition? Wo und wie verdienen wir damit eigentlich Geld? Und so ein Business Modell ist zum Beispiel sehr statisch. Und dann geht es eigentlich über diese Value Streaming kriegst du eine Dynamik rein. Und auch DA ist es oft natürlich, wird es sehr komplex und unübersichtlich, und DA würde dann wahrscheinlich auch dann so ein 3D-Modell helfen, weil das natürlich dann auch wieder da nochmal, ja, die Möglichkeit hat, verschiedene Perspektiven einzunehmen, und da noch im Dialog einen gewissen Fokus zu setzen." (App. III.7, Heckmann, K., 2021, April 28, Pos. 373-390).

10.4.3 Digital Tool Prototype

At the end of each interview, the experts were presented with a digital medium-resolution, medium-fidelity prototype.[128] It is a digital application with basic features and functions to represent the principle idea of constructing a 3-dimensional network model by manual inputs. The prototype displays departments of organizations, their sizes and their connections in between as spheres in a virtual 3-dimensional work space. The connections can be further distinguished by type (e.g., face-to-face, e-mail, messaging) and by strength (i.e. intensity of interaction). The 3-dimensional space makes it possible to transform and place the spheres in different proximities to each other, to navigate through the model and change the viewpoints. With a feature of dynamics, changes in locations of one sphere and its connections affect the positions of other spheres. The prototype and demonstration video were developed as an interdisciplinary project with Master's degree students in informatics based on preliminary results and the hypothesis of this thesis (see App. IIII.1, Prototype 1). After the video, the experts were asked to formulate possible use cases for the tool.

From the interviews five supporting and four refuting aspects could be derived, with at least three experts agreeing as shown in Table 13. Seven experts could think of different use cases, four experts related the prototype to applications developed and used in their field of work. Four experts positively valued the visual transparency the tool offers. Three experts emphasized the possibility of becoming immersed and playing as a user with a tangible object and taking different viewpoints as well as the dynamics the tool could visualize. In contrast, four experts raised concerns regarding the practicability of the tool. Three experts questioned its usability and user experience, its appropriateness for the intended use, and the simplicity or level of abstraction.

Aspects regarding Tool Prototype		01 Alison Rushworth	02 Jürgen Eckel	03 Matthias Ziegler	04 Sven Bibi	05 Philip Tidd	06 Uli Blum	07 Konstantin Heckmann	08 Deepa Gautam-Nigge
		BCGDV	**BCGDV**	**accenture**	**Futurice**	**Gensler**	**ZHA**	**Ottobock**	**SAP**
Supporting									
Proposing Use Cases	**7**	■	■	■	■	■	■		■
Referencing to Work	**4**			■	■	■		■	
Visual Transparency	**4**			■	■	■		■	
Immersion and Play	**3**		■		■			■	
Dynamics	**3**		■				■	■	
Refuting									
Practicability	**4**	■	■	■					■
Usability & Experience	**3**		■	■	■				
Appropriateness (Distr.)	**3**		■	■				■	
Simplicity	**3**			■	■		■		

Table 20: Evaluation of Aspects Raised by Experts Regarding Tool Prototype

Use cases. The use cases the expert roughly described showed a broad variety. At an operational level, for two experts the tool could be useful to describe, display and analyze value streams of physical processes and the interaction of people (01, 02). In the view of innovation consultancies, large organizations with complex physical infrastructures, logistics and organizational processes

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[128] Resolution of prototypes refers to the "amount of details" (Houde & Hill, 1997, p. 369) modeled and displayed, fidelity refers to "closeness to the eventual design" (ibid.).

could benefit from the kind of visualization the tool proposes. Regarding the spatial dimension, one expert valued it as an extra level for understanding and analysis of "blockages in the physical infrastructure" (App. III.1, Rushworth, A., 2021, March 03, Pos. 295), while one expert, as mentioned, questioned the need for a 3-dimensionality (App. III.2, Eckel, J., 2021, March 10, Pos. 371-374).

At an organizational level, for two experts the tool could support the analyses of organizational structures and social networks, to detect silos and "disconnects" (App. III.4, Bibi, S., 2021, March 16, Pos. 419-420) between people, teams and departments (04, 06). Especially when enterprises grow, formerly small units with close proximity to each other evolve into larger separate entities and disconnect from each other. The tool displaying this evolved structure could also represent these disconnects and the allocation of knowledge (paraphrased after App. III.4, Bibi, S., 2021, March 16, Pos. 411-434). The tool could provide visual analysis based on business data and information regarding processes, interaction and performances, to discuss measures for bridging the communication breaks in between and the dispersion of knowledge (ibid.).[129]

One expert from architecture proposes applying the tool for engagement purposes and considers it as a "communication tool with the client" (App. III.5, Tidd, P., 2021, March 17, Pos. 527). By first developing a configuration of departments and their interactions with the client, it would be possible to deduct a physical model of a building. The expert discovered an important aspect in the proposed prototype to combine the physical model of how people work with a "virtual collaboration component" (ibid., Pos. 544). Collaboration and communication between people in an organization could then be enhanced beyond the constraints of a physical space. For a "new reality," accelerated by the Covid-19 pandemic, where physical distance does not prevent collaboration, he considers the "overlay" (ibid., p. 543) of the virtual and physical collaboration component as relevant (ibid., 541-544). Three experts, from innovation consulting, architecture and enterprise backgrounds, suggested a use case at a conceptual level: to spatialize ideas, their complex structure and flows as well as the knowledge residing within an organization (03, 06, 07).

Referencing. Four experts related the prototypical tool to existing tools in the marketplace or to tools they have been developing or using in their practice (03, 04, 05, 07). Regarding available tools, one expert from innovation consultancy, mentioned insights visualized by social graphs offered by Microsoft 365 or facebook (App. III.3, Ziegler, M., 2021, April 20, Pos. 423-440). He earlier in the interview explained the use of collaborative whiteboarding tools and the possibility of transferring the collaboration into an augmented reality space. Regarding the tools they had developed themselves, three experts explained similar functionalities they had built in as shown in the prototype. One expert from architecture uses "very, very similar tools internally (…) to help clients

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[129] „Unternehmen fangen irgendwann klein an, sind relativ kompakte Einheiten mit Nähe und geringen Personenzahlen. Und irgendwann fangen die an zu wachsen und bilden diese einzelnen Finger- und Units aus (...) die notwendig sind, weil die Komplexität der Gesamtstruktur so groß geworden ist, dass man es nicht im Griff hat oder nicht in den Griff kriegen kann, wenn man nicht sagt, wir brauchen einzelne Business-Units. Wir brauchen Sales, wir brauchen Vertrieb, wir brauchen R&D, wir brauchen Produktportfolio, Produktmanagement etc. Und dann passiert folgendes. Da entstehen Disconnects zwischen diesen einzelnen Bereichen und die gilt es zu schließen. So. Und um diese Disconnects überhaupt erst mal zu erkennen und zu visualisieren, ist Research wichtig. Also Research im Business-Kontext ist ein bisschen anders als wir das im Consumer-Bereich machen würden, also Research im Business-Kontext, der eben nicht nur auf einer qualitativen Ebene im ethnografischen Sinne beruht, sondern wo wir sehr stark in den Research von Daten reingehen müssen, also sozusagen in den Kern von Organisationen, um zu identifizieren, was fehlt denn da eigentlich? An welcher Stelle bricht es und was müssen wir bauen als Brücke dazwischen, um so eine Art Formschluss hinzubekommen. Das heißt, es geht gar nicht so sehr darum die Dinge physisch aneinander zu bringen, sondern zu sagen, was baue ich da eigentlich in diese einzelnen Bereiche hinein, damit das wieder sauber funktioniert oder damit es überhaupt sauber funktioniert? Und da könnte ich mir vorstellen, dass ein solches Modell im Kontext einer Wissens-Organisation überhaupt erst mal als Analyse-Tool dienen könnte, wo man sagt, wen haben wir denn überhaupt? Wen haben wir? Wer redet heute mit wem? Was sind die Austauschformate? Was sind die Informationen, die der eine braucht? Wer gibt sie ihm? Was schickt er wohin? Auf welchen Plattformen wird miteinander kommuniziert?“ (App. III.4, Bibi, S., 2021, March 16, Pos. 411-434)

visualize how they work together” (App. III.5, Tidd, P., 2021, March 17, Pos. 518-521). One expert from innovation consultancy referenced an internal tool they use named “Bubble-Burster” (App. III.4, Bibi, S., 2021, March 16, Pos. 440). It visualizes the knowledge, experience and interests of people as circles representing the respective people and offers as a second layer, personal information and information on their projects, capabilities and skills. When searching for a particular theme in the tool, according circles are shown as a result. (ibid., Pos. 439-458). In this way, the company attempts to share implicit or tacit knowledge residing among its employees. The third dimension of the presented prototype could be beneficial to visualize different point of views in an organization, e.g., from human resources, from the sales department or from the product development angle (ibid., Pos. 510-517). Similarly, one expert from enterprise, valued the 3-dimensionality to maintain clarity when visualizing value streams (App. III.7, Heckmann, K., 2021, April 28, Pos. 387-390). In his former professional work he has used 2-dimensional methods. A spatial dimension, as demonstrated in the interview, could show crossings more comprehensive and make it possible to alter the view points and discuss particular points in the value stream (ibid., Pos. 373-390).

Visual Transparency. Related to 3-dimensionality, the tool supports a visual transparency of processes and structures, which was positively rated by four experts. Three experts stressed the possible benefits of becoming immersed and playing with the tool. In particular the dynamics displayed when moving elements in the 3-dimensional workspace or changing the parameters of department size and strength of communication sparked further comments. One expert from innovation consultancy referred to a kind of gravity between the different elements in the model. In his view, it would be exciting to see how the organizational structure changes in response to shifting elements or in response to dramatically increasing the connections between the elements (paraphrased after App. III.2, Eckel, J., 2021, March 10, Pos. 353-363). You could then be able to visualize a non-linear process. By adding the dimension of time, simulations could be modelled between the elements and show, in his words, a natural power of attraction and repulsion.[130] However, the same expert questioned at another time the necessity and benefits of offering a third dimension in the tool and in the methodology.

Three experts valued the aspects of immersion and play, as mentioned before, regarding the methodology. This also included the possibility of obtaining different viewpoints in the 3-dimensional workspace. Dynamics in the tool were also regarded as positive. In contrast, the experts’ answers also conveyed concerns and questions regarding the tool. They were counted as refuting aspects of practicability, usability, appropriateness, and simplicity.

Practicability. Four experts were critical regarding the tool’s practicability. In their view, the tool should provide cues about how to deduct concrete measures for implementation (01, 02, 03, 08). Though they could imagine possible use cases, the experts would have favored more actionable outcomes.

Usability. Three experts from innovation consulting considered the

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[130] „Aber den Aspekt jetzt über unterschiedliche quasi Kommunikationsstärken, vielleicht kann man da ja wie auch mehrere Layer drüberlegen - und dann zu sagen, „schau mal hier, ich bewege Dinge auseinander, ich schiebe die zusammen. Ich sehe, was passiert denn eigentlich mit meiner Organisation.“ Das ist ja dann auf einmal ein nicht linearer Prozess, Es ziehen sich, verziehen sich, verschieben sich Dinge. Also zumindest alle die ich nicht so direkt oft verstehe. Die Interaktion finde ich total spannend. Kann man halt wieder mal sagen, was wäre wenn oder was, wenn ich jetzt hier Verbindungen zwischen zwei, drei Bereichen dramatisch erhöhe. Kann man fast schon sagen: ich kriege teilweise schon so etwas wie eine Gravitation? Oder Anziehungskraft. Oder dicke Verbindung, wir ziehen enger zusammen. Dünne, wir laufen auseinander. Das finde ich spannend. Ein anderer Punkt, der mir so in den Kopf kommt, ist Zeitachse. Also vielleicht gibt es hier so etwas, wie eine natürliche Abstoßungs- oder Zusammenziehungsreaktion. Du lässt das und du kriegst aber auch Vorspulen. Also da passiert vielleicht natürlicherweise was mit dieser Organisation. Halt nicht statisch, sondern da driften Dinge ab, oder andere fallen zusammen. Also das finde ich toll. Der 3D Teil, der lenkt mich eher so ein bisschen ab.“ (App. III.2, Eckel, J., 2021, March 10, Pos. 353-368)

usability, user experience and aesthetics of the tool as important properties for its acceptance (02, 03, 04).

Appropriateness. Related to this argument, three experts questioned the appropriateness of the tool. A tool applied in their work with people also causes distraction. People need to learn to use the tool, and they need to be able to interpret the developed results (02, 03, 07). To model a process spatially and gain new insights could also be achieved in fast ways with analog tools and a high level of creative freedom. Working with paper, cardboard, foam or other tangible model materials could be sufficient to create a new understanding for a problem (03, 07). The creation of a tangible artifact would foster a playful collaboration and address further senses than a digital application could (App. III.7, Heckmann, K., 2021, April 28, Pos. 252-256; Pos. 395-398). One expert from an enterprise background would have preferred to use a guideline of questions and develop a model based on personal communication (08). The guideline would make it possible to pose new questions and retrieve information that had not been foreseen before or prescribed as in the digital prototype. The visual model would then have to be constructed based on the answers to the particular questions raised, and it would look different from case to case (App. III.8, Gautam-Nigge, D., 2021, March 09, Pos. 423-449). The expert, however, acknowledged that the digital prototype attempts to blend the structural and process organization in an enterprise (ibid.).

Simplicity. While one expert considered the prototype with its 3-dimensional workplace as too complex, three experts regarded the tool as too simple (03, 04, 06). In their perspective the prototype should transport more information on ideas, knowledge, and processes on further layers; it should integrate augmented realities and sensory perceptions; it should rely on quantitative data directly retrieved from available business analytics sources; and it should be connected to processes in reality, simulate and modify them, as well as retrieve feedback from the modifications (03, 04). One expert from architecture suggested the need for more complexity in the tool. On the one hand, the prototype "is very simple, which is good" for companies to understand their networks (App. III.6, Blum, U., 2021, March 12, Pos. 309-312). On the other hand to visualize organizational structures and collaborate with companies on issues of restructuring their processes he states:

> *"[I]t needs to be a little bit more complex than that. It needs to encompass also the possibility of cross interaction between the departments and so on. I think these networks quite quickly become complex. And the question is how much can you simplify it?"*
>
> *(App. III.6, Blum, U., 2021, March 12, Pos. 329-332).*

To sum up, the tool prototype was valued as an interesting contribution to already existing tools and applications. This probably explains how the experts could formulate different use cases quickly. Though the demonstration sparked discussion on further directions for development, the value of the tool prototype was questioned with several arguments. Experts from innovation consulting mentioned positive as well as negative aspects, while experts from the field of architecture engaged to a lesser extent in the discussion. Compared to the methodology, the tool prototype was less convincing.

10.5 Evaluation of Hypothesis

The final part of the evaluation focused on the hypothesis and sub-hypotheses stated at the beginning of this research. The interviews and the coded segments regarding themes (Chapter 10.3) and the AID methodology (Chapter 10.4) were reviewed and coded at a secondary layer, as the hypothesis and sub-hypotheses were not directly stated in the interviews. For evaluating the hypothesis, passages were coded that regard designerly ways of thinking (in architecture) as appropriate to provide new insights on innovation processes. When answers emphasized different kinds of thinking as relevant, they were coded as refuting the hypothesis. For sub-hypothesis 1, answers were coded as supportive if aspects of non-linearity, multi-dimensionality and dynamics were considered valuable when analyzing and designing innovation processes. When the experts highlighted other aspects or raised concerns regarding the relevance of the aspects mentioned, the answers were coded as refuting. Sub-hypothesis 2 was evaluated by answers related to the use of design tools and the display of formal and informal organizational structures and processes in a 3-dimensional space. Answers outlining the benefits of such an application, and formulating possible use cases were coded as supportive. Answers questioning practicability, reliability and appropriateness were coded as refuting the usefulness of architectural thinking and tools. If the number of supportive and refuting coded segments in an interview differed by 8-10, strong support or refusal was stated for the expert. A difference by 5-7 codes, was interpreted as 'tend to support' or 'tend to refuse.' If supportive and refuting passages differed by 2-4 codes, interest or rejection was stated. A neutral or indifferent position was inferred if an expert answered with equal scores of supportive or refuting, or his or her answers differed only by the account of 1 (see Table 21).

Four experts showed strong support for the hypothesis, two from innovation consultancy, one from the field of architecture and one from an enterprise background (01, 03, 05, 07). Three experts, two from innovation consultancy and one from architecture, gave answers that were supportive. One expert with an enterprise background gave answers that were restrained; in this interview, interest regarding the hypothesis is stated. While the other experts who were familiar with design approaches and non-verbal boundary objects, the experts with an enterprise perspective centered verbal communication and lines of authorities. There, architectural design was related primarily to buildings and physical spaces.

Sub-hypothesis 1 was strongly supported indirectly by four experts, with two from innovation consultancy, one architectural and one enterprise expert. Two experts showed decent support in a multi-dimensional, non-linear approach, while the answers of two experts expressed only interest. In the latter case, one innovation consultancy and one enterprise perspective questioned the applicability and practicability of the stated approach.

Sub-hypothesis 2 received, after balancing the coded segments, strong support by one expert from innovation consultancy. For the two architects interviewed, one expert from innovation consultancy and one from enterprise their answers only expressed support. The answers of three experts revealed refusal or strong refusal. Sub-hypothesis 2 was evaluated by coded segments regarding the constructive modeling and the digital tool prototype. At this concrete level, the experts required more information regarding the tool's use and raised concerns regarding its applicability. As described in the evaluation of the digital tool prototype above, the experts felt it lacked immediate cues to deduct measures for implementation.

Summarizing from an innovation consulting standpoint, the approach to transfer architectural thinking and tools to the design of innovation processes, was seen as

- “super interesting” (App. III.1, Rushworth, A., 2021, March 03, Pos. 247; 261-262; 275)
- very exciting („ganz spannend“, „total spannend“, „spannender Ansatz“; App. III.2, Eckel, J., 2021, March 10, Pos. 178; 232; 287; 346-346; 359; 392-339)
- valuable and useful (App. III.4, Bibi, S., 2021, March 16, Pos. 180-181; 252; 267; 318-324; 402-403; 511-512; 524-526)
- interesting with potential for further development steps (App. III.3, Ziegler, M., 2021, April 20, Pos. 234-241; 265-266; 281-282; 298-299; 302-304; 313-315; 337-340; 385-386)

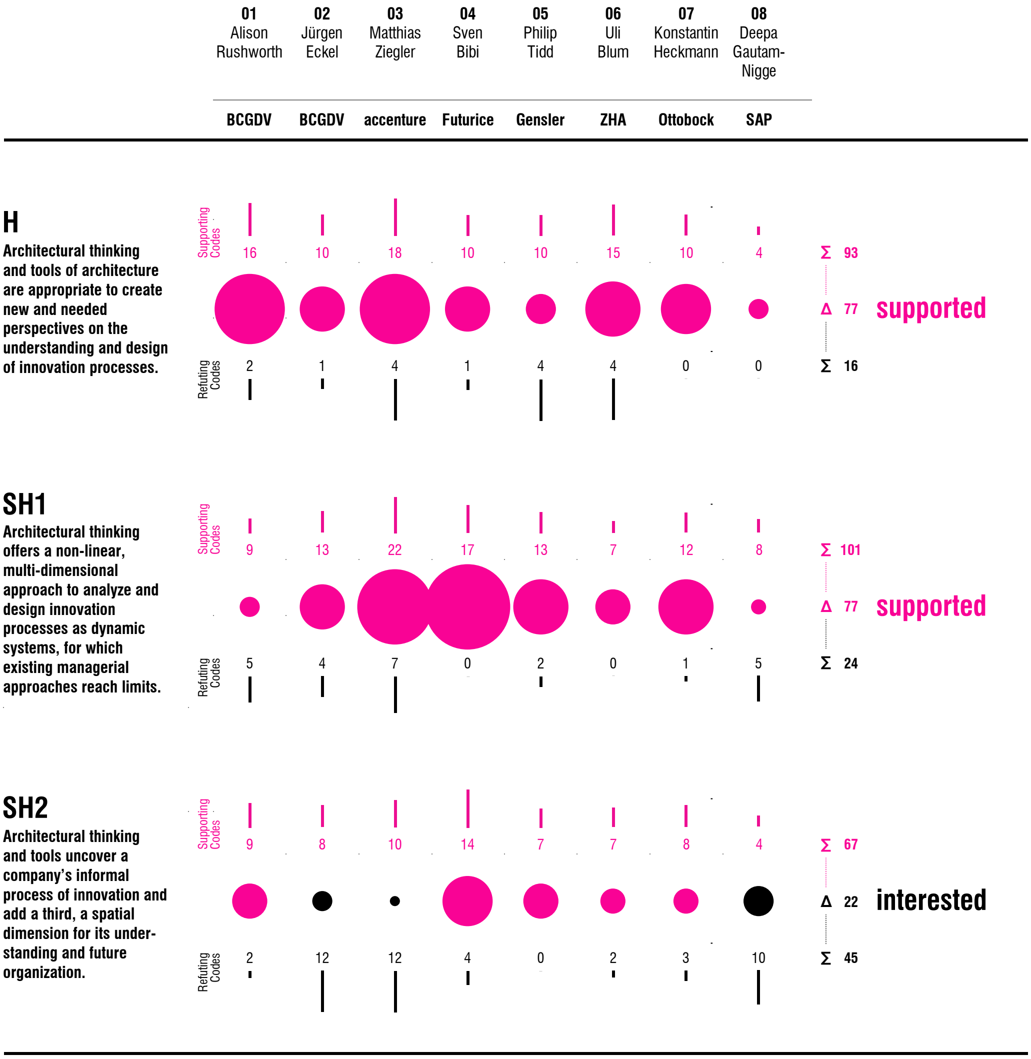
While in two interviews the research “gave (…) a lot food for thought” (post-interview memo, App. III.1, Rushworth, A., 2021, March 03) and supported a different awareness regarding architectural work (01, 02), two experts were already aware of the potentials. Their answers suggested the need for a further liberation from an architectural design process towards more interdisciplinary collaboration and interaction. As further development steps they thought of augmented reality spaces and the migration of virtual and physical environments. They also considered the perspective of a new user, who would need to be introduced to the approach.

The experts from architectural practice weighted their point of view with their experience in practice. The proposed approach was regarded as

- familiar, “powerful” and interesting, (App. III.5, Tidd, P., 2021, March 17, Pos. 482; 518-522; 525) but at the same time limited in practice, as they are “not experts in that field“ (ibid., 551-552).
- as very valuable and “onto something really great”, but opposed to obstacles residing in the common practice of architecture (App. III.6, Blum, U., 2021, March 12, Pos. 126-127; 132-133; 211-212; 227-228;242-243; 328-329; 350; 381-386; 389-391; 399; 462)

The experts from an enterprise background differed in their attitude towards the approach from each other. While one expert was familiar with architectural thinking and tools, and could see benefits, the other expert considered the approach an interesting addition to their existing way of dealing with innovation processes. In their view the approach was perceived as

- familiar and interesting (App. III.7, Heckmann, K., 2021, April 28, Pos. 358-364; 373-376; 393; 395-398; 512-517)
- interesting and possibly useful (App. III.8, Gautam-Nigge, D., 2021, March 09, Pos. 195; 208-209; 239-240; 264; 283-285; 296-297; 302-304; 330-333; 338; 342; 353-354; 379-380; 395-396; 478-479)



		01 Alison Rushworth BCGDV	02 Jürgen Eckel BCGDV	03 Matthias Ziegler accenture	04 Sven Bibi Futurice	05 Philip Tidd Gensler	06 Uli Blum ZHA	07 Konstantin Heckmann Ottobock	08 Deepa Gautam-Nigge SAP		
H **Architectural thinking and tools of architecture are appropriate to create new and needed perspectives on the understanding and design of innovation processes.**	Supporting Codes	16	10	18	10	10	15	10	4	Σ 93	
										Δ 77	supported
	Refuting Codes	2	1	4	1	4	4	0	0	Σ 16	
SH1 **Architectural thinking offers a non-linear, multi-dimensional approach to analyze and design innovation processes as dynamic systems, for which existing managerial approaches reach limits.**	Supporting Codes	9	13	22	17	13	7	12	8	Σ 101	
										Δ 77	supported
	Refuting Codes	5	4	7	0	2	0	1	5	Σ 24	
SH2 **Architectural thinking and tools uncover a company's informal process of innovation and add a third, a spatial dimension for its under-standing and future organization.**	Supporting Codes	9	8	10	14	7	7	8	4	Σ 67	
										Δ 22	interested
	Refuting Codes	2	12	12	4	0	2	3	10	Σ 45	

● strong support (+10)
● support (+5 to 9)
● interest (+2 to 4)
○ indifference (0 to 1)
● refutation (-2 to -4)

Table 21: Evaluation of Hypothesis and Sub Hypotheses

10.6 Limitations & Findings

The expert interviews provide several preliminary findings regarding the relevance of an architectural approach to innovation process design. Before explaining the findings in detail, several limitations need be kept in mind regarding feasibility, the sample, and the depth of discussion. Regarding feasibility, the methodology and the tool were only qualitatively evaluated. Testing them in a practical use case jointly with innovation managers, architects and management executives could bring forth insights for refinement and development. Regarding the sample, the experts deal with novel ideas and innovation on a daily base and are consequently positively inclined to new approaches. However, the experts may also be more critical. Regarding the sample size, eight experts were interviewed from the fields of architecture, innovation consulting and innovative enterprises. The experts are leading in their field, but not representative of their industries. In particular, the experts from an architectural practice have a distinguished knowledge and expertise at the intersection of architectural design and innovation processes, which is atypical for architectural practices. Regarding the depth of discussion, the interviews remained on a conceptual level. Single phases of the methodology as well as concrete applications of methodology and the tool in practice have not been discussed. Against this background, the findings are only first approximations that require further research and testing.

The professional background and expertise of the experts correspond to the answers and the support of the approach. Experts whose professional environment is characterized by direct communication, execution and outcome orientation, viewed non-verbal means such as sketching, drawing and modeling as secondary (02, 08). Experts who focus on the innovative project in their work, e.g., a new product, service or building design, refrain from dealing with overriding organizational structures and processes (01, 02, 05, 06, 08). For experts whose main activity is based on oral communication and verbal exchange, spatial representations and 3-dimensionality seem to complicate the design process (02, 08). For experts whose main activity is embedded in design collaboration, drawings, visualizations and models, 3-dimensionality seems to simplify the context and should be augmented with further elements such as sensory perception and direct connection to processes in reality (03, 04, 06).

Experts from innovation consultancies were open to the approach and interested in a possible application. They thought of possible use cases and suggested directions for further developments. Experts from architectural practice were aware of the potentials of applying architectural thinking to the design of innovation processes. At the same time, they remained restrained regarding the possibility of a broader implementation. Their answers indicated that the majority of architectural practices would follow the traditional scope of work as architects. Though both experts represent industry-leading and innovative practices, they see their main focus as being on the design of physical spaces (02, 03). Affirming this perception, one expert from innovation consultancy doubts whether a larger number of architects would feel encouraged to transfer their thinking, expertise and tools to innovation management (App. III.2, Eckel, J., 2021, March 10, Pos. 295-299).

Experts with enterprise background acknowledged the attempt to understand and develop innovation processes with an architectural design attitude. Their answers illustrate a preference for a more outcome-oriented approach. Designing an innovation process should follow a defined goal or result, and be measured accordingly. An innovation process design should provide concrete and actionable measures for an enterprise and its employees to implement and assess. Across the interviews, the architectural contribution to innovation process design was seen as one part among others. Though playing a leading role in moderating and guiding the design process was communicated as being necessary, a multi-disciplinary team with diverse capabilities and skills was considered essential. For successful innovation processes, the team requires the support of an executive level and corresponding incentives to pursue the innovation initiative. Working with spatial visualizations, a 3-dimensional space and non-verbal boundary objects was valued positively. It could create visual transparency, deepen understanding and foster interaction, engagement and collaboration. Modeling of configurations and simulation of changes in the structures could provide new insights into the organization of innovation processes. In contrast, further non-spatial dimensions of information, such as time, performance indices, role complexity of individuals, personal relationships and knowledge need to be considered in the methodology and the tool.

Experts from innovation consultancy and architecture suggest further development stages of the approach, to handle a "new reality" (App. III.5, Tidd, P., 2021, March 17, Pos. 541-544) of work and innovation, where digital spaces blend with physical spaces. It could support to share ideas, expertise and knowledge, and to develop a seamless collaboration, which – against the background of the global pandemic – may become necessary. For the development of new products and services, a new form of innovation interaction could evolve ("Innovations-Interaktion"; App. III.3, Ziegler, M., 2021, April 20, Pos. 302-304) with the support of the prototype tool. One expert from architecture referenced similar approaches in the past to increase the influence of architectural thinking, design and tools on the challenges of organization:

> *"And but I have to say what I'm talking about is not new. In the 70s there was a lot of that being done. It hasn't caught on I'm afraid. But one can say, you know there were even some computational blocking and stacking tools and all of that. Maybe it's a chance of restart now that technology has evolved and has become better and companies are more under pressure than at that time. The pressures were different at that time. And today, they found answers that to the questions. But today there is a whole new, yeah it's time to retry that."*
>
> *(App. III.6, Blum, U., 2021, March 12, Pos. 386-392)*

Reviewing the evaluation, there are three important considerations. Firstly, the methodology of an architectural innovation design is valuable, but not necessarily in an environment of architectural practices. As the answers from innovation consultancies revealed, their field of practice would be interested in further development and implementation. Secondly, the methodology is a feasible approach, but should not be conducted solely by professionals from the field of architecture. Several experts stressed in the interviews the importance of a multidisciplinary approach combining diverse capabilities and skills depending on the client's need. From the capabilities an AID proposed, only visual thinking and the use of non-verbal boundary objects received support. Spatial intelligence was not directly mentioned but indirectly valued through the possibilities the expert saw by working in a 3-dimensional space. Additionally, the importance of a lead and guidance was reported. Thirdly, the methodology represents a first step into a migrated reality of virtual and physical spaces. The basic proposal to visualize people, teams and departments with their connections and relationships was considered by the experts as conservative. With advancements in digital technologies, augmented realities, simulations and real-time feedback, iterations could offer a new form of interaction for innovation.

11

11 – Leaving the Plan: Review & Outlook[131]

Throughout this thesis, one argument has been repeatedly placed. Managerial decisions and attitudes prevalent since the second half of the past century are reaching their limits in addressing the challenges of the dynamic environments of today. While a design attitude has gained in popularity as well as in acceptance in managerial practice since the turn of the millennium, the discipline of architecture and the profession has barely contributed. The field of innovation research and management has welcomed and integrated novel approaches and designerly ways to tame complex processes. Innovation processes have evolved from linear conceptualizations into system models. Both groups of conceptualizations are now in parallel use. At this point, the discipline and profession of architecture offers the thinking and tools to develop the system models further. The elaborated extended process view on innovation in this thesis poses requirements that match with the capabilities and ways of working architects possess. However, the capabilities and way of working have to be valued in the context of innovation design, rather than building design with which architecture is commonly associated. They need to become accessible to the different parties involved in the design of an innovation process. This relates to management professionals and architects alike.

The methodology and tool concept of an architectural innovation design seeks to integrate the requirements of an extended process with an architectural design process. The resulting spatial model of innovation processes in a firm represents a dynamic, multidimensional, socio-technical system. It intends to offer innovation managers, management executives and people involved in innovation processes a new mental as well as a new visual frame. Innovation processes can be constructed as spatialized social networks, modelled and considered from different viewpoints. In a critical reflection with experts in innovation, a first evaluation of this approach has been conducted. The findings summarized in Chapter 10.6 (in consideration of the findings summarized before) lead to conclusive notes. They carry implications about how the approach should be treated and put into perspective. They touch on the current conditions of a global pandemic, which have been excluded from consideration so far. And lastly, they support future paths for research and practice that have been sketched throughout the thesis for new spatial thinking about organizations and their processes.

11.1 Implications

The intended goal of the thesis is to connect architectural design thinking and its tools with innovation research and management. In the management of innovation, architecture has been used as mean to design physical spaces, that ressembles an organizational structure (e.g., Allen & Henn, 2007, pp. 3, 109; Knittel-Ammerschuber, 2006). In the design of innovation and its processes, architecture is proposed as the medium through which an organizational structure takes shape in the first place. An architectural innovation design (AID) considers complex environments, problems and processes. It integrates the human element through social proximities and interactions. And it applies a

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[131] The title was similar used in Chantzaras (2019b, p. 537) as "Leaving the Plan."

design process, based on a systems view, reflection-in-action and visual thinking. The capabilities an AID requires reside in visual thinking, spatial intelligence, the use of non-verbal boundary objects, holistic thinking, and design synthesis. The methodology it applies consists of interdependent phases of context design, structural concept design and the design of a transformational model. Although capabilities and design phases were not evaluated in detail, the evaluation through expert interviews partially supports the approach. As summarized in the findings, the experts - including architects - communicated prevailing conceptions about architectural work, closely related to physical space. The experts preferred to speak from skill-sets in a team and interdisciplinary collaboration than from individual capabilities. The introduction of a third dimension to represent and understand innovation processes was valued as beneficial. The decent answers and comments of experts from the field of architecture underline the challenge to direct professional work into managerial areas. The findings of the first evaluations convey several implications.

An architectural innovation design can be seen as a first approach to open the discourse among management professionals and architects. The approach may be more valued by trained architects, who are already distant from the field of building design and building construction. As a first approach, the AID needs to be tested in practice and challenged by actual users. The capabilities and design phases derived from theoretical considerations and two case studies may require refinement based on feedback from practice about how the approach could be applied and if the methodology improved innovation processes in a firm. Regarding the importance of innovation and innovation processes, an appropriate use case with an enterpise may be difficult to find. The enterprise needs to be committed to explore a different and new approach to design its innovation processes. The architectural thinking put forth as advantageous for innovation process design is disadvantageous in so far as it seeks to provide a final synthesis, or finished outcome, which leaves little space for adjustments. In this regard, the approach of an architectural innovation design presented here should not be regarded as final, but as a preliminary synthesis for further exploration with other disciplines.

This leads to the second implication. If the AID should become a feasible and integrative approach, other disciplines need to be involved in its development. The multiple dimensions of an innovation process in an organizational setting, especially in large-sized companies, cannot be covered by simply spatializing its structure. Responsibilities, personal characteristics and preferences as well as incentive structures and cultural aspects require consideration. However, the methodology and the tool should not increase in complexity to the point where it hinders the initial intent of a design process that is essentially based on intuitive thinking, on visual-spatial thinking and on reflection-in-action.

A third implication addresses the migration of physical and virtual work environments. In this thesis, architectural thinking is directed to fields of management, detached from a physical building design. An architect is understood as a designer of systems and in particular as a designer of innovation processes as socio-technical systems. In this field, the architectural innovation designer brings together organizational structure, culture, people, purpose and space. She or he develops in collaboration with other stakeholders a transformational model that subsequently becomes implemented in reality. In this reality, physical space is an equally important element next to people, technologies and ideas. As conceptualized in the digital tool in Chapter 9.3, the transformational model can be maintained as a virtual innovation system, which employees can relate to permanently. If the tool is developed further from a mean for strategic design into an individual innovation management application, employees can act in a virtual reality of innovation processes. The migration of physical and analog realities, which experts envisioned in the interviews, can be facilitated by tools architects can access and handle. On the virtual side, advancements in augmented and virtual realities, parametric design approaches and increasing computational performances enable the construction and design of virtual spaces. On the physical side, spatial design and configurations are still relevant for creative and innovative work. The design, planning and construction of both realities can be supported by architectural practices, and provide a seamless transition between working in physical space and working in virtual settings. Taking this implication further, virtual and physical realities of organizations and their processes would be designed simultantously and in reference to each other. The design of a virtual space would then have elements and cues linking it to the physical space, and vice versa, the physical space would comprise a design, that allows transitions into the virtual space. In this direction, it should be noted that a design of innovation processes, virtually and physically, may not reach a final stage, but be subject to iterations and redesign. What has been said for innovations being a "fact and an act" (Dodgson et al., 2015b, p. 5), an output and a process, applies to the organizational system in similar ways. It is an object and a process, or more precisely: a boundary object and a process, everyone involved is also co-designing it.

Kieser (1998; p. 45) argues from a constructivist perspective on organizations that the communication between people in an organization shapes, constructs and manifests the organizational structures. An organization resides in the individual's head and becomes externalized through communication e.g., of "visions, metaphors and stories" (ibid., p. 45). A rhetorical means of communication and the way communication is initiated and structured between different stakeholders matters (ibid., p. 67). He titles his arguments with reference to a literature essay by Heinrich von Kleist "On the gradual construction of thoughts during speech" (Hamburger, 1951):[132]

> *"On the progressive consolidation of the organisation through discourse. Organisation as communication.*
>
> *Über die allmähliche Verfertigung der Organisation beim Reden. Organisieren als Kommunizieren"*
>
> *(Kieser, 1989; p. 1)*

The arguments and title, especially when referring to "construction of thoughts" (Hamburger, 1951) support indirectly the value of an architectural design approach to innovation processes. Firstly, they underline the importance of social interaction and discourse. Secondly, they underline the abductive thinking and reflection-in-action process for the construction of new thoughts and ideas. In the methodology of architectural innovation design, the innovation system is constructed gradually through visual discourse.

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[132] Alfred Kieser is a researcher and lecturer in organizational theories, history and design of organizations. From 1978-2010 he was Professor of Organizational Behavior at the University of Mannheim (IfM Mannheim, 2022). The original essay by Heinrich von Kleist dated back to the year 1805 is titled: „Über die allmähliche Verfertigung der Gedanken beim Reden." Translations differ by referring to "gradual completion of thoughts" (Taylor, 2011), "gradual construction of thought" (Hamburger, 1951), „Gradual Production of Thoughts" (Constantine, 1999) or "Gradual Formation of Thoughts" (Harbsmeier, 1996). See also Whickham (2019).

11.2 Conditions due to the Covid-19 Pandemic

The work on this doctoral project began in 2017, when topics such as 'new work' (e.g., Bergmann, 2019, pp. 1–4), 'new ways of working' (e.g., Mitev, Aroles, Stephenson, & Malaurent, 2021, p. 3) and 'the future of work' were intensively discussed as managerial challenges in relation to physical space (e.g., Groves & Marlow, 2016; Katsikakis, 2017).[133] Though various organizations had implemented spatial configuration to optimize workflows and improve knowledge exchange during the 20th century, the relevance of physical space changed after the turn of the millennium (ibid.). Spatial layouts and designs became subject to decisions at executive level as tools for fostering collaboration, creativity and innovation processes. The digital transformation in industries was contingent on a spatial transformation. Individuals, teams and organizations had begun to work differently in spatial terms. At an operational level, collaboration and self-organization of teams started to be promoted. At a strategic level, a narrative for agile and flexible ways of working as well as the optimization of spaces needed for desk work became standard. Office spaces and buildings are now seen as "‚object institutions' shaping the behavior of the people within" (Chantzaras & Ford, 2020, p. 102), and need to be placed in their design in the scope of executive levels (Welpe, personal communication, November 2019).[134] In parallel, the virtualization of collaboration and personal interaction has increased and become a major challenge for organizations, either in transforming their existing processes – based on physical presence – or building up their business models on remote working but with networked entities (Florida, 2020).

The global pandemic caused by Covid-19 starting at the beginning of 2020 marked a major disruption in the way organizations and people used and could use spaces for work. It also revealed a contradictory situation, wherein on the one hand physical spaces were redundant for routine processes or processes with known protocols, and could be reduced. On the other hand, physical spaces were still needed for creative work and innovation, as personal interaction remained relevant for tacit knowledge exchange, for the perception of non-verbal information with multiple senses and the cognitive ease afforded by spatial experience (Chantzaras & Ford, 2020, p. 102; Bailenson, 2021, p. 3–4). Though remote work for creative and innovative challenges is increasingly supported and facilitated with digital tools, informal interaction, unconscious perception, confrontation with and exploration of diverse views as well as the unpredictability of human action are limited. First studies on remote work during the pandemic have found negative effects on knowledge diffusion, collaboration and innovation. For example, silo structures are found to increase, unplanned encounters are seen to decline, maintaining and building relationships at international level are challenged (e.g., Coscia et al., 2020; Sailer, Thomas, Pomeroy & Pachilova, 2021; Yang, Holtz, Jaffe et al., 2022, p. 43). Furthermore, a fatigue by non-verbal overload using video conferencing could be argued (e.g., Bailenson, 2021).

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[133] ‚New Work' has been coined as concept first by Frithjof Bergmann (Bergmann, 2019, pp. 94–98; Schnell & Schnell, 2021, pp. 5–11). It describes a self-determined work, „for oneself" (Bergmann, 2019, p. 95) based on real desire, purpose and skill-building. ‚New Ways of Working' and ‚Future of Work' have not a unified meaning. Scholars and professionals define them according to their respective field. In general, both terms consider the impact of automatization, digitalization, knowledge work, social networks and individual preferences on the working processes and development of new occupational profiles requiring a different or new skill set.

[134] In a personal communication Isabell Welpe, Chair of Strategy and Organization at the TUM School of Management, summarized the relevance of physical space for management executives as follows: "Räume sind Objektinstitutionen und beeinflussen das Verhalten aller in ihnen arbeitenden Menschen. Die zentrale Aufgabe von Führung besteht darin, Verhalten zu beeinflussen im Sinne des Unternehmens. Damit ist Entwurf und Gestaltung von Räumen Führungsaufgabe."

Nevertheless, the virtualization (and digitalization) of processes in organizations are continuing apace. The approaches adopted by various organizations, such as dispensing with physical headquarters, working in co-located spaces and flexibly aligning or composing teams across areas, had already begun prior to the pandemic. With the onset of the pandemic, and presumably following it, hybrid work modes, third places and digital creative collaboration tools will increase in relevance.[135] Through hybrid work modes, organizations will offer a mix of in-person work and remote work, according to the organization's culture and process demands. Third places are intermediary spaces, which are neither dedicated spaces of the organization, nor private spaces of the individual employed (Abernathy & Malcolm, 2008).[136] Third places, e.g., accessible public spaces, co-working spaces and repurposed or converted spaces (such as malls, cultural institutions, areas of food & beverage), will become an integral part of an organization's workplace strategy. Digital creative collaboration tools, may displace physical interaction as an essential precondition for innovative work to some extent. Digital twins, as mentioned in one expert interview are already in use in architectural design processes to mirror building structures and provide a virtual or augmented reality of 3-dimensional spaces. The digital twin environment of an organization makes it possible to digitally align in virtual spaces, collaborate and model challenges of innovation, exchange and explore ideas and knowledge, prototype and test concepts, services or products. If organizational structures are virtually – visually and spatially – designed and developed, as this thesis suggests, a third place of a different understanding may evolve. This third place would blend elements of the physical working area with elements of the virtual working area, and allow a seamless transition between these both areas. Ideas and concepts of a metaverse, that are receiving increasing attention, may contribute to this direction and take the development of virtual organizations further.[137]

Against this background, the thesis still remains valid. In first place, it addresses the thinking of architects separated from physical building design. Their contribution to innovation management and research is worked out at a systemic and strategic level. The proposal put forward in this thesis is to extend the scope of architectural practices into the field of organizational and innovation process design. Thinking and tools of architecture are suitable for addressing managerial challenges, how people and objects work, and how they interact with each other physically and remotely. In the development of future hybrid work environments with interaction between co-located individuals, teams, departments, architectural approaches offer numerous advantages. In order to balance the need for personal interaction and exchange face-to-face with workspaces that can be covered remotely, where expertise and talent reside, enterprise will need an understanding of spatial networks, and the visualization of their informal organization and differently weighted interlinkages. The

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[135] See for example Bandaru (2021); McLaurin (2021); Makarius, Larson & Vroman (2021); Sailer, Thomas, Pomeroy, & Pachilova (2021).

[136] Oldenburg & Brissett (1982, p. 269) had introduced and defined the term 'third places' from an urban and sociological point of view: "Third places exist outside the home and beyond the "work lots" of modern economic production. They are places where people gather primarily to enjoy each other's company. They are not like businessmen clubs and singles bars which people inhabit in order to informally encourage the achievement of formal goals."

[137] As general comment on opportunities through metaverse concepts see for example Fleishman (2022). An overview on research and definitions of metaverse is provided in Park & Kim (2021, pp. 4213–4216). Dionisio, Burns III & Gilbert (2013, pp. 34:6–34:7) explain the term as follows: "The word Metaverse is a portmanteau of the prefix "meta" (meaning "beyond") and the suffix "verse" (shorthand for "universe"). Thus it literally means a universe beyond the physical world. More specifically this "universe beyond" refers to a computer-generated world, distinguishing it from metaphysical or spiritual conceptions of domains beyond the physical realm. In addition, the Metaverse refers to a fully immersive three-dimensional digital environment in contrast to the more inclusive concept of cyberspace that reflects the totality of shared online space across all dimensions of representation."

approach will aid in prototyping alternative configurations of the organization and testing its performance either as simulation by computational means or literally ‘on site’ in temporary physical set-ups and evaluating its adoption. With the help of such constructed models, an organization can track and simultaneously display change processes in its structure.

Besides the relevance of collaboration and co-creation, the aspect of confrontation also needs to be considered. Rooted in an architectural design process, the methodology of architectural innovation design seeks to develop an alternative configuration that promotes knowledge flows, chance encounters, exploration and the confrontation with contrarian views.

Architectural practices will offer consultancy at early decision phases and cover both the virtual and physical realities of an organization. The proposed methodology of architectural innovation design provides an advanced design brief for building digital as well as physical architectures. Though the pandemic constrains physical interactions, face-to-face encounters in physical space remain essential to human experience, exchange of ideas and tacit knowledge, as well as creative processes. The design of these spaces may change from known central headquarter designs into designs of organizational satellite spaces, physical and virtual third places or work-from-home environments, for which organizations will become responsible as well. From an urban development perspective, city authorities may also be interested in spatially analyzing and modeling where to provide or transform spaces and infrastructures for organizations, teams and individuals to settle. The design of an innovation ecosystem could benefit from integrating architectural innovation design.

Architectural practices may advance further in the field of virtual organizations. Their capabilities to design an organization and its processes virtually and phyiscally as socio-technical systems may be needed in the design of an organizational metaverse. Architectural designs, and architectures of innovative interactions are in the first place virtual concepts, until they are constructed in reality (DWIH New York, 2021).[138] In future, these virtual concepts may become the essential outcome and value-add of architects.

11.3 Paths for Research & Practice

The arguments and methodology developed in this thesis provide a new field for research at the intersection of architectural design and innovation management. The field encompasses different subjects: firstly, methodology and tool; secondly, innovation and physical space; thirdly: physical space and real estate development; and fourthly: education in architecture and management studies.

Methodology & Tool. The expert interviews demonstrated the interest in an architectural approach to innovation management. It will be necessary to formulate concrete use cases for particular firms and apply the methodology in practice. In this regard, architects are needed to implement the methodology as well as enterprises willing to advance their innovation design with an architectural approach to construct an innovation system that fits their way of working. Both, architectural practices and enterprises need to be introduced in the methodology and accompanied during the process by further research in this field. The evaluation of benefits and shortcomings in action with

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[138] In a virtual panel titled ‘InnoSpacing: The role of physical space and its value proposition for inducing innovation ecosystems’ the author discussed the relevance of building architecture with Chris Ford, architect and Ph.D. student from the Mechanical Engineering Design Group at Stanford University, and Michael Shanks, archaeologist and professor of Classics at Stanford University. Michael Shanks questions the precondition of physical space for creative and innovative collaboration and outilined the virtuality of architecture (DWIH New York, 2021).

architectural practices and innovation management professionals will be essential for refinement and development. The concerns mentioned during the expert interviews need to be addressed if the spatial dimension put forward actually improves understanding and decision making for designing innovation processes; if architectural practices implement and adopt the methodology; if innovation managers learn to collaborate and model innovation processes in designerly ways. Reflecting on his mission to – using his term - 'demystify' the design process, Lawson states:

> *„Even after all this effort I remain tormented by a continuing concern. It is that when I read another book or article or listen to a conference paper about the design process I can usually tell whether the author is actually a designer or not. It remains the case that the design process can be learned chiefly through practice and is very difficult to teach well. It is extremely difficult to understand design without actually doing it."*
>
> *(Lawson 2005, p. 303)*

The separation from physical space and building architecture needs to be formulated more clearly to avoid misconceptions about the work of architects. On the other hand, key indices of relevance in innovation management need to be researched in order to be integrated in the methodology. Testing and evaluating the methodology will also affect the development of the digital tool that aids visualization, collaboration and modeling. As the tool prototype in this thesis received limited support from the experts, other alternatives need to be researched, developed and tested. A further analysis of currently available digital tools and tools in development within innovation management software is necessary. The possibilities of augmented realities and hologram technologies need to be investigated as well.

Innovation & Space. By applying the methodology in case studies, 3-dimensional configurations of organizational structures will be developed. The resulting architectural models of organizations and their innovation processes open a further field for research. In analogy to building architecture, the modelled organizational structures can be analyzed as typologies that share similarities or are distinct from each other. By abstracting from their form and representing the structure of the models as graphs, the models can be compared with each other and distinct aspects can be retrieved that may impact innovation performance. A graph is a "set[s] of positions" or situations and "the transitions or relationships between these positions" (Hovestadt, 2021, p. 178). Graphs can be used e.g., to describe paths between different nodes or the centrality of a node within a network (ibid., pp. 187–188). The space syntax methodology uses a graph approach to compare the configuration or structure of spaces. The resulting "justified graphs" (Hillier 2007, p. 22) show the interrelations of spaces and their depth that explain how many other spaces can be accessed (ibid., pp. 23–25). The deeper a space is located, the fewer the possibilities to access other spaces through it, and the less integrated it is in the overall configuration of spaces. The representation of organizational models and spatial configurations with graphs, as proposed in the space syntax methodology, opens another direction. The space-innovation relationship, or more precisely, the space-innovation process relationship could be analyzed based on existing floor plans, in which knowledge intense companies operate. The floor plans and physical facilities a company uses for its innovative initiatives could be represented as structure (or graph) and compared to the structure developed with an architectural innovation design. A question for research would be if it is possible to deduct, or decode, an innovation process model from floor plans and enterprise data e.g., regarding people, projects, interactions, knowledge and skills.[139]

The principle logic of the methodology to spatialize innovation processes, to collaborate and model alternative configurations is applicable to single units of organizations, to small enterprises or to enterprises with a globally spread structure. It could be further applied and tested with challenges in urban planning and urban design. The relationship between space and innovation processes could be analyzed and developed at a neighborhood, district, city or regional level.

Space & Real Estate Development. Developing physical spaces and innovation processes simultaneously also opens a new direction in real estate. Simply the provision of spaces for knowledge work may not suffice in future. Developers could seek to offer intentionally designed spatial configurations of work environments with e.g., workshops, labs, communal areas and an accompanying digital application, which supports leasees and users – including the local society – in their innovative actions. Development and management of real estates could become an essential part in the workplace strategy and the nurturing of people and culture in an organization. Human resources and space management would merge.

Education. The third field of interest for further research is related to higher education in the disciplines of architecture and management. Applying architectural thinking to managerial challenges is new to both disciplines. It would therefore be necessary to develop interdisciplinary formats and courses that create awareness of a different conception of architectural work and a different conception of innovation processes. Regarding architectural work, higher education in architecture needs to work out the particular skill-set architects possess and define architecture as a system and innovation design discipline. The prevailing conceptions about architecture need to be addressed within a new discourse, as proposed in this thesis: A discourse that investigates and outlines the innovative capacity of the architectural design process, a discourse that emphasizes the capability for system thinking and synthesis independent from a building project. Regarding a different conception of innovation processes, higher education in management is offered an access to architectural thinking and its tools. Management studies can introduce perspectives of decision making in architectural studies and pose managerial challenges as matter of architecture. Design thinking as a method has gained in awareness and relevance in management studies over the past decades. If design thinking education for innovation can be reasonably delivered with the absence or exclusion of designers trained and educated in disciplines that are traditionally associated with design stands in need of investigation. In particular, for the discipline of architecture, there is an opportunity to build on the introduction of design thinking in management studies, offer interdisciplinary architectural design thinking courses and educate an architectural design attitude beyond building design. It may equip future architects to embark on challenges of designing organizations and innovation processes.

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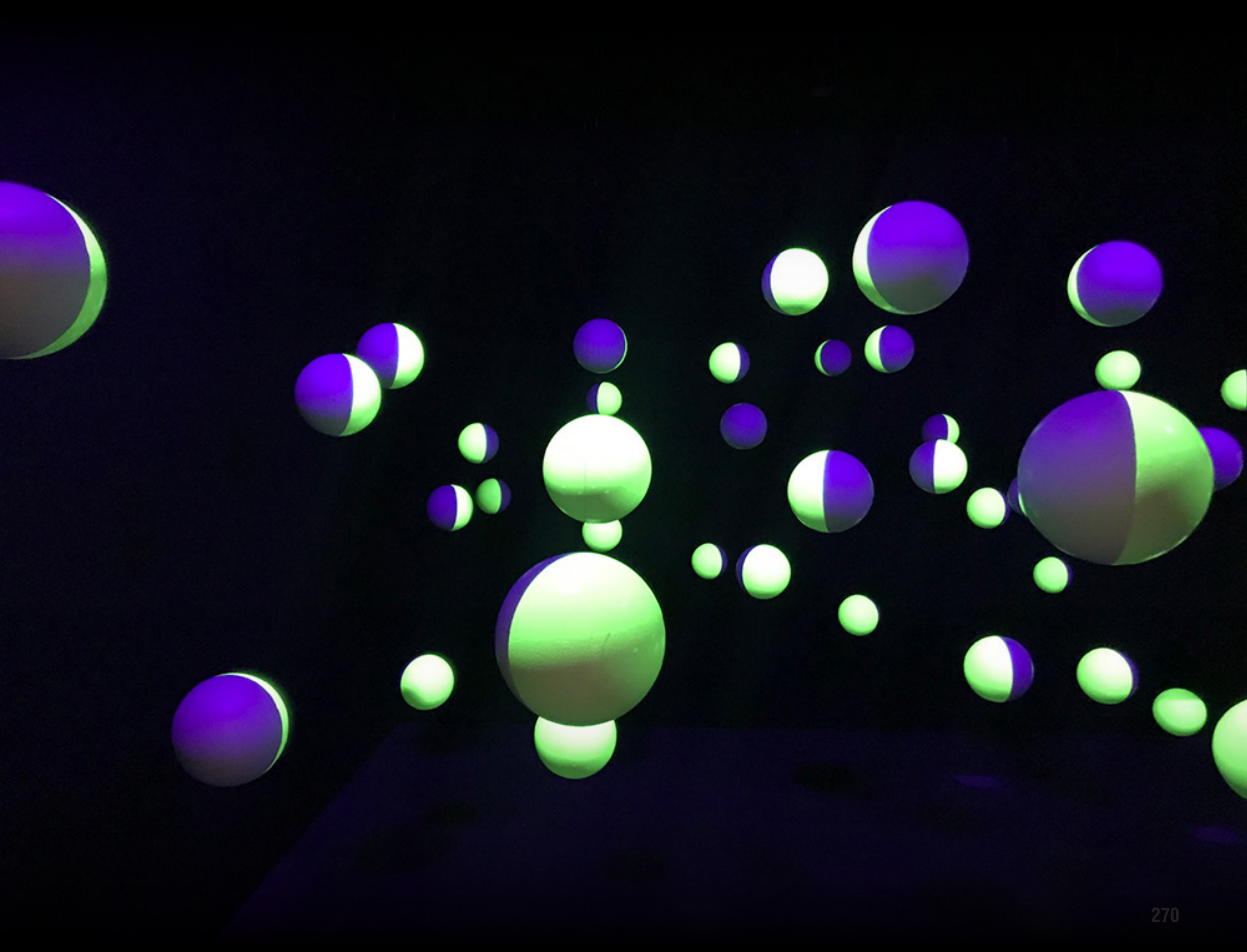
[139] Konstantin Flöhl developed a proposal in this direction with his master thesis “Building Innovation Modelling”, shown in Appendix II.2.

11.4 Leave & Return

The recurring call in this thesis for the application of architectural approaches in dynamic environments of organizational structures also entails leaving the known and established terrain of architectural practices. The practices of designing and planning buildings. Architects communicate through sketches, diagrams, drawings and models. For architectural innovation design, the discipline and profession of architecture needs to outline its system thinking capability and the knowledge it develops and graft it onto the relationships and interactions of organizations. This requires architects to move beyond the building as the sole outcome of their work and the plan as primary means of communication (Chantzaras, 2019b, p. 537–538). The plan, as researched in the thesis, disguises the value an architectural design process has for the design of innovation processes. It prevents architects from transferring their work to other fields. Innovation management is challenged in a similar way. The thesis elaborates arguments against the linearity of sequential innovation in process models and explains the shortcomings of systemic innovation process models. The potential of spatiality and non-verbal boundary objects for gaining deeper understanding and for the conduct of a design process is sadly overlooked. In this regard, innovation management must move beyond its plan for innovation processes, as represented and embodied in its different models. It needs to allow a design process to unfold, and a constructive practice to take place.

Referring to the origin of the word architect, as explained in Chapter 5.1, it means to govern, to rule, to take the lead, in construction works or in building ships (Fischer, 2014, pp. 23–24). Over the course of time, the design and planning of physical buildings distilled itself as the central outcome of architectural work. The building suggests an immovable estate. Whereas the ship is a structure to carry people from A to B or through uncharted waters. It is a medium for travel and exploration. For the journey of innovation that each organization has to undertake, it is necessary to question which medium it will choose and who will be contributing to its design. Architects need to build ships again. As mediums for innovation.

Appendix



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Appendix I - Glossary

The terms listed in the following are defined in the context of this thesis and based on the arguments elaborated throughout the work. The definitions are restricted to their notions of relevance for the given context. Terms used in close relation or synonymously are added with a hashtag at the beginning of the definition.

Abduction

#Abductive Reasoning #Abductive Thinking. Third mode of reasoning besides induction and deduction. Abduction is a way of thinking that proceeds with a preliminary hypothesis based on previous knowledge, experience, visual and diagrammatic thinking and intuition. Abduction serves to explore possible directions for a problem resolution, especially in cases where a phenomenon cannot be approached with pure logic, and to iterate, if the conducted approach provides insights and learnings that require revision of the initial guess or working hypothesis. The hypothesis is tested in a back-and-forth process, iterated and adjusted if necessary, or assumed as preliminary support for the thinking process.

Architectural Design Thinking

Architectural design thinking is built upon architectural thinking and considered as a methodology for solving complex problems with the thinking and tools of architecture. Its conduct depends on the individual characteristics of architects, architectural practices and design studios, who apply their methodology consciously or unconsciously. The characteristics share commonalities regarding the level of design expertise, the performance of design skills and the use of design tools. There is a constant commute between problem and solution space during a design process. Architectural design thinking continuously represents a problem with various non-verbal tools to gain a deeper understanding; the thinking space is extended by non-verbal boundary objects and persuasive artifacts, such as tangible models, sketches, diagrams and interactions with others; it adds context to the actions of creativity and invention. Architectural design thinking generates new alternatives, maintains and sustains uncertainties and ambiguity during a liquid process that remains open and adaptive to changing requirements, new insights and perspectives.

Architectural Innovation Design / AID

A methodology for applying an architectural design and consulting process to innovation management. It consists of three interdependent phases: the analysis of context, the construction of an organization as a 3-dimensional model of interacting parts; the design of the innovation processes and the modelled organizations as a multi-dimensional, dynamic and emergent system. The methodology is an explorative and constructive design process, which uses the different capabilities of architectural practice for interdependent and collaborative design phases. Architectural practices incorporate their individual design approaches according their preferences and demands.

Architectural Intelligence

The ability to explore relationships between elements across different spatial scales, to detect possible proximities and to establish new connections between them in the mind, or externalized through non-verbal means, in order to design a themed system, i.e. system with a meaning or purpose.

Architectural Thinking

The way of thinking in the discipline of building architecture. Architectural thinking is abductive, lateral and visual thinking that balances descriptive modes of 'what is' with the reflective, constructive and imaginative capacity to create 'what ought to be.' Architectural thinking is optimistic and persuasive about achieving an improvement for a situation from a long term perspective. It immerses itself in a problem's space, understands and creates by using non-verbal tools, by analyzing, structuring and modeling relationships and elements visually and spatially. Architectural thinking is directed towards synthesis, to developing a new whole that exceeds the sum of its parts, and that will be implemented in the real world, at different building scales from abstract masterplans to concrete details on the scale 1:1.

Architectural Tools

#Design Tools. #Tools of Architecture. Tools that enable architects to commute between problem and solution space. They are tools for non-verbal thinking and abductive work. Sketching, diagramming, drawing and modeling make it possible to switch flexibly between different subjects and between different levels of abstraction, and focus simultaneously on the details of a situation and the situation as a whole. The different degree of vagueness, indeterminacy and fuzziness in sketches, diagrams, drawings and models facilitate exploration of elements of context from different viewpoints while keeping other aspects in view.

Artifacts

#Persuasive Artifacts. These are a kind of boundary object that contain a conviction of the creator for direction of thought or influence a design direction through their presence. Persuasive artifacts have an interpretative flexibility and facilitate understanding, communication, development and transformation of a design idea or concept. They convey different levels of information and knowledge, from abstract, metaphorical levels of thought to concrete levels of details for construction. They function in first place as inspirational aid and invitation to engage in and contribute to the design process without requiring a particular structure or scale.

Boundary Objects

#Non-verbal Boundary Objects. Visually or verbally externalized data, information, knowledge and thought that function as a bridge of communication or intermediary device between people of different disciplinary backgrounds and between different stakeholders without requiring consensus about the object or the content of the objects represented. Boundary objects differ depending on case and use in type and level of abstraction, in materiality and scale. They function as tools for reframing existing and creating new mental models of a situation, support integration of different parties, and facilitate reflection and construction in a design process. Non-verbal boundary objects address the senses of sight and touch, and invite people to discuss and transform the structure they represent.

Capability

Individual, team or organizational capacity to perform an activity with a distinct ability, skill, attitude or mind-set is subsumed. While the ability constitutes a residing potential for an activity, the capability defines the extent to which an ability can be turned into action, is learned and trained.

Center of Gravity

Organizational, social and physical elements that attract, promote and guide interaction between people in exchanging ideas and knowledge for innovative initiatives and forming a center. The center is characterized by longevity to be recognized as center and an ephemerality to outline its informal nature and the dynamic changes caused by changes in the interactions and the elements.

Complexity

A situation or state in which a multitude of interrelated parts interact in a non-linear and emergent way. Complexity is characterized by a variety of elements, connectivity in interdependent relations, and an unpredictable dynamic in the behavior of these elements and actions. A complex system is a set of different parts with multiple relationships and behaviors that has a function or purpose that exceeds the performance of the parts. A complex (adaptive) system shares the properties of non-linearity, emergence, self-organization and unpredictability.

Construction

#Constructive Practice. This is continuous thinking and active creating of preliminary and final artifacts that represent the status of thought of the practitioner and build a (preliminary) problem understanding or form a future state or reality. Construction integrates the thinking about a solution and the actual making of it with the use of non-verbal means or design tools. Artifacts or boundary objects make it possible to add, remove, modify the elements of the construction and propose a new configuration as a design solution.

Design Attitude

The attitude to approaching a problem, performing work and proposing a solution based on architectural and other kinds of design thinking, design expertise, design skills and design tools. It questions given constraints and challenges, seeks and develops alternative solutions, remains open and adaptive to changes, and uses non-verbal tools as means for thinking and creating. A design attitude implies responsibility and care for clients, environment and society. It is holistic in that it relates the impacts and effects of a design in the context of larger environments (e.g. industry, society, natural environment) and considers long-term perspectives; it fosters co-creative engagement; it is optimistic in achieving a betterment of a situation.

Design Synthesis

Art of arrangement, thematization, composition and combination of the tangible and intangible, the implicit and explicit, the informal and formal elements as new whole that exceeds the sum of its parts. Design synthesis is the outcome of a design process as answer (and solution) to a problem. In architecture, synthesis is seen as complex principle of organization to create and develop structures, connections and relations between people, functions and spaces with a new theme and meaning. A good design synthesis includes aesthetics as features of clarity and usability, which can evoke behavioral change on user's side.

Immersion

#Empathy. Immersion and empathy are core capabilities in understanding people, interactions, processes, culture and organization. Immersion represents the capability to enter the problem space, to understand and analyze the situation and imagine a resolution on behalf of clients or users. To immerse oneself in a situation means to identify with it through cognition and emotion, and to construct a new perspective from the inside. It is a perpetual inquiry, dialectical reasoning of qualitative aspects of values, experiences, atmospheres and emotions which span the individual perspective – how someone feels, behaves and acts – to groups, organizations and the external social environment of e.g., the public, the broader industry or the innovation ecosystem. Architectural immersion comprises empathy and responsibility, to understand the problem on the one hand and uncover latent needs, and to confront client and user on the other hand with the social and ethical aspects of the imagined solutions.

Innovation

A novel idea, turned into an invention and successfully applied or implemented in scaled products, services or processes.
An overview of the definition of innovation as outcome is given in: Hauschildt et al. (2016, p. 5) and Götzendörfer (2014, pp. 12–13).

Innovation Process

A social process of understanding, learning, creativity and interaction, causing change through the creation and successful introduction of a different new whole (e.g., a service, product, process, or configuration).

Innovation Process, Extended View

An innovation process is as a multi-dimensional system – consisting of three spatial dimensions, the dimension of time and further parameters, which are not referred to as dimensions – that represents relational and spatial proximities between human actors, and between human actors and non-human elements, which interact, explore, assemble and implement change through the creation and successful introduction of a different new whole (e.g., a service, product, process, or configuration).

Long-term Thinking

#Holistic Thinking. The consideration of implications and consequences of a proposed design solution in the future. Long-term thinking anticipates possible future requirements and needs in the design process in order propose an adaptive design solution, which may occur beyond currently stated user, business or market needs. The structures and systems architects develop need to provide permanence on the one hand and remain adaptive to changes on the other. Long-term thinking is essential to practicing critique and leading the design discourse beyond the short-term perspectives.

Model

#In General #In Innovation # In Architecture. The representation of distinct part of reality, which illustrates something, abbreviates and abstracts, and serves a practical function or purpose. In innovation research and management, models help to organize knowledge, give form to a theory, externalize conceptualizations or serve as guiding device for action. Models in architecture are a design tool for construction and representations of an idea, a concept or worked-out drawing in a 3-dimensional, bodily form. In contrast to sketches, diagrams and drawings, which are also viewed as models in the general theory of models, a model in architectures addresses the process of making and thinking in three dimensions. Actors can add, take away, shuffle and re-arrange objects in it or they can reconstruct the entire model, while reflecting and evaluating the conducted actions and their consequences. Models in architecture are embodied knowledge and a process of knowledge creation. By integrating time as fourth dimension, simulations and dynamics become part of the design process.

Parametric Design

A generative method in computer-aided design that defines a process based on different parameters interrelated by sets of rules to generate computer-aided complex design forms or optimized design solutions. Optimized design solutions are conducted by computational means against defined design criteria that independently adjust and test different values of parameters to generate a satisfying solution. The relation between the design intent (what is aimed for as a preferred state) and design response (what is proposed as a solution) can be defined and embedded through the use of algorithms and computing technology.

Proximity

Proximity defines the degree of possible and factual interaction in relational and spatial ways between human actors. The human aspect of individuals, teams and departments, and their interactions according to type, intensity and proximity to each other influences the innovation performance. In social proximity creativity and awareness of people, processes and challenges evolve. The proximities of actors, facilities and processes can be depicted in spatial ways, and reveal vital connections as well as the informal structure of an organization, based on how people actually behave, communicate and interact with other people or with technologies, artifacts and spaces.

Spatial Intelligence

#In General # In Architecture. The human ability in general and a particularly pronounced ability in architectural thinking and architectural work. Spatial intelligence is the ability to recognize and manipulate spatial images. It provides a different way of representing and reasoning that complements linguistic intelligence and is essential to productive thinking. Thinking spatially in architecture means to think about problems in a non-linear, 3-dimensional way, to view the different aspects of a problem from varying perspectives and scales. Spatial intelligence integrates qualitative information and knowledge about an organization and its processes in the arrangement of its elements to each other.

Visual Thinking

Visual thinking and the creation and use of visualizations are a mode of thinking used to understand, communicate and act on complex structure, interactions and relations in non-verbal ways. Visual thinking is based on the mutual influence of perception and cognition. Visual perception and visual imagery shape the thinking of individuals and accordingly the production of thought. In design, visual thinking is the conscious and subconscious application of mental imagery or externalized graphical, non-verbal means to reflect upon a situation, develop an understanding and create a new image for its future state. It includes the activities of seeing, imagining and drawing.

Appendix II - Prototypes

The prototypes presented in the following resulted from students' projects at the Chair of Architectural Informatics, Department of Architecture at the Technical University of Munich. The students were required to address the spatialization of relationships and processes from the perspective of architecture and with the application of digital tools used in architectural studies and practice. The projects differ in scope and level of detail. Interdisciplinary project (IDP; II.1), master thesis (II.2) and one course project (II.3) built upon preliminary findings of this thesis here and the hypothesized requirements of an extended view of innovation processes. They were directly related to the doctoral project. The second course project (II.4) was developed in a separate course and supervised as basic approach to parametrize spatial relationships in architecture.

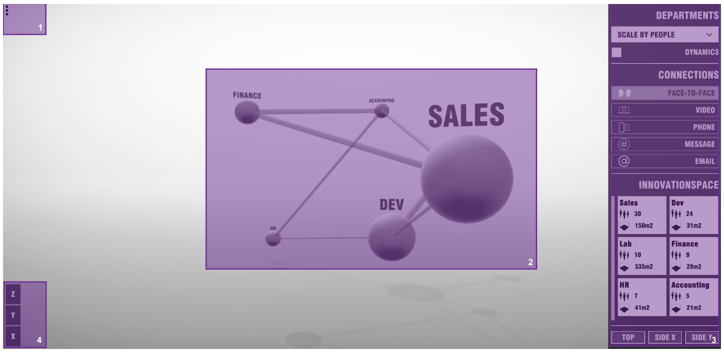
Appendix II.1 DisruptAR

The interdisciplinary project „DisruptAR“ (Semin & Shohina, 2019b) was developed by two Master‘s degree students in informatics. The students were introduced into the problem space to visualize relationships and proximities of organizational entities spatially. They were required to develop a working digital application, that communicates spatial organizational structures - as understood by architects during an architectural programming - to non-architects respectively organizational clients. The application was expected to be easy to use, follow a visual aesthetic and provide a user experience to model and navigate a 3-dimensional structure. The students assessed the feasibility of a software plug-in for existing CAD-software, a plug-in for existing data-visualization and mind-mapping tool, and an independent stand-alone application, which was favored. Developed with the game engine Unity the stand-alone application met the requirements posed on:

- a software (to be light-weight, customizable, independent)
- user-experience (to be easy-to-use, visually appealing, and familiar to architectural work environments)
- features for an appropriate level of abstraction (to visualize spatially proximities, relationships and connections, to navigate through a 3-dimensional space, and to display dynamics, when entities are manipulated).

The students defined a formula for dynamic repositioning of nodes when location of nodes are moved in relation to the strength of their mutual connections. Actions in the application are performed using defined keys on the keyboard, mouse and touchpad.

Type of Work:	Interdisciplinary Project
Semester:	Winter Semester 2018/19
Students:	Aleksei Semin, Natalia Shohina
Supervisors:	Christos Chantzaras, Prof. Dr.-Ing. Frank Petzold



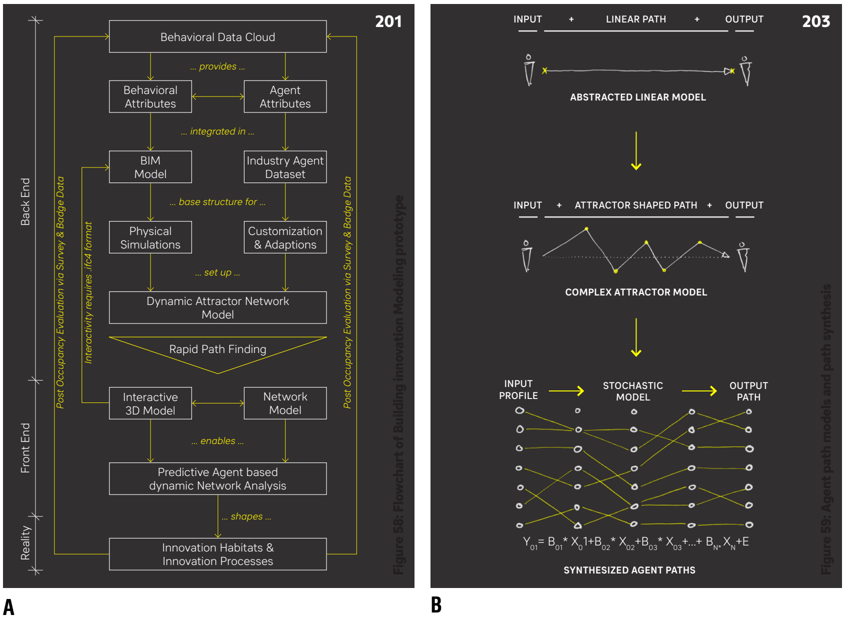
1. Main Menu
2. 3D Space
3. Control Panel
4. Mini-view Controls

DisruptAR
(Semin & Shohina, 2019)
User interface of the prototype for an Interactive Design Tool Visualization by Semin & Shohina (2019, p. 21).

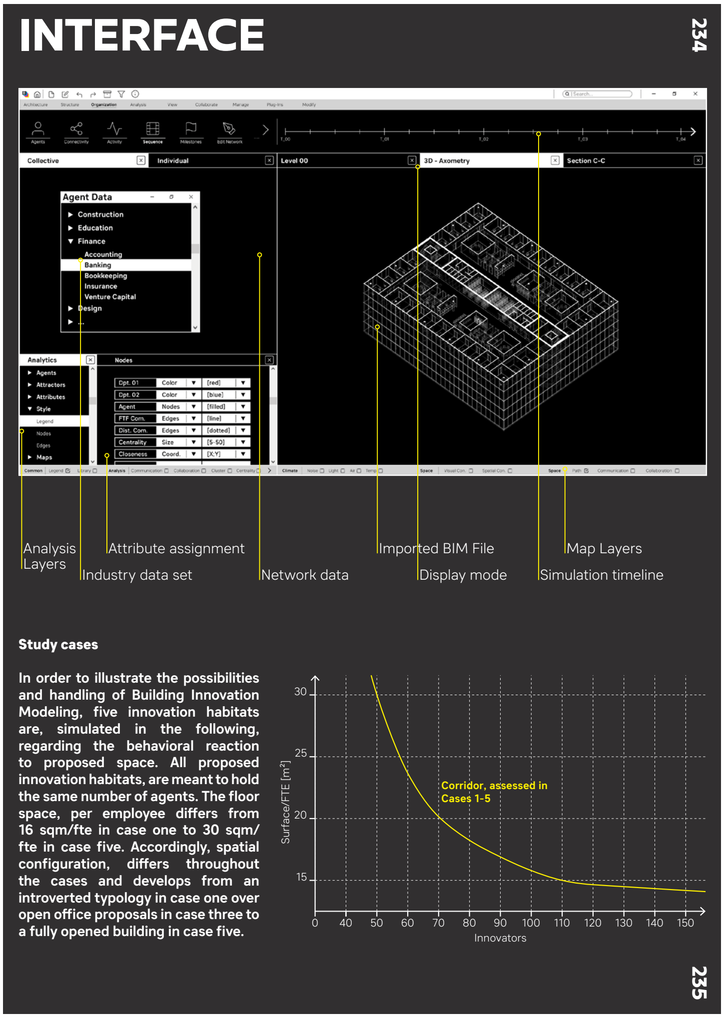
Appendix II.2 Building Innovation Modelling

The master thesis investigates two hypotheses in alignment with the doctoral project. At first, the construction of an innovation process is posed as design challenge; at second architects posses distinct cognitive abilities for this design challenge. Spatial configurations, behavioral data of individuals and time are considered simultaneously in an approach defined as „Building Innovation Modelling“ (Flöhl, 2021, p. 16). Physical elements of a building structure and floor plan layout are attributed with values that attract people to different degrees while using the spaces. The resulting attractor network model allows to simulate agent-based movements and display paths that the agents follow to conduct their work and innovation processes. In a prototypical simulation, the student relates the network of interaction to the spatial model of a building. Changes in the building elements and floor plan layouts (e.g. moving of staircases, corridors, partition walls) are simultaneously shown as changes in the network model. It supports the development of a physical innovation habitat, e.g. a floor or a building, that facilitates innovation processes.

Type of Work:	Master Thesis
Semester:	Summer Semester 2021
Student:	Konstantin Flöhl
Supervisors:	Christos Chantzaras, Prof. Dr.-Ing. Frank Petzold



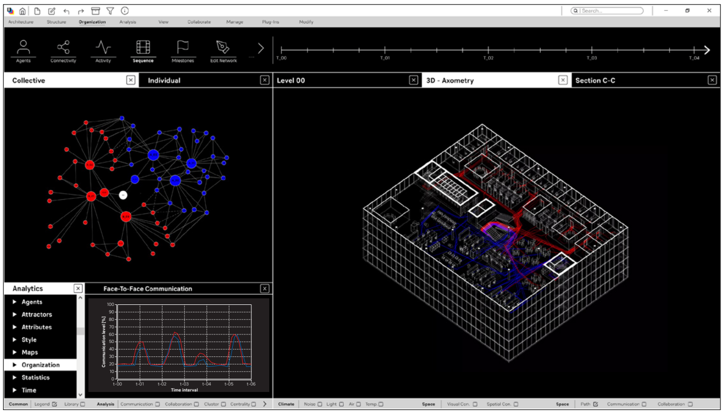
Building Innovation Modelling (Flöhl, 2021)
A Concept flowchart for the development of space-behavior-based prototypes. **B** Concept for aggregation of agent paths in dependence to attractors. Visualization by Flöhl (2021, pp. 201, 203).



Study cases

In order to illustrate the possibilities and handling of Building Innovation Modeling, five innovation habitats are, simulated in the following, regarding the behavioral reaction to proposed space. All proposed innovation habitats, are meant to hold the same number of agents. The floor space, per employee differs from 16 sqm/fte in case one to 30 sqm/fte in case five. Accordingly, spatial configuration, differs throughout the cases and develops from an introverted typology in case one over open office proposals in case three to a fully opened building in case five.

A



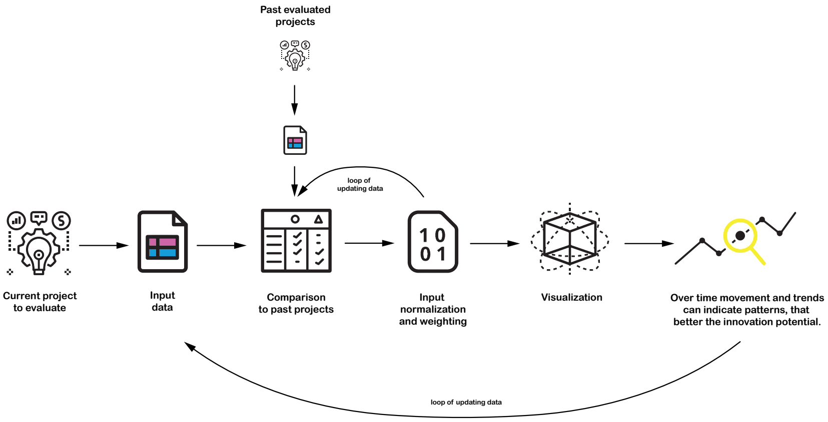
B

User Interface for a Building Innovation Modelling (Flöhl, 2021)
A The user interface displays information related to agents, innovation processes and phyiscal building strucure. **B** In a case study the agent network is displayed in accordance to the phyisical paths agents use on a building floor. Visualization by Flöhl (2021, pp. 235, 240).

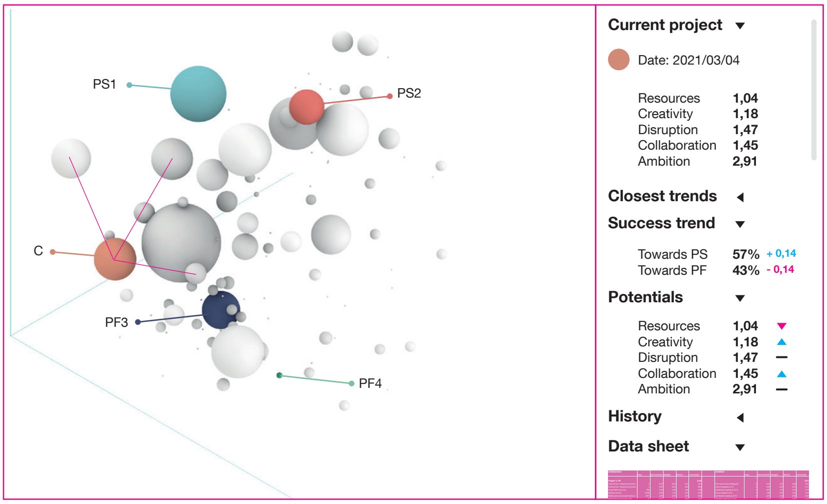
Appendix II.3 InnoTract

InnoTract is a conceptual prototypical tool developed as course project in the seminar of Architectural Design Thinking. The tool proposes the visualization of data and information of past innovation processes in a 3-dimensional space in order to visually compare their routes with current innovation processes. The three dimensions defining the space are: resources, creatvity and disruption. The dimension communication and ambition are considered by color and size. The dimension of time is captured by the changes becoming apparent by visually comparing current projects with past projects. InnoTract is described as tool to track innovation performances of the past and act on present innovation processes, that deviate from succesful paths.

Type of Work: Course Project in Architectural Design Thinking
Semester: Winter Semester 2020/21
Student: Sebastian Clark Koth
Supervisors: Christos Chantzaras, Prof. Dr.-Ing. Frank Petzold



A



Current project ▼

Date: 2021/03/04

Resources	1,04
Creativity	1,18
Disruption	1,47
Collaboration	1,45
Ambition	2,91

Closest trends ◀

Success trend ▼

Towards PS	57%	+ 0,14
Towards PF	43%	- 0,14

Potentials ▼

Resources	1,04	▼
Creativity	1,18	▲
Disruption	1,47	–
Collaboration	1,45	▲
Ambition	2,91	–

History ◀

Data sheet ▼

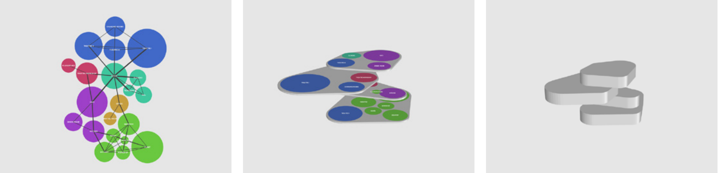
B

InnoTract (Koth, 2021)
A Concept diagram for the development of the prototype.
B Illustrative visualization of current processes (C) in proximity to past failures (PF) and past successes (PS). Visualization by Koth (2021, pp. 12, 18).

Appendix II.4 Spatially

„Spatially“ (Andonov, 2018) was developed as project in the course Performance Based Design. It visualizes spatial requirements and their relations based on data sheets (e.g., excel tables), and computes optimal configurations of spaces. The resulting 3-dimensional diagram can be modified further by the user and provides the basic structure for a subsequent building design. The tool is conceptualized to ease the work of architects in programming the arrangement of spaces and accelerate the design process.

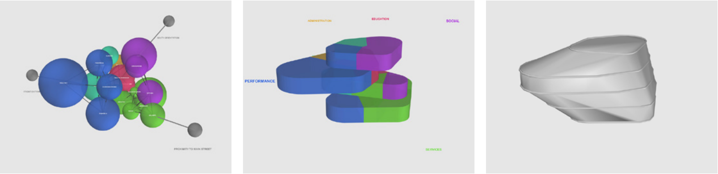
Type of Work: Course Project in Performance Based Design
Semester: Winter Semester 2017/18
Student: Teodor Andonov
Supervisors: Dr. Gerhard Schubert, Nils Seifert,
Prof. Dr.-Ing. Frank Petzold, Christos Chantzaras



<1> 2D Diagram - simulation arranges spaces to satisfy the given connections in the datasheet.

<4> Floor Plates - the layout is further simplified and divided into a limited number of floors.

<5> Massing Model - quick volumetric represantation.



<3> External Factors - the user can modify the diagram through extra objects.

<6> Programmatic Model - the mass is divided into sector according to program.

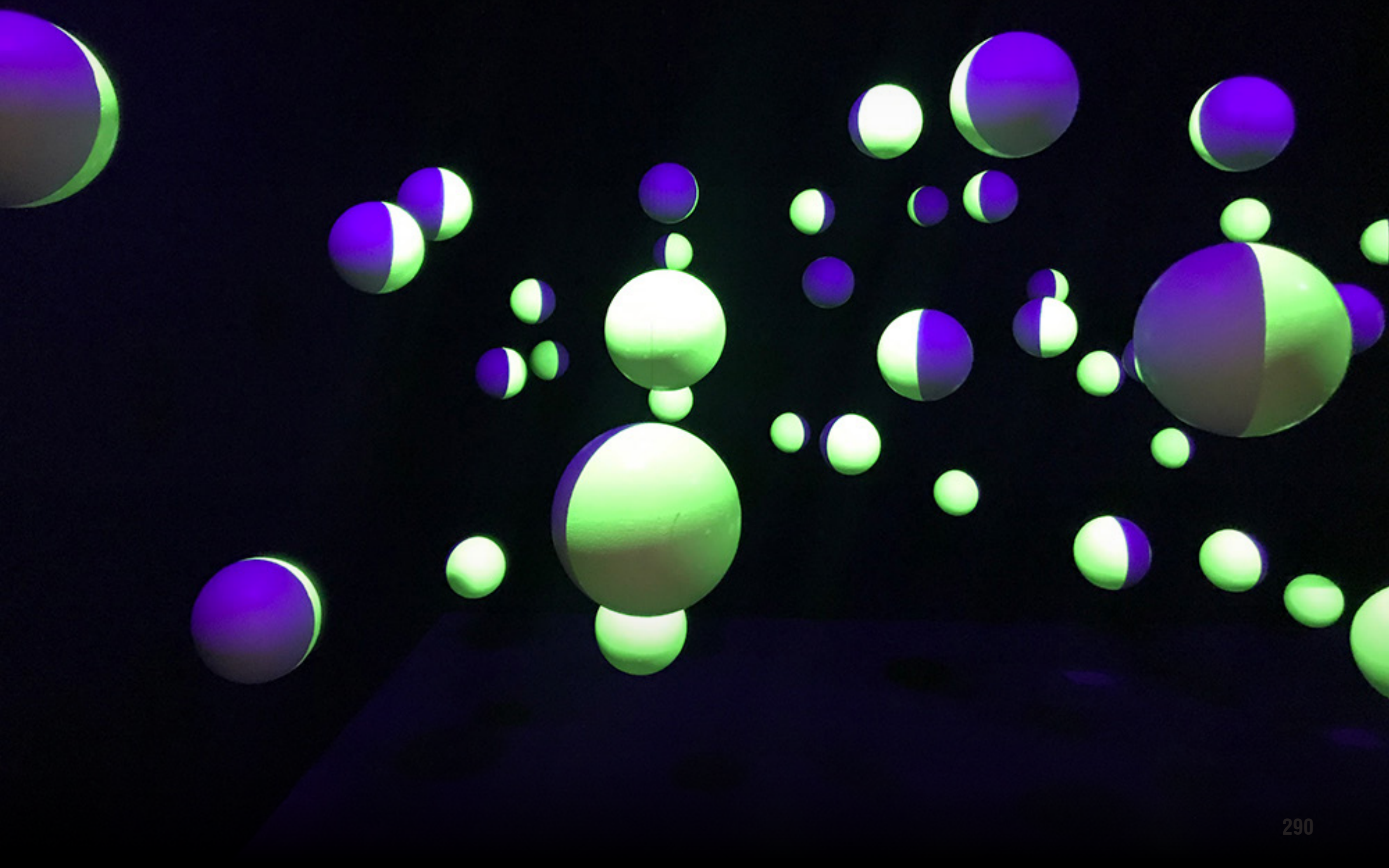
<7> Adaptive Skin - one step further to an architectural proposal.

Spatially - Space Planning Toolbox (Andonov, 2018)
Principle work flow using the space planning tool. Visualization by Andonov (2019).

Appendix III – Interviews [excluded]

The complete transcripts of the interviews are excluded from publication for reasons of confidentiality.

References



References

Abernathy, R., & Malcolm, C. (2008). Third Spaces - Viewpoint. In N. B. Solomon (Ed.), *Architecture: Celebrating the Past, Designing the Future,* (p. 223). Visual Reference Publications; The American Institute of Architects.

Acar, O. A. (2019, December 13). Why crowdsourcing often leads to bad ideas. *Harvard Business Review*. https://hbr.org/2019/12/why-crowdsourcing-often-leads-to-bad-ideas

Ackoff, R. L. (1999). A lifetime of systems thinking. *The System Thinker*, *10* (5), 1–4.

Agars, M. D., Kaufman, J. C., Deane, A., & Smith, B. (2012). Fostering individual creativity through organizational context. In M. D. Mumford (Ed.) *Handbook of organizational creativity* (pp. 271–291). Elsevier. Academic Press. https://doi.org/10.1016/B978-0-12-374714-3.00012-4

Ahrens, D., & Molzberger, G. (Eds.) (2018). *Kompetenzmanagement in Organisationen. Kompetenzentwicklung in analogen und digitalisierten Arbeitswelten: Gestaltung sozialer, organisationaler und technologischer Innovationen.* Springer.

Ahrens, S. (2011). Soziale Netzwerktheorie. In M. Schwaiger & A. Meyer (Eds.), *Theorien und Methoden der Betriebswirtschaft* (pp. 297–312). Vahlen. https://doi.org/10.15358/9783800644377_297

Aksamija, A. (2016). *Integrating innovation in architecture: Design, methods and technology for progressive practice and research* (First Edition). AD Smart. John Wiley & Sons.

Alexander, C. (2002). *Notes on the Synthesis of Form* (17. Printing). Harvard University Press.

Alexander, C., Ishikawa, S., & M. Silverstein, M. (1977). A pattern language: Towns. Buildings. Construction. Oxford University.

Allen, S. (1998). Diagrams matter. *ANY: Architecture New York*, *23*, 16–19.

Allen, T. J. (1995). *Managing the flow of technology: Technology transfer and the dissemination of technological information within the R&D organization* (7. print). MIT Press.

Allen, T. J. (2000). Architecture and communication among product development engineers. In *Proceedings of the 2000 IEEE Engineering Management Society. EMS - 2000* (pp. 153–158). doi: 10.1109/EMS.2000.872493

Allen, T. J., & Henn, G. W. (2007). *The Organization and architecture of innovation: Managing the flow of technology.* Routledge. (Published 2006).

Altmann, G. (1998). Technologiemanagement im Mittelstand: Eine Metaanalyse empirischer Forschungsergebnisse. In N. Franke (Ed.), *Innovationsforschung und Technologiemanagement: Konzepte, Strategien, Fallbeispiele* (pp. 339–350). Springer.

Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal*, *39*(5), 1154–1184.

Amabile, T. M. (1988). A Model of Creativity and Innovation in Organizations. *Research in Organizational Behavior*, *10*, 123–167.

Amt, S. (2009). Von Vitruv bis zur Moderne: Die Entwicklung des Architektenberufes. In R. Johannes (Ed.), *Entwerfen: Architektenausbildung in Europa von Vitruv bis Mitte des 20. Jahrhunderts; Geschichte, Theorie, Praxis* (1st ed., pp. 10–45). Junius.

Andler, N. (2013). *Tools für Projektmanagement, Workshops und Consulting: Kompendium der wichtigsten Techniken und Methoden* (5., wesentlich überarb. und erw. Aufl.). Publicis Corporate Publishing.

Andonov, T. (2018). *Spatially – Space planning tool box* [Unpublished course project, Winter Semester 2017/18, Chair of Architectural Informatics]. Technical University of Munich.

ardoq (2019, July 2). *What are ardoq's main features?* [Video]. YouTube. https://www.youtube.com/watch?v=azK8v3iFfqo

Arnheim, R. (1969). *Visual thinking*. University of California Press.

Arnheim, R. (1974). *Art and visual perception: A psychology of the creative eye* (The new version, expanded and rev. ed.). University of California Press.

Attocube systems AG (2018, October 11). *Shaping the future: Opening of the NanoFactory in Haar: Official ceremony at the new headquarters* [Press release]. https://www.wittenstein.de/fileadmin/04-3-Presse/2018/2018_10_15/pm-attocube-nanofactory-eroeffnungsfeier-2018-10-12-en.pdf

Auernhammer, J. M. (2012). *Autopoietic organisation of knowledge, creativity and innovation: A case study of the automotive manufacturer Daimler AG.* [Doctoral dissertation, Edinburgh Napier University]. http://researchrepository.napier.ac.uk/id/eprint/6653

Auernhammer, J., & Roth, B. (2021). The origin and evolution of Stanford University's design thinking: from product design to design thinking in innovation management. *Journal of Product Innovation Management, 00*, 1–22.

Autio, E., Kenney, M., Mustar, P., Siegel, D., & Wright, M. (2014). Entrepreneurial innovation: The importance of context. *Research Policy*, *43*(7), 1097–1108. https://doi.org/10.1016/j.respol.2014.01.015

Avolution (2022, January 26). *Powerful Collaboration*. Abacus. Retreived on January 26, 2022, from https://www.avolutionsoftware.com/abacus/digital-business-collaboration/

Awan, N., Schneider, T., & Till, J. (2011). *Spatial agency: Other ways of doing architecture*. Routledge.

Axelrod, R., & Cohen, M. D. (2000). *Harnessing complexity: Organizational implications of a scientific frontier.* Basic Books.

Bachman, L. R. (2012). *Two spheres: Physical and strategic design in architecture*. Routledge.

BAK Bundesarchitektenkammer. (2019). *Ergebnisse der Befragung selbstständig tätiger Mitglieder – im Rahmen der bundesweiten Strukturbefragung selbstständig tätiger und abhängig beschäftigter Mitglieder der Architektenkammern der Länder im Jahr 2020 für das Berichtsjahr 2019*. Bundesarchitektenkammer mit Reiß & Hommerich. https://bak.de/wp-content/uploads/2021/12/2020_BAK_Strukturbefragung_Bericht-SELBSTSTAeNDIGE_Gesamt.pdf

Bailenson, J. N. (2021). Nonverbal overload: A theoretical argument for the causes of zoom fatigue. *Technology, Mind, and Behavior*, *2*(1), 6 pages. https://doi.org/10.1037/tmb0000030

Bandaru, N. (2021, August 20). The future of work is hybrid. What does that mean? *Forbes.* Rertreived January 26, 2022, from https://www.forbes.com/sites/forbestechcouncil/2021/08/20/the-future-of-work-is-hybrid-what-does-that-mean/?sh=139b2b3b1f17

Bauer, J. M., & Herder, P. M. (2009). Designing socio-technical systems. In A. Meijers (Ed.), *Philosophy of technology and engineering sciences* (pp. 601–630). Series Handbook of the philosophy of science: Vol. 9. Elsevier.

Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., . . . Thomas, D. (2001). *Manifesto for Agile Software Development*. https://agilemanifesto.org

Beetz, J., Borrmann, A., Both, P. von, Petzold, F., & Schoch, O. (2020). Building Information Modelling (BIM). In U. Hirschberg, L. Hovestadt, & O. Fritz (Eds.), *Atlas of digital architecture: Terminology, concepts, methods, tools, examples, phenomena* (pp. 507–526). Birkhäuser.

Behymer, K. J., & Flach, J. M. (2016). From autonomous systems to sociotechnical systems: Designing effective collaborations. *She Ji: The Journal of Design, Economics, and Innovation*, *2*(2), 105–114. https://doi.org/10.1016/j.sheji.2016.09.001

Berkun, S. (2007). *The myths of innovation* (1st ed.). O'Reilly Media.

Bessant, J. R. (2003). Challenges in Innovation Management. In L. V. Shavinina (Ed.), *The international handbook on innovation* (1st ed.). Elsevier.

Best, J. (2008). Ambiguity, uncertainty, and risk: Rethinking indeterminacy. *International Political Sociology*, *2*(4), 355–374. https://doi.org/10.1111/j.1749-5687.2008.00056.x

Beucker, N. (2016). Transformation design: a pieceemeal situational change. In W. Jonas, K. v. Anshelm, & S. Zerwas (Eds.), *Transformation design: Perspectives on a new design attitude*. Birkhäuser.

Birkinshaw, J., Bouquet, C., & Barsoux, J.-L. (2010). The 5 myths of innovation. *MIT Sloan Management Review*, *52*(2), 43–50.

Bissola, R., & Imperatori, B. (2011). Organizing individual and collective creativity: Flying in the face of creativity clichés. *Creativity and Innovation Management*, *20*(2), 77–89. https://doi.org/10.1111/j.1467-8691.2011.00597.x

Bitar, J. (2003). The impacts of organizations on innovation: A systemic view [Working paper]. HEC Montréal, Cahier de recherche N 24-01, April 2003, 32 pages.

BiZZdesign (2022a, January 26). *HoriZZon Demo: On-Demand*. BiZZdesign. Retrieved January 26, 2022, from https://go.bizzdesign.com/lp/on-demand-horizzon-demo-replay-thank-you

BiZZdesign (2022b, January 26). *Modeling a Strategy on a Page*. BiZZdesign. Retrieved January 26, 2022, from https://support.bizzdesign.com/display/knowledge/Modeling+a+Strategy+on+a+Page

Blättel-Mink, B. (2006). *Kompendium der Innovationsforschung* (1. Aufl.). VS Verlag für Sozialwissenschaften.

Blättel-Mink, B., & Ebner, A. (2009). Innvationssysteme im wissenschafltichen und gesellschaftlichen Diskurs. In B. Blättel-Mink & A. Ebner (Eds.), *Innovationssyteme: Technologie, Institutionen und die Dynamik der Wettbewerbsfähigkeit*. VS Verlag für Sozialwissenschaften.

BCG (2022, January 26). *Innovation Strategy and Delivery*. BCG Boston Consulting Group. Retrieved January 26, 2022, from https://www.bcg.com/de-de/capabilities/innovation-strategy-delivery/overview

Boddy, C. R. (2016). Sample size for qualitative research. *Qualitative Market Research: An International Journal*, *19*(4), 426–432.

Boehnert, J. (2018). The visual representation of complexity: Sixteen key characteristics of complex systems. In S. Barbero (Chair), *Relating Systems Thinking and Design (RSD7) 2018 Symposium*. Symposium conducted at the meeting of Systemic Design Association, Politecnico di Torino, Turin.

Bogner, A., Littig, B., & Menz, W. (2014). *Interviews mit Experten*. Springer Fachmedien. https://doi.org/10.1007/978-3-531-19416-5

Boland, R. J., & Collopy, F. (2004a). Design Matters for Management. In R. J. Boland & F. Collopy (Eds.), *Managing as designing*. [Workshop held at the Weatherhead School of Management in June 2002 …] (pp. 3–18). Stanford Business Books.

Boland, R. J., & Collopy, F. (Eds.) (2004b). Managing as designing. [Workshop held at the Weatherhead School of Management in June 2002 …]. Stanford Business Books.

Boland, R. J., Collopy, F., Lyytinen, K., & Yoo, Y. (2008). Managing as designing: Lessons for organization leaders from the design practice of Frank O. Gehry. *Design Issues*, *24*(1).

Borasi, G. (2015a). The other architect: Another way of building architecture. In G. Borasi (Ed.), *The other architect: Another way of building architecture*. [… In conjunction with the exhibition "The Other Architect" organized by the Canadian Centre for Architecture, Montreal, and presented at the CCA from 27 October 2015 to 10 April 2016] (pp. 362–366). CCA Canadian Centre for Architecture; Spector Books.

Borasi, G. (Ed.) (2015b). *The other architect: Another way of building architecture*. [… In conjunction with the exhibition "The Other Architect" organized by the Canadian Centre for Architecture, Montreal, and presented at the CCA from 27 October 2015 to 10 April 2016]. CCA Canadian Centre for Architecture; Spector Books.

Borgatti, S. P., & Halgin, D. S. (2011). On network theory. *Organization Science*, *22*(5), 1168–1181. https://doi.org/10.1287/orsc.1100.0641

Borja de Mozota, B. (2013). Design stratigic value revisited: A dynamic theory for design as organizational function. In R. Cooper, S. Junginger, & T. Lockwood (Eds.), *The handbook of design management*. Bloomsbury.

Bos, C. (2007). Architecture and its shadow: Reflections on past, present and future Incarnations of the artist-architect. In E.-L. Pelkonen & E. Laaksonen (Eds.), *architecture + art: New Visions, New Strategies* (pp. 189–198). Alvar Aalto Foundation.

Bouman, O. (2007). A new brief for architecture. In M. Shamiyeh (Ed.), *Organizing for Change \ Profession: Integrating architectural thinking in other fields* (pp. 91–97). Birkhäuser; Springer.

Brand, S. (1995). *How buildings learn: What happens after they're built*. Penguin Books.

Brandner, G. (2008). Architekten als Berater. In F. P. Jäger (Ed.), *Der neue Architekt: Erfolgreich am veränderten Markt ; Akquisition Management Marketing* (1st ed., pp. 20–29). Detail, Institut für internationale Architektur-Dokumentation.

Brant, S. (2010, October 23). *If Russ Ackoff had given a TED Talk.* [Video]. YouTube. Video excerpt from an event in 1994. https://www.youtube.com/watch?v=OqEeIG8aPPk

Breiger, R. L. (2004). The analisys of social networks. In M. A. Hardy & A. Bryman (Eds.), *Handbook of Data Analysis* (pp. 505–526). SAGE Publications.

Brem, A., & Viardot, É. (2013). Conclusion: Evolution of innovation management: trends in an International context. In A. Brem & É. Viardot (Eds.), *Evolution of Innovation Management* (pp. 348–353). Palgrave Macmillan UK.

Brenner, W., & Uebernickel, F. (Eds.) (2016). Design thinking for innovation: Research and practice (1st ed. 2016). Springer International Publishing.

Brenner, W., Uebernickel, F., & Abrell, T. (2016). Design thinking as mindset, process, and toolbox: Experiences from research and teaching at the University of St. Gallen. In W. Brenner & F. Uebernickel (Eds.), *Design thinking for innovation* (pp. 3–21). Springer International Publishing. https://doi.org/10.1007/978-3-319-26100-3_1

Brookes, A., & Poole, D. (Eds.) (2005). *Innovation in architecture*. Spon Press.

Brown, C., Efstratiou, C., Leontiadis, I., Quercia, D., Mascolo, C., Scott, J., & Key, P. (2014). The architecture of innovation: Tracking face-to-face interactions with ubicomp technologies. In A. J. Brush, A. Friday, J. Kientz, J. Scott, & J. Song (Eds.), *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing - UbiComp '14 Adjunct* (pp. 811–822). ACM Press. https://doi.org/10.1145/2632048.2632056

Brown, T. (2008). Design thinking. *Harvard Business Manager*, (*June 2008)*, 84–92.

Brown, T. (2009). *Change by design: How design thinking transforms organizations and inspires innovation* (1. ed.). Harper Business.

Brown, T., & Martin, R. (2015). Design for action: How to use desgin thinking to make great things actually happen. *Harvard Business Manager*, *(Septeember 2015)*, 1–10.

Brown, T., & Wyatt, J. (2010). Design thinking for social innovation. *Development Outreach*, *12*(1), 29–43. https://doi.org/10.1596/1020-797X_12_1_29

Brunswicker, S., & van de Vrande, V. (2014). Exploring open innovation in small and medium-sized enterprises. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.), *New frontiers in open innovation*, (pp. 135–156). Oxford University Press.

Bruyn, G. d., & Reuter, W. (2011). Das Wissen der Architektur: Vom geschlossenen Kreis zum offenen Netz. *ArchitekturDenken: Vol. 5*. Transcript.

Bryant, C., Rodgers, C., & Wigfall, T. (2018). The changing forms and values of architectural practice. *Architectural Design*, *88*(5), 6–13. https://doi.org/10.1002/ad.2336

BSI (2011). *Systems and software engineering — Systems and software quality requirements and evaluation (SQuaRE) — System and software quality models*. (BS ISO/IEC 25010:2011). British Standards Institution.

Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues*, *8*(2), 5–21. https://doi.org/10.2307/1511637

Buchanan, R. (2001). Design research and the new learning. *Design Issues*, *17*(4), 3–23. https://doi.org/10.1162/07479360152681056

Buchanan, R. (2008). Introduction: Design and organizational change. *Design Issues*, *24*(1), 2–9. https://doi.org/10.1162/desi.2008.24.1.2

Buchanan, R. (2015). Worlds in the making: Design, management, and the reform of organizational culture. *She Ji: The Journal of Design, Economics, and Innovation*, *1*(1), 5–21. https://doi.org/10.1016/j.sheji.2015.09.003

Buchanan, R. (2017, October 18–20). Dialectic and inquiry in design: Understanding surroundings and systems, designing environments [Conference session]. *Relating Systems Thinking and Design (RSD6) 2017 Symposium*. Oslo School of Architecture and Design, Oslo, October 18–20, 2017. https://rsdsymposium.org/dialectic-and-inquiry-in-design/

Budds, D. (2016, June 21). Rem Koolhaas: "Architecture has a serious problem today": At the 2016 AIA convention, the legendary architect gave the profession an honest appraisal of its failures. *FastCompany*. https://www.fastcompany.com/3060135/rem-koolhaas-architecture-has-a-serious-problem-today

Bullinger, H.-J., Auernhammer, K., & Gomeringer, A. (2004). Managing innovation networks in the knowledge-driven economy. I*nternational Journal of Production Research*, *42*(17), 3337–3353. https://doi.org/10.1080/00207540410001695970

Burkhard R.A. (2005) Towards a framework and a model for knowledge visualization: Synergies between information and knowledge visualization. In: Tergan S-O., Keller T. (Eds.), *Knowledge and information visualization. lecture notes in computer science,* vol. 3426 (pp. 238–255). Springer. https://doi.org/10.1007/11510154_13

Burgelman, R. A., Christensen, C. M., & Wheelwright, S. C. (2009). *Strategic management of technology and innovation* (5. ed., internat. ed.). McGraw-Hill.

Burke, A., & Tierney, T. (Eds.) (2007). *Network practices: New strategies in architecture and design*. Princeton Architectural Press.

Burr, W. (2014a). Die frühen Phasen der deutschsprachigen betriebswirtschaftlichen Innovationsforschung (bis 1980). In W. Burr (Ed.), Innovation: Theorien, Konzepte und Methoden der Innovationsforschung (1st ed., pp. 11–39). Kohlhammer Verlag.

Burr, W. (Ed.) (2014b). Innovation: Theorien, Konzepte und Methoden der Innovationsforschung (1. Aufl.). Kohlhammer Verlag.

Burt, R. S. (2001). Structural holes versus network closure as social capital. In N. Lin, K. S. Cook, & R. S. Burt (Eds.), *Sociology and Economics. Social Capital: Theory and Research* (pp. 31–56). Routledge. https://doi.org/10.4324/9781315129457-2

Camillus, J. C. (2008). Strategy as a wicked problem. *Harvard Business Review, (May 2008). https://hbr.org/2008/05/strategy-as-a-wicked-problem*

Carlgren, L. (2013). Design thinking as an enabler of innovation [Doctoral dissertation, Chalmers University of Technology]. Chalmers Research. https://research.chalmers.se/en/publication/185362

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442–455. https://doi.org/10.1287/orsc.13.4.442.2953

Carpo, M. (2013a). The art of drawing. *Architectural Design*, *83*(5), 128–133. https://doi.org/10.1002/ad.1646

Carpo, M. (Ed.) (2013b). *The digital turn in architecture 1992-2012*. AD Reader. John Wiley & Sons.

Carpo, M. (2017). *The second digital turn: Design beyond intelligence*. Writing Architecture Ser. MIT Press.

Carvalho, R. M., de Castro Andrade, R. M., Marçal de Oliveira, K., de Sousa Santos, I., & Moreira Bezerra, C. I. (2016). Quality characteristics and measures for human–computer interaction evaluation in ubiquitous systems. *Software Quality Journal*, *25*(3), 743–795. doi:10.1007/s11219-016-9320-z

Casadesus-Masanell, R., & Ricart, J. E. (2010). From strategy to business models and onto tactics. *Long Range Planning*, *43*(2-3), 195–215. https://doi.org/10.1016/j.lrp.2010.01.004

Castle, H. (2018). Going from zero to 00: Indy Johar on shifting the focus of practice from objects to outcomes. *AD Architectural Design - Special Issue: New Modes: Redefining Practice*, *88*(5), 78–85. https://doi.org/10.1002/ad.2346

Cichocki, P., & Irwin, C. (2014). *Organization Design. A Guide to Building Effective Organizations* (2nd ed.). Kogan Page.

Chantzaras, C. (2017). Architecture as systems design & innovation design discipline [Working paper]. In *Proceedings of Relating Systems Thinking and Design (RSD6) 2017 Symposium*. Oslo School of Architecture and Design, Oslo, Norway, October 18–20, 2017, 16 pages. https://rsdsymposium.org/architecture-as-systems-design-innovation-design-discipline/

Chantzaras, C. (2019a). Architecture as a system and innovation design discipline. *FORMakademisk*, *12*(2), Art. 5, 1–17 . https://doi.org/10.7577/formakademisk.3077

Chantzaras, C. (2019b). The 3rd dimension of innovation processes. In E. Bohemia, G. Gemser, N. Fain, C. de Bont, & R. Assoreira Alemandra (Eds.), *Conference Proceedings of the Academy for Design Innovation Management 2019: Research Perspectives In the era of Transformations* (Vol. 2, pp. 537–553). Academy for Design Innovation Management. http://academicarchives.org/index.php/adim/article/view/56

Chantzaras, C. (2020). Less structure, more Impact? An evaluation of structured design thinking methods in higher education in architecture. In A. Ghaffarianhoseini, A. Ghaffarianhoseini, & N. Naismith (Eds.), *Imaginable futures: Design thinking, and the scientific method* (pp. 689–698.). The Architectural Science Association (ANZAScA).

Chantzaras, C., & Ford, C. (2020). InnoSpacing: An integrated research sketch on physical space and innovation before, during and after the COVID-19 pandemic. In TUM Department of Architecture (Ed.), *Research Review. Review 2021* (pp. 102–104). Technische Universität München. https://mediatum.ub.tum.de/doc/1595663/1595663.pdf

Chantzaras, C., & Rung, H. (2017). interVIEW - Christos Chantzaras and Hanne Rung with Stephen Bates and Bruno Krucker. In TUM Department of Architecture (Ed.), *Jahrbuch Yearbook 2016/17* (pp. 32–35). Technische Universität München.

Checkland, P. (1981). *Systems thinking, systems practice*. Wiley & Sons.

Cheng, Y.-T., & Van de Ven, A. H. (1996). Learning the innovation journey; Order out of chaos? *Organization Science*, *7*(6), 593–614.

Cherry, E. (1999). *Programming for design: From theory to practice*. John Wiley & Sons.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press.

Christensen, C. M. (2016). *The innovator's dilemma: When new technologies cause great firms to fail*. The management of innovation and change series. Harvard Business Review Press.

Christensen, C. M., Kaufman, S. P., & Shih, W. C. (2008). Innovation killers: How financial tools destroy your capacity to do new things. *Harvard Business Review*, *(January 2008)*. https://hbr.org/2008/01/innovation-killers-how-financial-tools-destroy-your-capacity-to-do-new-things

Christensen, K., & Conklin, J. (2009). Building shared understanding of wicked problems. *Rotman - The magazine of the Rotman School of Management*, *Winter 2009*, 16–20.

Cichocki, P., & Irwin, C. (2014). *Organization design: A guide to building effective organizations* (2nd ed.). Kogan Page.

Clarke, A. E. (2003). Situational Analyses: Grounded Theory Mapping After the Postmodern Turn. *Symbolic Interaction*, *26*(4), 553–576. https://doi.org/10.1525/si.2003.26.4.553

Clarke, A. E. (2016). Anticipation work: Abduction, simplification, hope. In G. C. Bowker, S. Timmermans, A. E. Clarke, & E. Balka (Eds.), *Boundary objects and beyond: Working with Leigh Star* (pp. 85–119). The MIT Press. http://ieeexplore.ieee.org/document/7580155

Çokpekin, Ö., & Knudsen, M. P. (2012). Does organizing for creativity really lead to innovation? *Creativity and Innovation Management*, *21*(3), 304–314. https://doi.org/10.1111/j.1467-8691.2012.00649.x

Cooper, R. G. (1983). A process model for industrial new product development. *IEEE Transactions on Engineering Management*, *EM-30*(1), 2–11. https://doi.org/10.1109/TEM.1983.6448637

Cooper, R. G. (1990). Stage-gate systems: A new tool for managing new products. *Business Horizons*, *33*(3), 44–54. https://doi.org/10.1016/0007-6813(90)90040-I

Cooper, R. G. (2008). Perspective: The Stage-Gate® Idea-to-Launch Process—Update, What's new, and NexGen Systems. *Journal of Product Innovation Management*, *25*(3), 213–232. https://doi.org/10.1111/j.1540-5885.2008.00296.x

Cooper, R. G. (2014). What's next? After Stage-Gate. *Research-Technology Management*, *57*(1), 20–31. https://doi.org/10.5437/08956308X5606963

Corsten, H. (Ed.) (1989). *Die Gestaltung von Innovationsprozessen: Hindernisse und Erfolgsfaktoren im Organisations-, Finanz- und Informationsbereich*. Technological economics: Vol. 29. Erich Schmidt Verlag.

Coscia, M., Neffke, F. M. H., & Hausmann, R. (2020). Knowledge diffusion in the network of international business travel. *Nature Human Behaviour*, 4(10), 1011–1020. https://doi.org/10.1038/s41562-020-0922-x

Crawley, E., Cameron, B., & Selva, D. (2016). *System architecture: Strategy and product development for complex systems* (Global Edition). Pearson.

Crawley, E., Weck, O. de, Eppinger, S., Magee, C., Moses, J., Seering, W., Schindall, J., Wallace, D., Whitney, D. (2004). The influence of architecture in engineering systems. *MIT Engineering Systems Monograph, March 29-31, 2004*, 1–29.

Cross, N. (1982). Designerly ways of knowing. *Design Studies*, *3*(4), 221–227. https://doi.org/10.1016/0142-694X(82)90040-0

Cross, N. (1990). The nature and nurture of design ability. *Design Studies*, *11*(3), 127–140. https://doi.org/10.1016/0142-694X(90)90002-T

Cross, N. (2001). Designerly ways of knowing: Design discipline versus design science. *Design Issues*, *17*(3), 49–55. https://doi.org/10.1162/074793601750357196

Cross, N. (2007). *Designerly ways of knowing*. Birkhäuser.

Cross, N. (2008). *Engineering design methods: Strategies for product design* (Fourth Edition). Wiley.

Cross, N. (2013). *Design thinking: Understanding how designers think and work* (Reprinted.). Bloomsbury Academic.

Cruickshank, L. (2010). The innovation dimension: Designing in a broader context. *Design Issues*, *26*(2), 17–26.

Csikszentmihalyi, M. (1988a). Motivation and creativity: Toward a synthesis of structural and energistic approaches to cognition. *New Ideas in Psychology*, *6*(2), 159–176. https://doi.org/10.1016/0732-118X(88)90001-3

Csikszentmihalyi, M. (1988b). Solving a problem is not finding a new one: A reply to Simon. *New Ideas in Psychology*, *6*(2), 183–186. https://doi.org/10.1016/0732-118X(88)90003-7

Csikszentmihalyi, M. (2007). Implications of a Systems Perspective for the Study of Creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (10th ed., pp. 313–336). Cambridge Univ. Press. https://doi.org/10.1017/CBO9780511807916.018

Csikszentmihalyi, M. (2013). Creativity: The psychology of discovery and invention (1. ed.). Harper Perennial.

Csikszentmihalyi, M. (2014). *The systems model of creativity: The collected works of Mihaly Csikszentmihalyi*. Springer. https://doi.org/10.1007/978-94-017-9085-7

Cutler, T. (2013). Designing tomorrow's innovation. *AD Architectural Design. Special Issue: The Innovation Imperative: Architectures of Vitality*, *83*(1), (221), 124–127.

Czaja, W. (2017, June 5). Architekt Carlo Ratti: „Die Spezies Architekt wird aussterben". Schwerpunktausgabe Wahrheit. *Der Standard*. http://derstandard.at/2000058656475/Architekt-Carlo-Ratti-Die-Spezies-Architekt-wird-aussterben?ref=article

Damanpour, F., & Aravind, D. (2012). Organizational structure and innovation revisited. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 483–513). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00019-7

Daniell, T. (2013). The mothers of invention. *AD Architectural Design. Special Issue: The Innovation Imperative: Architectures of Vitality*, *83*(1), (221), 114–123.

Dark Horse Innovation (2017). *Digital innovation playbook: The essential exercise book for founders, doers and managers* (English version). Murmann Publishers.

Dator, J. (2016). Alternative futures in architecture. In M. Kanaani & D. A. Kopec (Eds.), *Routledge Companions. The Routledge companion for architecture design and practice: Established and emerging trends* (pp. 549–564). Routledge Taylor & Francis Group.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Harvard Business School Press.

Davis, K., Christodoulou, J., Seider, S., & Gardner, H. The theory of multiple Intelligences. In In R.J. Sternberg & S.B. Kaufman (Eds.), *Cambridge handbook of intelligence* (pp. 485–503).

Dettlaff, W. (2014). Space syntax analysis – methodology of understanding the space. *PhD Interdisciplinary Journal - Gdańsk University of Technology*, 283–291. http://sdpg.pg.gda.pl/pij/wp-content/blogs.dir/133/files/2014/12/01_2014_30-dettlaff.pdf

Deutsch, R. (2017). *Convergence: The redesign of design*. AD Smart: Vol. 05. John Wiley & Sons.

Dionisio, J. D. N., Burns III, W. G., & Gilbert, R. (2013). 3D Virtual worlds and the metaverse: Current status and future possibilities. *ACM Computing Surveys*, *45*(3, June 2013), Article No.: 34, 1–38. https://doi-org.eaccess.ub.tum.de/10.1145/2480741.2480751

Dirmoser, G. (2013). Diagramm-Begriffe im Vergleich. In D. Boschung & J. Jachmann (Eds.), *Morphomata: Vol. 6. Diagrammatik der Architektur*. Fink.

Do, E. Y.-L., & Gross, M. D. (2001). Thinking with diagrams in architectural design. *Artificial Intelligence Review*, *15*(1), 135–149. https://doi.org/10.1023/A:1006661524497

Dodgson, M. (2018). *Innovation management: A research overview*. Routledge.

Dodgson, M., Gann, D., & Phillips, N. (Eds.) (2015a). *The Oxford handbook of innovation management* (Paperback edition). Oxford University Press.

Dodgson, M., Gann, D., & Phillips, N. (2015b). Perspectives on innovation management. In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (Paperback edition, pp. 3–25). Oxford University Press.

Dodgson, M., Gann, D., & Salter, A. (2011). *Think, play, do: Technology, innovation, and organization* (Reprinted). Oxford University Press.

Dodgson, M., Salter, A. J., & Gann, D. (2008). *The management of technological innovation: Strategy and practice* (New ed., rev. and updated.). Oxford University Press.

Doll, B. (2009). *Prototyping zur Unterstützung sozialer Interaktionsprozesse* [Doctoral dissertation, Technical University of Munich]. Gabler.

Dooley, K. (2004). Complexity science models of organizational change. In A. H. Van de Ven & M. S. Poole (Eds.), *Handbook of organizational change and innovation* (pp. 354–373). Oxford University Press.

Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies*, *32*(6), 521–532. https://doi.org/10.1016/j.destud.2011.07.006

Dorst, K. (2015). *Frame innovation: Create new thinking by design. Design thinking, design theory*. The MIT Press.

Dorst, K., & Cross, N. (2001). Creativity in the design process: co-evolution of problem–solution. *Design Studies*, *22*(5), 425–437. https://doi.org/10.1016/S0142-694X(01)00009-6

Dortdivanlioglu, H. (2018). The diagram in continuum. *ARCC Conference Repository*. 1–8. https://arcc-journal.org/index.php/repository/article/download/511/402

Drexler, G., & Janse, B. (2013). Social network analysis: An important tool for innovation management. In A. Brem & É. Viardot (Eds.), *Evolution of innovation management* (pp. 115–131). Palgrave Macmillan UK.

Dubberly, H. (2004). *How do you design? A Compendium of Models*. Dubberly Design Office. http://www.dubberly.com/wp-content/uploads/2008/06/ddo_designprocess.pdf

Düchs, M. (2012). Edel sei der Architekt, hilfreich und gut – Zum Berufsethos der Architekten. In W. Nerdinger & H. Böhm (Eds.), *Der Architekt: Geschichte und Gegenwart eines Berufsstandes*. [Anlässlich der Ausstellung

„Der Architekt - Geschichte und Gegenwart eines Berufsstandes“ im Architekturmuseum der TU München in der Pinakothek der Moderne, 27. September 2012 bis 3. Februar 2013] (pp. 418–427). Prestel.

Düchs, M. (2017). Die ethische Funktion von The Ethical Function of Architecture. *Wolkenkuckucksheim : internationale Zeitschrift für Theorie und Wissenschaft der Architektur = Cloud-Cuckoo-Land = Vozdušnyj zamok. 22*(35), 187–201. http://cloud-cuckoo.net/fileadmin/issues_en/issue_36/article_duechs.pdf

Dunne, D. D., & Dougherty, D. (2012). Organizing for change, innovation, and creativity. In M. D. Mumford (Ed.), Handbook of organizational creativity (pp. 569–583). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00022-7

Duran, H. (2020, March 19). Innosabi update: “One stop shop” for innovation. *Munich Startup*. Retreived November 10, 2020, from https://en.munich-startup.de/2020/03/19/innosabi-update-interview/

Duschlbauer, T. (2007). Everlasting change. In M. Shamiyeh (Ed.), *Organizing for change \ profession: Integrating architectural thinking in other fields* (pp. 125–129). Birkhäuser; Springer.

DWIH New York (2021, October 14–15). InnoSpacing: The role of physical space and its value proposition for inducing innovation ecosystems [Conference session]. In *Future Forum: Before After. DWIH New York's annual spotlight conference*. https://www.dwih-futureforum.org/virtuallunchsessions

Dworkin, S. L. (2012). Sample size policy for qualitative studies using in-depth interviews. *Archives of Sexual Behavior*, *41*, 1319–1320.

Ednie-Brown, P., Burry, M., & Burrow, A. (2013). The innovation imperative: Architectures of vitality. *AD Architectural Design. Special Issue: The Innovation Imperative: Architectures of Vitality*, *83*(1), (221), 8–17.

Edquist, C. (2005). Systems of innovation - Their emergence and characteristics. In C. Edquist (Ed.), *Systems of innovation: Technologies, institutions and organizations* (pp. 1–35). Taylor and Francis.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550. https://doi.org/10.5465/AMR.1989.4308385

Endres, H., Huesig, S., & Pesch, R. (2021). Digital innovation management for entrepreneurial ecosystems: services and functionalities as drivers of innovation management software adoption. *Review of Managerial Science*, 1–22. https://doi.org/10.1007/s11846-021-00441-4

Eppler, M. J., & Hoffmann, F. (2011). Challenges and visual solutions for strategic business model innovation. In M. Hülsmann & N. Pfeffermann (Eds.), *Strategies and communications for innovations* (pp. 25–36). Springer.

Eppler, M. J., & Hoffmann, F. (2013). Strategies for business model innovation: challenges and visual solutions for strategic business model innovation. In N. Pfeffermann, T. Minshall, & L. Mortara (Eds.), Strategy and communication for innovation (pp. 3–14). Springer. https://doi.org/10.1007/978-3-642-41479-4_1

Eppler, M. J., & Kernbach, S. (2016). Dynagrams: Enhancing design thinking through dynamic diagrams. *Design Studies*, 47, 91–117. https://doi.org/10.1016/j.destud.2016.09.001

Eppler, M. J., Kernbach, S., & Pfister, R. A. (2016). *Dynagrams - Denken in Stereo: Mit dynamischen Diagrammen schärfer denken, effizienter zusammenarbeiten und klarer kommunizieren* (1st edition). Schäffer-Poeschel Verlag.

Faatz, S. (2009). Architectural programming: providing essential knowledge of project participants needs in the pre-design phase. *Organization, Technology and Management in Construction · an International Journal*, *1*(2). 80–85.

Fagerberg, J. (2005). Innovation: A guide to the literature. In J. Fagerberg, D. C. Mowery, & R. R. Nelson (Eds.), *The Oxford handbook of innovation* (pp. 1–26). Oxford University Press.

Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.) (2005). The Oxford handbook of innovation. Oxford University Press.

Farling, M. (2015). From intuition to immersion: Architecture and neuroscience. In J. Pallasmaa & S. Robinson (Eds.), *Mind in architecture: Neuroscience, embodiment, and the future of design* (pp. 181–196). The MIT Press.

Fichter, K. (2009). Interaktionsökonomik [White paper]. *Borderstep-Diskussionspapier*, 1/2009, 1–12. https://www.borderstep.de/wp-content/uploads/2014/07/Fichter-Interaktionsoekonomik_Borderstep_Diskussionspapier_1-2009.pdf

Fichter, K. (2014). Interaktive Innovationstheorien als alternative „Schule“ der Innovationsforschung. In W. Burr (Ed.), *Innovation: Theorien, Konzepte und Methoden der Innovationsforschung* (1st ed., pp. 63–91). Kohlhammer Verlag.

Fischer, G. (2014). *Architekturtheorie für Architekten: Die theoretischen Grundlagen des Faches Architektur*. Bauwelt Fundamente: Vol. 152. Bauverlag; Birkhäuser.

Fischer, G. (2018). *Architekturtheorie für Architekten: Die theoretischen Grundlagen des Faches Architektur* (2., überarbeitete Auflage). Bauwelt Fundamente: Vol. 152. Bauverlag; Birkhäuser.

Fisher, T. (2000). *In the scheme of things: Alternative thinking on the practice of architecture*. University of Minnesota Press.

Fisher, T. (2015a). Labor and talent in architecture. In P. Deamer (Ed.), *The architect as worker: Immaterial labor, the creative class, and the politics of design*. Bloomsbury Academic.

Fisher, T. (2015b). Welcome to the Third Industrial Revolution: Mass-Customisation of Architecture, Practice and Education. *AD Architectural Design. Special Issue: 2050 - Designing our tomorrow*, *85*(4), 40–45.

Fisher, T. (2016). The designed environment and deep ecology. In M. Kanaani & D. A. Kopec (Eds.), *Routledge Companions. The Routledge companion for architecture design and practice: Established and emerging trends* (pp. 437–449). Routledge Taylor & Francis Group.

Fjeldstad, Ø. D., Snow, C. C., Miles, R. E., & Lettl, C. (2012). The architecture of collaboration. *Strategic Management Journal*, *33*(6), 734–750. https://doi.org/10.1002/smj.1968

Fleishman, H. (2022, January 19). Metaverse reality check: Should you care, and opportunities you can grab. *Forbes*. Retreived January 26, 2022, from https://www.forbes.com/sites/hodfleishman/2022/01/19/metaverse-reality-check-should-you-care-and-opportunities-you-can-grab/?sh=1a4eef1f22b6

Flöhl, K. (2021). *Building innovation modelling. Virtualizing and substantiating organizational structures in innovation processes* [Unpublished master's thesis, Summer semester 2021, Department of Architecture]. Technical University of Munich.

Florida, R. (2014). The rise of the creative class, revisited. (Paperback ed.). Basic Books.

Florida, R. (2020, September 18). The uncertain future of corporate HQs. *Harvard Business Review*. https://hbr.org/2020/09/the-uncertain-future-of-corporate-hqs

Flynn, P., Dunn, M., Price, M., & O’Connor, M. (2020). Rethinking the crit. *EAAE Annual Conference Proceedings*, 3(1), 176–187. https://doi.org/10.51588/eaaeacp.61

Förster, A. (2014). *Planungsprozesse wirkungsvoller gestalten: Wirkungen, Bausteine und Stellgrößen kommunikativer planerischer Methoden* [Doctoral

Dissertation, Technical University of Munich]. mediaTUM – the media and publications repository of the Technical University of Munich. https://mediatum.ub.tum.de/doc/1210593/1210593.pdf

Franck, K. A. (2016). Designing with time in mind. *AD Architectural Design. Special Issue: Architecture Timed: Designing With Time in Mind*, *86*(1), 8–17.

Frank, H., Lueger, M., & Korunka, C. (2010). Innovative Kleinunternehmen: Eine qualitative Systemanalyse. *Zeitschrift für KMU und Entrepreneurship: ZfKE*, *58*(1), 1–30.

Franken, R., & Franken, S. (2011). *Integriertes Wissens- und Innovationsmanagement*. Gabler.

Frazer, J. (2016). Parametric computation: History and future. *AD Architectural Design. Special Issue: Parametricism 2.0: Rethinking Architecture's Agenda for the 21st Century*, *86*(2), 18–23.

Fu, K. K., Yang, M. C., & Wood, K. L. (2016). Design principles: Literature review, analysis, and future directions. *Journal of Mechanical Design*, *138*(10), 101103-1–101103-13. https://doi.org/10.1115/1.4034105

Gage, M. F. (2016). A hospice for parametricism. *AD Architectural Design. Special Issue: Parametricism 2.0: Rethinking Architecture's Agenda for the 21st Century*, *86*(2), 128–133.

Gal, U., Yoo, Y., & Boland, R. J., JR. (2005). The dynamics of boundary objects, social Infrastructures and social identities. In D. Bartmann, F. Rajola, J. Kallinikos, D. E. Avison, R. Winter, P. Ein-Dor, . . . C. Weinhardt (Chairs), *Proceedings of the 13th European Conference on Information Systems, Information Systems in a Rapidly Changing Economy, ECIS 2005, Regensburg, Germany, May 26-28, 2005*. 13 pages. http://aisel.aisnet.org/ecis2005/57

Galbraith, J. R. (1977). *Organization design*. Addison-Wesley.

Gann, D. M., & Salter, A. J. (2000). Innovation in project-based, service-enhanced firms: The construction of complex products and systems. *Research Policy*, *29*(7-8), 955–972. https://doi.org/10.1016/S0048-7333(00)00114-1

Gänshirt, C. (2012). *Tools for ideas: Introduction to architectural design*. de Gruyter.

Garcia, M. (Ed.) (2010a). *AD reader. The diagrams of architecture*. Wiley.

Garcia, M. (2010b). Introduction: Histories and theories of the diagrams of architecture. In M. Garcia (Ed.), *AD reader. The diagrams of architecture* (pp. 18–45). Wiley.

Gardner, H. (2011). *Frames of mind: The theory of multiple intelligences*. Basic Books.

Garud, R., Tuertscher, P., & Van de Ven, A. H. (2013). Perspectives on innovation processes. *The Academy of Management Annals*, *7*(1), 775–819. https://doi.org/10.1080/19416520.2013.791066

Gasperoni, L. (2016). Möglichkeitsräume Entwerfen. Eine Re-Aktualisierung Der Kantischen Philosophie Für Die Heutige Architektur. *Con-Textos Kantianos. International Journal of Philosophy*. (4), 252–286. https://doi.org/10.5281/zenodo.164007

Gassmann, O., & Sutter, P. (2013). *Praxiswissen Innovationsmanagement: Von der Idee zum Markterfolg* (3., überarbeitete und erweiterte Auflage, . Hanser Verlag. https://doi.org/10.3139/9783446435131

Gehry, F., Lloyd, M., & Shelden, D. (2020). Empowering Design: Gehry Partners, Gehry Technologies, and Architecture-Led Industry Change. *AD Architectural Design. Special Issue: The Disruptors. Technology-driven architect-entrepreneurs*, *90*(2), 14–23.

Gehry, F. O. (2004). Reflections on designing and architectural practice. In R. J. Boland & F. Collopy (Eds.), *Managing as designing* [workshop held at the Weatherhead School of Management in June 2002 …] (pp. 19–35). Stanford Business Books.

Gelbmann, U., Vorbach, S., & Zotter, K. (2004). Konzepte fur das Innovationsmanagement in Klein- und Mittelunternehmen. In E. J. Schwarz (Ed.), *Nachhaltiges Innovationsmanagement* (pp. 247–273). Gabler Verlag.

Gensler, M. A., & Lindenmayer, M. (2015). *Art's principles: 50 years of hard-learned lessons in building a world-class professional services firm*. Wilson Lafferty.

Gerpott, T. J. (2005). *Strategisches Technologie– und Innovationsmanagement* (2., überarbeitete und erweiterte Auflage). Schäffer-Poeschel Verlag.

Gerybadze, A. (2014). Zur Entwicklung der englischsprachigen betriebswirtschaftliche und volkswirtschaftlichen Innovationforschung. In W. Burr (Ed.), *Innovation: Theorien, Konzepte und Methoden der Innovationsforschung* (1st ed., pp. 40–60). Kohlhammer Verlag.

Gharajedaghi, J. (2011). *Systems thinking: Managing chaos and complexity: A platform for designing business architecture* (3rd ed.). Elsevier; Morgan Kaufmann.

Gießmann, S., & Taha, N. (Eds.) (2017). *Susan Leigh Star - Grenzobjekte und Medienforschung*. transcript Verlag.

Gilson, L. L., Lim, H. S., Litchfield, R., & Gilson, P. W. (2015). Creativity in teams: A key building block for innovation and entrepreneurship. In J. Zhou, C. E. Shalley, & M. A. Hitt (Eds.), *Oxford library of psychology. The Oxford handbook of creativity, innovation, and entrepreneurship* (pp. 177–204). Oxford University Press.

Gleiniger, A. (2008). "The Difficult Whole," or the (re)discovery of complexity in architecture. In A. Gleiniger & G. Vrachliotis (Eds.), *Context architecture. Complexity: Design strategy and world view* (pp. 37–57). Birkhäuser.

Gleiniger, A., & Vrachliotis, G. (2008). Editorial: The complexity of complexity. In A. Gleiniger & G. Vrachliotis (Eds.), *Context architecture. Complexity: Design strategy and world view* (pp. 7–11). Birkhäuser.

Godin, B. (2008). Innovation: The history of a category: Project on the Intellectual history of innovation [Working paper No. 1]. http://www.csiic.ca/PDF/IntellectualNo1.pdf

Godin, B. (2015a). *Innovation contested: The idea of innovation over the centuries.* Routledge studies in social and political thought: Vol. 98. Routledge.

Godin, B. (2015b). Models of innovation: Why models of innovation are models, or what work is being done in calling them models? *Social Studies of Science*, *45*(4), 570–596. https://doi.org/10.1177/0306312715596852

Godin, B. (2017). *Models of innovation: The history of an idea. Inside technology.* The MIT Press.

Götzendorfer, M. (2014). *Untersuchung von Designprinzipien in Innovationsprojekten aus der Wissensperspektive. Eine qualitative Studie im universitären Umfeld als Grundlage für einen Business Design Approach* [Doctoral Dissertation, Technical University of Munich]. Technical University of Munich.

Goffin, K., & Mitchell, R. (2017). *Innovation management: Effective strategy and implementation* (Third edition). Palgrave; Macmillan Education.

Gómez, L. (2013). Entwerfen als Wissensorganisation. Kulturelle Transformationsprozesse im Spiegel der amerikanischen Architektur der 1950er und 1960er Jahre. In S. Ammon & E. M. Froschauer (Eds.), *Eikones. Wissenschaft entwerfen: Vom forschenden Entwerfen zur Entwurfsforschung der Architektur* (pp. 109–132). Wilhelm Fink. https://doi.org/10.30965/9783846755211_006

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, *78*(6), 1360–1380.

Grondzik, W. T., & Kwok, A. G. (2019). *Mechanical and electrical equipment for buildings* (Thirteenth edition). John Wiley & Sons.

Groves, K., & Marlow, O. (2016). *Spaces for innovation: The design and science of inspiring environments*. Frame Publishers.

Haberer, L. (2013). Der Raum des Denkens. Überlegungen zur Rolle der Diagrammatik für die Theoriebildung einer ›dekonstruktivistischen‹ Architektur. In D. Boschung & J. Jachmann (Eds.), *Morphomata: Vol. 6. Diagrammatik der Architektur* (pp. 194–226). Fink.

Haller, C. (2003). Verhaltenstheoretischer Ansatz für ein Management von Innovationsprozessen [Doctoral Dissertation, Universität Stuttgart), https://elib.uni-stuttgart.de/bitstream/11682/5467/1/Dissertation_Christine_Haller.pdf

Hanson, A. (2018, April 12). A toolkit by any other name: A toolkit taxonomy. *OECD Organisation for Economic Cooperation and Development*. https://www.oecd-opsi.org/toolkit-taxonomy/

Hansson, S. O. (2009). Risk and safety in technology. In A. Meijers (Ed.), *Handbook of the philosophy of science: Vol. 9. Philosophy of technology and engineering sciences* (pp. 1069–1102). Elsevier. https://doi.org/10.1016/B978-0-444-51667-1.50043-4

Hargadon, A. (2015). Borkerage and innovation. In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (Paperback edition, pp. 163–180*)*. Oxford University Press.

Harrigan, J. E., & Neel, P. R. (1996). *The executive architect: Transforming designers into leaders*. Wiley.

Hasse, R., & Krücken, G. (2013). Neo-institutionalistische Theorie. In G. Kneer & M. Schroer (Eds.), *Handbuch. Handbuch soziologische Theorien* (1st ed.). Springer VS.

Hatchuel, A. (2001). Towards design theory and expandable rationality: The unfinished program of Herbert Simon. *Journal of Management and Governance*, *5*(3/4), 260–273. https://doi.org/10.1023/A:1014044305704

Hauschildt, J., Salomo, S., Schultz, C., & Kock, A. (2016). *Innovationsmanagement* (6., vollständig aktualisierte und überarbeitete Auflage). Franz Vahlen.

Held, M. (2016). Framing als Analysemodell und Gestaltungsfrage. *Arch+ Zeitschrift für Architektur und Städtebau*, *222*(1), 60–63.

Henderson, K. (1991). Flexible sketches and inflexible data bases: Visual communication, conscription devices, and boundary objects in design engineering. *Science, Technology, & Human Values*, *16*(4), 448–473. https://doi.org/10.1177/016224399101600402

Henn, G. (1998). Architektur ist eine soziale Tatsache, die sich räumlich formt. In N. Franke (Ed.), *Innovationsforschung und Technologiemanagement: Konzepte, Strategien, Fallbeispiele* (pp. 429–435). Springer.

Henn, G. (2004). Programming - Projekte effizient und effektiv entwickeln. In O. Schürer & G. Brandner (Eds.), *Architektur: Consulting: Kompetenzen, Synergien, Schnittstellen* (pp. 42–49). Birkhäuser.

Henn, G. (2010). *Konzept für das Innovationslabor: LAI – Laboratory for Architecting Innovation* [Concept Paper]. Technische Universität Dresden. https://doi.org/10.2314/GBV:643946454

Henn, G. (2013). *Innovationslabor „LAI – Laboratory for Architecting Innovation“: Schlussbericht* [Report]. Technische Universität Dresden. https://doi.org/10.2314/GBV:784252211

Henn, G. (2016). Architektur als Medium der Innovation. In HENN & WITTENSTEIN AG (Eds.), *Innovationsfabrik WITTENSTEIN AG. Dokumentation* (pp. 6–7). HENN / WITTENSTEIN AG.

HENN (2009). *Jahrbuch 2009* [Company report]. Henn Architekten.

HENN (2016). *Jahrbuch 2016* [Company report]. HENN.

HENN & attocube systems AG (2015a). *HENN Programming attocube "NanoFactory" - Module A*. [Internal Document, unpublished].

HENN & attocube systems AG (2015b). *HENN Programming attocube "NanoFactory" - Module A Draft*. [Internal Document, unpublished].

HENN & WITTENSTEIN AG (2008a). *HENN Programming Wittenstein AG "Produktionsarena" - Module A* [Internal Document, unpublished].

HENN & WITTENSTEIN AG (2008b). *HENN Programming Wittenstein AG „Produktionsarena" - Module B*. [Internal Document, unpublished].

HENN & WITTENSTEIN AG (2009a). *HENN Programming Wittenstein AG „Produktionsarena" - Module C*. [Internal Document, unpublished].

HENN & WITTENSTEIN AG (2009b). *HENN Programming Wittenstein AG "Produktionsarena" - Module A and B*. [Internal Document, unpublished].

HENN & WITTENSTEIN AG (Eds.) (2016). *Innovationsfabrik WITTENSTEIN AG*. Dokumentation. HENN / WITTENSTEIN AG.

Hershberger, R. G. (1999). *Architectural programming and predesign manager*. McGraw-Hill.

Herstatt, C., & Verworn, B. (Eds.) (2007). *Management der frühen Innovationsphasen: Grundlagen - Methoden - Neue Ansätze* (2., überarbeitete und erweiterte Auflage). Gabler; GWV Fachverlage.

Hidalgo, A., & Albors, J. (2008). Innovation management techniques and tools: A review from theory and practice. *R&D Management*, *38*(2), 113–127. https://doi.org/10.1111/j.1467-9310.2008.00503.x

Hill, D. (2013). Foreword. In R. Hyde (Ed.), *Future practice: Conversations from the edge of architecture* (pp. 6–15). Routledge.

Hillier, B. (2007). *Space is the machine*. Space Syntax.

Hillier, B., & Hanson, J. (1984). *The social logic of spcae*. Cambridge University Press.

Hillier, B., Hanson, J., Peponis, J., Hudson, J., & Richard, B. (1983). Space syntax: A different urban perspective. *Architects' Journal*, *30*(178), 47–63.

Hirschberg, U., & Fritz, O. (2020). Generative methods. In U. Hirschberg, L. Hovestadt, & O. Fritz (Eds.), *Atlas of digital architecture: Terminology, concepts, methods, tools, examples, phenomena* (pp. 145–173). Birkhauser.

Hnilica, S. (2013). Architektonische Form als Datenspur. Zur Wissenschaftlichkeit in Designprozessen. In D. Boschung & J. Jachmann (Eds.), *Morphomata: Vol. 6. Diagrammatik der Architektur* (pp. 229–250). Fink.

Hobday, M., Boddington, A., & Grantham, A. (2011). An innovation perspective on design: Part 1. *Design Issues*, *27*(4), 5–15. doi: https://doi.org/10.1162/DESI_a_00101

Hobday, M., Boddington, A., & Grantham, A. (2012). An innovation perspective on design: Part 2. *Design Issues*, *28*(1), 18–29. doi: https://doi.org/10.1162/DESI_a_00137

Hodulak, M., & Schramm, U. (2019). *Nutzerorientierte Bedarfsplanung. Prozessqualität für nachhaltige Gebäude* (2., überarbeitete und aktualisierte Auflage). Springer Vieweg.

Hof, B. E. (2018). The cybernetic "General Model Theory": Unifying science or epistemic change? *Perspectives on Science*, *26*(1), 76–96.

Hofbauer, G., & Wilhelm, A. (2015). *Innovationsprozesse erfolgreich managen: Ein Praxisabgleich für die frühe Phase des Innovationsmanagements*. *Working Papers / Nr. 35*. Technische Hochschule Ingolstadt. https://www.thi.de/fileadmin/daten/Working_Papers/thi_workingpaper_35_hofbauer.pdf

Holland, J. H. (2014). *Complexity: A very short introduction* (1st ed.). *Very short introductions: Vol. 392*. Oxford University Press.

Holzer, B. (2013). Netzwerktheorie. In G. Kneer & M. Schroer (Eds.), *Handbuch. Handbuch soziologische Theorien* (1st ed., pp. 253–275). Springer VS.

Hovestadt, L. (2021). Graphs & Graphics. In U. Hirschberg, L. Hovestadt, & O. Fritz (Eds.), *Atlas of digital architecture: Terminology, concepts, methods, tools, examples, phenomena* (175–213). Birkhäuser.

Houde, S., & Hill, C. (1997). Chapter 16 - What do Prototypes Prototype? In M. G. Helander, T. K. Landauer, P. V. Prabhu (Eds.), Handbook of Human-Computer Interaction (2nd ed., pp. 367–381). https://doi.org/10.1016/B978-044481862-1.50082-0

HPI of Design (2010). *An introduction to design thinking: process guide* [Brochure]. d.school. Hasso Plattner Institute of Design at Stanford University. 11 pages. Retreived January 13, 2018, from https://web.stanford.edu/~mshanks/MichaelShanks/files/509554.pdf

HPI of Design (2018). *Design thinking bootleg deck* [Brochure]. d.school. Hasso Plattner Institute of Design at Stanford University. 90 pages. Retreived March 21, 2021, from https://dschool.stanford.edu/resources/design-thinking-bootleg

Huesig, S., & Endres, H. (2019). Exploring the digital innovation process. *European Journal of Innovation Management*, *22*(2), 302–314. https://doi.org/10.1108/EJIM-02-2018-0051

Humanyze (2021a, October 20). *About us*. Humanyze. Retrieved October 20, 2021, from https://humanyze.com/about-us/

Humanyze (2021b, October 20). *Organizational health: Maintain an effective, healthy organization with science-backed insights*. Humanyze. Retrieved October 20, 2021, from https://humanyze.com/solutions-org-health/

Hunter, S. T., Cassidy, S. E., & Ligon, G. S. (2012). Planning for Innovation. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 515–545). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00020-3

Huppatz, D. J. (2015). Revisiting Herbert Simon's "Science of Design". *Design Issues*, *31*(2), 29–40. https://doi.org/10.1162/DESI_a_00320

Hüsig, S., & Waldmannstetter, K. (2013). Empirical analysis and classification of innovation management software. *International Journal of Product Development*, *18*(2), 134. https://doi.org/10.1504/IJPD.2013.053497

Hyde, R. (Ed.) (2013). *Future practice: Conversations from the edge of architecture* Routledge.

IfM Bonn (2019a, October 10). *Definition "Deutscher Mittelstand"*. IfM Institut für Mittelstandsforschung Bonn. Retrieved October 10, 2019, from https://en.ifm-bonn.org/definitions/definition-deutscher-mittelstand/

IfM Bonn (2019b, October 10). *SME-definition of IfM Bonn*. IfM Institut für Mittelstandsforschung Bonn. Retrieved October 10, 2019, from https://en.ifm-bonn.org/definitions/sme-definition-of-ifm-bonn/

IfM Mannheim (2022, January 26). *Prof. (em.) Dr. Dr. h.c. mult. Alfred Kieser*. ifm Institut für Mittelstandsforschung der Universität Mannheim. Retreived January 26, 2022, from http://www.institut-fuer-mittelstandsforschung.de/kos/WNetz?art=Person.show&id=240

Illies, C., & Nicholas, R. (2009). Philoshophy of architecture. In A. Meijers (Ed.), *Handbook of the philosophy of science: Vol. 9. Philosophy of technology and engineering sciences* (pp. 1199–1256). Elsevier.

innosabi (2022a, Januar 26). *About innosabi*. innosabi. Retrieved January 26, 2022, from https://innosabi.com/en/about/

innosabi (2022b). *The innosabi software suite: Covering innovation end-to-end*. innosabi. Retrieved January 26, 2022, from https://innosabi.com/en/suite/

Jabi, W. (2013). *Parametric design for architecture*. Laurence King Publishing.

James, K., & Drown, D. (2012). Organizations and creativity. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 17–38). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00002-1

Johansson-Sköldberg, U., Wodilla, J., & Çetinkaya, M. (2013). Design thinking: Past, present and possible futures. *Creativity and Innovation Management*, *22*(2), 121–146. https://doi.org/10.1111/caim.12023

Johnson, S. (2010). *Where good ideas come from: The natural history of innovation*. Riverhead Books.

Jönsson, S. (2004). Persuasive artifacts. In R. J. Boland & F. Collopy (Eds.), *Managing as designing [workshop held at the Weatherhead School of Management in June 2002 …]* (pp. 214–220). Stanford Business Books.

Jörg, T., & Hughes, S. A. (2013). Harnessing the complexity of innovation. *International Journal of Knowledge and Systems Science*, *4*(3), 1–13. https://doi.org/10.4018/ijkss.2013070101

Kaicker, A., Blum, U., Siedler, P., & Espaillat, L. (2019). Enhancing workplace design through advanced floor plate analytics. *Technology | Architecture + Design*, *3*(2), 151–160. https://doi.org/10.1080/24751448.2019.1640526

Karimi, K. (2012). A configurational approach to analytical urban design: 'Space syntax' methodology. *URBAN DESIGN International*, *17*(4), 297–318. https://doi.org/10.1057/udi.2012.19

Kastelle, T., & Steen, J. (2015). Networks of Innovation. In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (Paperback edition, pp. 102–120). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199694945.013.027

Katsikakis, D. (2017). Flexible architecture for evolving work practices. AD *Architectural Design. Special Issue: Loose-Fit Architecture: Designing Buildings for Change*, *87*(5), 68–75. https://doi.org/10.1002/ad.2218

Keeley, L., Pikkel, R., Quinn, B., & Walters, H. (2013). *Ten types of innovation: The discipline of building breakthroughs*. Wiley.

Khazanchi, S., Sprinkle, T. A., Masterson, S. S., & Tong, N. (2018). A spatial model of work relationships: The relationship-building and relationship-straining Effects of workspace design. *Academy of Management Review*, *43*(4), 590–609. https://doi.org/10.5465/amr.2016.0240

Kirzner, I. M. (2011). Between useful and useless innovation: The entrepreneurial role. In D. B. Audretsch, O. Falck, S. Heblich, & A. Lederer (Eds.), *Handbook of research on innovation and entrepreneurship* (pp. 12–16). Elgar.

Kline, S. J. (1985). Innovation is not a linear process. *Research Management*, *28*(4), 36–45. https://doi.org/10.1080/00345334.1985.11756910

Kline, S. J., & Rosenberg, N. (1986). An Overview of Innovation. In R. Landau & N. Rosenberg (Eds.), *The Positive Sum Strategy. Harnessing Technology for Economic Growth* (pp. 275–305). National Academy Press.

Knittel-Ammerschuber, S. (2006). *Erfolgsfaktor Architektur: Strategisches Bauen für Unternehmen*. Birkhäuser

Knoespel, K. J. (2002). Diagrams and space in srchitecture. *Philosophica*, *70*, 11–36.

Koen, P., Ajamian, G., Burkart, R., Clamen, A., Davidson, J., D'Amore, R., Elkins, C., Herald, K., Incorvia, M., Johnson, A., Karol, R., Seibert, R., Slavejkov, A., & Wagner, K. (2001). Providing clarity and a common language to the "Fuzzy Front End". *Research-Technology Management*, *44*(2), 46–55. https://doi.org/10.1080/08956308.2001.11671418

Koen, P. A., Ajamian, G. M., Boyce, S., Clamen, A., Fisher, E., Fountoulakis, S., Johnson, A., Puri, P., & Seibert, R. (2002). Fuzzy Front End: Effective methods, tools, and techniques. In P. Belliveau, A. Griffin, & S. Somermeyer (Eds.), *The PDMA toolbook for new product development* (pp. 5–35). Wiley.

Kolko, J. (2010). Abductive thinking and sensemaking: The drivers of design synthesis. *Design Issues*, *26*(1), 15–28. https://doi.org/10.1162/desi.2010.26.1.15

Koolhaas, R., & Obrist, U. (2004a). Re-learning form Las Vegas. Interview with Denise Scott Brown & Robert Venturi - Interview by Rem Koolhaas & Hans Ulrich Obrist. In R. Koolhaas & B. McGetrick, *Content: Triumph of realization* (pp. 150–157). Taschen

Koolhaas, R., & McGetrick, B. (2004b). *Content: Triumph of realization*. Taschen.

Koth, S. K. (2021). *Innovation – Track to act: Understanding & visualizing innovation processes* [Unpublished Course Project, Wintersemeter 20/21, Chair of Architectural Informatics] Technical University of Munich.

KPMG (2011). *Confronting complexity: Research findings and insights [Report]*. KPMG. http://www.ub.unibas.ch/digi/a125/sachdok/2011/BAU_1_5663533.pdf

Kühn, C. (2007). Towards an architecture of change: From open plan to open planning. In M. Shamiyeh (Ed.), *Organizing for change \ space: Positions of neorealism* (pp. 102–110). de Gruyter.

Kulick, A., Quarch, C., & Teunen, J. (Eds.) (2017). *Officina Humana: Das Büro als Lebensraum für Potenzialentfaltung*. avedition.

Kulper, P. (2013). A world below. In *AD Architectural Design. Special Issue: Drawing Architecture, 83*(5), 56–63). https://doi.org/10.1002/ad.1663

Kumlin, R. R. (1995). *Architectural programming: Creative techniques for design professionals.* McGraw Hill.

Laloux, F. (2014). *Reinventing organizations: A guide to creating organizations inspired by the next stage of human consciousness* (1. ed.). Nelson Parker.

Lam, A. (2005). Organizational innovation. In J. Fagerberg, D. C. Mowery, & R. R. Nelson (Eds.), *The Oxford handbook of innovation* (pp. 115–147). Oxford University Press.

Lam, A. (2010). Innovative organizations: Structure, learning and adaptation. In BBVA (Ed.), *Innovation. Perspectives for the 21st Century* (pp. 163–177).

Lamnek, S. (2010). *Qualitative Sozialforschung: Lehrbuch. Mit Add-on* (5., überarb. Aufl.). Beltz Verlagsgruppe.

Langley, A. (1999). Strategies for Theorizing from Process Data. *Academy of Management Review*, *24*(4), 691. https://doi.org/10.2307/259349

Lassl, W. (2020). *The viability of organizations, Vol. 3 - Designing and Changing Organizations*. Springer International Publishing.

Latour, B. (1996). On actor-network theory: A few clarifications. *Soziale Welt*, *47*(4), 369–381.

Lawson, B. (1997). *How designers think: The design process demystified* (3rd ed.). Architectural Press.

Lawson, B. (2005). *How designers think: The design process demystified* (4. ed.). Elsevier; Architectural Press.

Lawson, B., & Dorst, K. (2009). *Design expertise*. Elsevier; Architectural Press.

Leatherbarrow, D. (2001). Architecture is it own discipline. In A. Piotrowski & J. W. Robinson (Eds.), *The discipline of architecture* (pp. 83–102). University of Minnesota Press.

Lee, T. W., Mitchell, T. R., & Sablynski, C. J. (1999). Qualitative Research in Organizational and Vocational Psychology, 1979–1999. *Journal of Vocational Behavior*, *55*(2), 161–187. https://doi.org/10.1006/jvbe.1999.1707

LEGO (2022, January 26). Lego® Serious Play®. LEGO. Retrieved January 26, 2022, from https://www.lego.com/en-de/themes/serious-play/about

Leifer, L. J., & Steinert, M. (2011). Dancing with ambiguity: Causality behavior, design thinking, and triple-loop-learning. *Information Knowledge Systems Management*, *10*(1-4), 151–173. https://doi.org/10.3233/IKS-2012-0191

Leitner, K.-H., Warnke, P., & Rhomberg, W. (2016). New forms of innovation: Critical issues for future pathways. *Foresight*, *18*(3), 224–237. https://doi.org/10.1108/FS-07-2014-0050

Leonard, D. A., & Barton, M. (2015). Knowledge and the management of creativity and innovation. In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (Paperback edition, pp. 121–138). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199694945.013.005

Lewrick, M., Link, P., & Leifer, L. (2017). *Design thinking playbook.* Vahlen.

Liedtka, J. (2004). Design thinking: The role of hypotheses generation and testing. In R. J. Boland & F. Collopy (Eds.), *Managing as designing [workshop held at the Weatherhead School of Management in June 2002 …]* (pp. 193–197). Stanford Business Books.

Liedtka, J. (2013). If managers thought like designers. In *Rotman on design: The best on design thinking from Rotman magazine* (pp. 26–31). University of Toronto Press.

Liedtka, J. (2015). Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction. *Journal of Product Innovation Management*, *32*(6), 925–938. https://doi.org/10.1111/jpim.12163

Liedtka, J., & Ogilvie, T. (2011). *Designing for growth: A design thinking tool kit for managers.* Columbia Business School Publishing; Columbia University Press.

Lin, N. (2001). Building a network theory of social capital. In N. Lin, K. S. Cook, & R. S. Burt (Eds.), *Sociology and Economics. Social Capital: Theory and Research* (pp. 3–29). Routledge.

Lindgaard, K., & Wesselius, H. (2017). Once more, with feeling: Design thinking and embodied cognition. *She Ji: The Journal of Design, Economics, and Innovation*, *3*(2), 83–92. https://doi.org/10.1016/j.sheji.2017.05.004

Lockwood, T. (2011). Foreword. In T. Lockwood (Ed.), *Design thinking: Integrating innovation, customer experience and brand value* (3rd ed., pp. vii–xvii). Allworth Press.

Lockwood, T., & Papke, E. (2018). *Innovation by design: How any organization can leverage design thinking to produce change, drive new ideas, and deliver meaningful solutions*. Career Press.

Longhi, C., & Keeble, D. (2000). High-technology clusters and evolutionary trends in the 1990s. In D. Keeble & F. Wilkinson (Eds.), *High-technology clusters, networking and collective learning in Europe* (pp. 21–56). Ashgate.

Luebkeman, C. (Guest-Ed.) (2015a). *AD Architectural Design. Special Issue: 2050 - Designing our tomorrow*, *85*(4). Wiley.

Luebkeman, C. (2015b). Design is our answer: An Interview with leading design thinker Tim Brown. *AD Architectural Design. Special Issue: 2050 - Designing our tomorrow*, *85*(4), 34–39.

LUMA Institute (2022, January 26). *The LUMA System: The most practical, flexible and versatile approach to innovation in the world that anyone can learn and apply. About LUMA*. LUMA Institute. Retrieved January 26, 2022, from https://www.luma-institute.com/about-luma/luma-system/

Lundberg, H., Sutherland, I., Blazek, P., Habicht, H., & Penzenstadler, B. (2014). The emergence of creativity, innovation and leadership in micro-level social interactions and how to research it. *International Journal of Industrial Engineering and Management*, *5*(4), 221–232.

Lundberg, H., Sutherland, I., Penzenstadler, B., Blazek, P., & Habicht, H. (2017). "La Chispa de la Ciudad de México": Co-creation of organizational innovations and its implications for managing innovation. In J. Bellemare, S. Carrier, K. Nielsen, & F. T. Piller (Eds.), *Springer Proceedings in business and economics. Managing complexity* (pp. 287–300). Springer International Publishing. https://doi.org/10.1007/978-3-319-29058-4_23

Mainemelis, C., & Dionysiou, D. D. (2015). Play, flow, and timelessness. In J. Zhou, C. E. Shalley, & M. A. Hitt (Eds.), *Oxford Library of psychology. The Oxford handbook of creativity, innovation, and entrepreneurship* (pp. 121–140). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199927678.013.0006

Makarius, E. E., Larson, B. Z., & Vroman, S. R. (2021). What Is Your Organization's Long-Term Remote Work Strategy? *Harvard Business Review*, (March 24). https://hbr.org/2021/03/what-is-your-organizations-long-term-remote-work-strategy

Maletz, M. C., & Nohria, N. (2001). Managing in the Whitespace. *Harvard Business Review*, *(February 2001)*, *79*(2), 102–111.

Marinova, D., & Phillimore, J. (2006). Models of innovation. In L. V. Shavinina (Ed.), *The international handbook on innovation* (pp. 44–53). Elsevier. https://doi.org/10.1016/B978-008044198-6/50005-X

Marion, R. (2012). Leadership of creativity. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 457–479). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00018-5

Martens, B. (2020). Simulations. In U. Hirschberg, L. Hovestadt, & O. Fritz (Eds.), *Atlas of digital architecture: Terminology, concepts, methods, tools, examples, phenomena* (475–489). Birkhäuser.

Martin, R. (2009a). *The design of business: Why design thinking is the next competitive advantage*. Harvard Business Review Press.

Martin, R. (2009b). Wicked Problems. *Rotman - The magazine of the Rotman School of Management, Winter 2009*, 3.

Martin, R. L. (2013). The Design of Business. In *Rotman on design: The best on design thinking from Rotman Magazine* (pp. 15–19). University of Toronto Press.

Mascia, D., Magnusson, M., & Björk, J. (2015). The role of social networks in organizing ideation, creativity and innovation: An introduction. *Creativity and Innovation Management*, *24*(1), 102–108. https://doi.org/10.1111/caim.12111

Mason, M. (2010). Sample size and saturation in phd studies using qualitative interviews. *Forum: Qualitative Social Research*, *11*(3), 19 pages. https://doi.org/10.17169/fqs-11.3.1428

Matheson, R. (2014, November 14). *"Moneyball for business": Startup's behavioral analytics on employees uncover ways to increase workplace productivity, satisfaction.* MIT News. https://news.mit.edu/2014/behavioral-analytics-moneyball-for-business-1114

McDonnell, J. (2015). Gifts to the future: Design reasoning, design research, and critical design practitioners. *She Ji: The Journal of Design, Economics, and Innovation*, *1*(2), 107–117. https://doi.org/10.1016/j.sheji.2016.01.007

McFadden, R. D. (2017, December 30). John Portman, architect who made skylines soar, dies at 93. *New York Times*. Retrieved December 11, 2021, from https://www.nytimes.com/2017/12/30/obituaries/john-portman-dead.html

McGovern, J., & Resnick, M. (2019, December 16). *Critical capabilities for enterprise architecture tools* [Report]. Gartner.

McKim, R. H. (1980). *Experiences in visual thinking* (2nd ed.). Brooks/Cole Publishing Company.

McLaurin (2021, July 27). *4 Emerging patterns about hybrid work and the future of the office*. Gensler. Retriveved January 26, 2022, from https://www.gensler.com/blog/4-emerging-patterns-about-hybrid-work-and-the-future-office

Meadows, D. H. (2009). *Thinking in systems: A Primer.* Earthscan.

Morgan, G. (1997). *Images of organization* (2nd ed.). Sage Publications.

Mortati, M. (2015). A framework for design innovation: present and future discussions. *Design Issues*, *31*(4), 4–16. https://doi.org/10.1162/DESI_a_00347

Mowles, C. (2018). Ralph Stacey: Taking experience seriously. In D. B. Szabla, W. A. Pasmore, M. A. Barnes, & A. N. Gipson (Eds.), *The Palgrave handbook of organizational change thinkers*. Springer International Publishing.

Müller-Prothmann, T., & Dörr, N. (2014). *Innovationsmanagement: Strategien, Methoden und Werkzeuge für systematische Innovationsprozesse* (3. Aufl.). *Pocket Power: Vol. 56*. Hanser.

Mumford, M. D., Hester, K., & Robledo, I. (2012). Methods in creativity research. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 39–65). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00003-3

Mumford, M. D. (2012). *Handbook of organizational creativity* (1st ed.). Elsevier; Academic Press.

Mumford, M. D., Hester, K. S., & Robledo, I. C. (2012). Creativity in organizations. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 3–16). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00001-X

Nasiri, A., Alleyne, A. R., Yihui, L., & Nisar, T. (2016). Analysis of innovation management in German enterprises. *Cogent Business & Management*, *3*(1), 223, 14 pages. https://doi.org/10.1080/23311975.2016.1216727

Nelson, G. (1974). *Problems of design* (3rd ed.). Whitney Library of Design.

Nelson, H. G., & Stolterman, E. (2012). *The design way: Intentional change in an unpredictable world* (2nd ed.). MIT Press.

Nerdinger, W., & Böhm, H. (Eds.) (2012). *Der Architekt: Geschichte und Gegenwart eines Berufsstandes [anlässlich der Ausstellung „Der Architekt - Geschichte und Gegenwart eines Berufsstandes" im Architekturmuseum der TU München in der Pinakothek der Moderne, 27. September 2012 bis 3. Februar 2013]*. Prestel.

Nilsson, F. (2013). Knowledge in the Making. On Production and Communication of Knowledge in the Material Practices of Architecture. *FORMakademisk*, *6*(2), Art. 3, 1–13. https://doi.org/10.7577/formakademisk.569

Nönnig, J. R. (2007). *Architektur, Sprache, Komplexität: Acht Essays zur Architekturepistemologie* [Doctoral Dissertation, Bauhaus-Universität Weimar]. Bauhaus-Universität Weimar. https://doi.org/10.25643/bauhaus-universitaet.931

Norman, D. A. (2005). *Emotional design: Why we love (or hate) everyday things*. Basic Books.

Norman, D. A. (2013). *The design of everyday things* (revised and expanded ed.). Basic Books.

Norman, D. A., & Verganti, R. (2014). Incremental and radical innovation: design research vs. technology and meaning change. *Design Issues*, *30*(1), 78–96. https://doi.org/10.1162/DESI_a_00250

NOSCO (2020, July 27). *Nosco Company Profile* [Brochure]. Nosco. Retrieved July 27, 2020, from https://nos.co/wp-content/uploads/2020/09/nosco-presentation.pdf

NOSCO (2021, August 15). *Nosco - About Us*. Nosco. Retrieved August 15, 2021, from https://nos.co/about-us/

Oldenburg, R., & Brissett, D. (1982). The third place. *Qualitative Sociology*, *5*, 265–284. https://doi.org/10.1007/BF00986754

Oldham, G. R., & Baer, M. (2012). Creativity and the Work Context. In *Handbook of Organizational Creativity* (pp. 387–420). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00016-1

Olesen, A. R. (2017). Mapping innovation processes: Visual techniques for opening and presenting the black box of service innovation processes. In F. B. Sørensen & F. Lapenta (Eds.), *Research methods in service innovation* (pp. 95–111). Cheltenham, UK: Edward Elgar Publishing. https://doi.org/10.4337/9781785364860.00012

O'Reilly, C., A., III, & Tushman, M. L. (2004). The ambidextrous organization. *Harvard Business Review, 82*(4), 74–81.

Ortt, J. R., & van der Duin, P. A. (2008). The evolution of innovation management towards contextual innovation. *European Journal of Innovation Management*, *11*(4), 522–538. https://doi.org/10.1108/14601060810911147

Osterwalder, A. (2004). *The Business Model Ontology: A Proposition in a Design Science Approach* [Doctoral dissertation, University of Lausanne]. University of Lausanne. http://www.hec.unil.ch/aosterwa/PhD/Osterwalder_PhD_BM_Ontology.pdf

Oswalt, P., & Hollwich, M. (1998). *O.M.A. at work* (first published in: Archis | Nummer 7-1998). Oswalt. Retrieved June 13, 2018, from http://www.oswalt.de/en/text/txt/omawork.html

Padalkar, M., & Gopinath, S. (2016). Are complexity and uncertainty distinct concepts in project management? A taxonomical examination from literature. *International Journal of Project Management*, *34*(4), 688–700. https://doi.org/10.1016/j.ijproman.2016.02.009

Pai, H. (2010). Scientific Management and the birth of the functional diagram. In M. Garcia (Ed.), *AD reader. The diagrams of architecture* (pp. 64–79). Wiley.

Paletz, S. B. F. (2012). Project management of innovative teams. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 421–455). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00017-3

Pallasmaa, J. (2009). *The thinking hand: Existential and embodied wisdom in architecture. AD primers*. Wiley.

Pallasmaa, J. (2015). Body, mind, and imagination: The mental essence of architecture. In S. Robinson & J. Pallasmaa (Eds.), *Mind in architecture: Neuroscience, embodiment, and the future of design* (pp. 51–74). The MIT Press.

Pallasmaa, J. (2016). Spatial Choreography and Geometry of Movement as the Genesis of Form. In M. Kanaani & D. A. Kopec (Eds.), *Routledge Companions. The Routledge companion for architecture design and practice: Established and emerging trends* (pp. 35–44). Routledge Taylor & Francis Group.

Park, S.-M., & Kim, Y.-G. (2022). A Metaverse: Taxonomy, components, applications, and open challenges. *IEEE Access*, *10*, 4209–4251. 10.1109/ACCESS.2021.3140175

Parker, S. C. (2011). Small Firms and Innovation. In D. B. Audretsch, O. Flack, S. Heblich, & A. Lederer (Eds.), *Handbook of research on innovation and entrepreneurship* (pp. 357–364). Edward Elgar.

Paulus, P. B., Dzindolet, M., & Kohn, N. W. (2012). Collaborative creativity—Group creativity and team innovation. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 327–357). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00014-8

Peña, W. M., & Parshall, S. A. (2012). *Problem Seeking: An Architectural Programming Primer* (5th ed.). John Wiley & Sons.

Pendleton-Jullian, A. M., & Brown, J. S. (2018). *Design unbound: Designing for emergence in a white water world. Designing for emergence - volume 1*. The MIT Press. https://doi.org/10.7551/mitpress/10592.001.0001

Penn, A., Desyllas, J., & Vaughan, L. (1999). The space of innovation: interaction and communication in the work environment. *Environment and Planning B: Planning and Design*, *26*(2), 193–218. https://doi.org/10.1068/b4225

Penn, A., Desyllas, J., & Vaughan, L. (1997). The space of innovation: Interaction and communication in the work environment. In *Proceedings Volume 1, Complex Buildings. Space Syntax, First International Space Syntax Symposium, London 1997*. 12.1–12.14.

Pentland, A. (2012). The new science of building great teams. *Harvard Business Review, (April 2012)*. https://hbr.org/2012/04/the-new-science-of-building-great-teams

Pentland, A. (2013). Beyond the echo chamber: When making decisions, seek ideas from diverse sources and test them with a wide network of contacts. *Harvard Business Review, (November 2013)*. https://hbr.org/2013/11/beyond-the-echo-chamber

Pentland, A. (2015). *Social physics: How social networks can make us smarter* (Published with a new preface). Penguin Books.

Penzenstadler, B. S., Sutherland, I., Lundberg, H., Blazek, P., & Habicht, H. (2013). *InnoTracing - Methodological Underpinnings* [White paper]. http://www.innotracing.org/assets/publications/InnoTracingMethodologicalUnderpinnings.pdf

Perminova, O. (2011). *Managing uncertainty in projects*. [Doctoral dissertation, Åbo Akademi University Turku]. Åbo Akademi University Press. https://www.doria.fi/bitstream/handle/10024/69174/perminova_olga.pdf

Perry, M., & Sanderson, D. (1998). Coordinating joint design work: The role of communication and artefacts. *Design Studies*, *19*(3), 273–288. https://doi.org/10.1016/S0142-694X(98)00008-8

Perry-Smith, J., & Mannucci, P. V. (2015). Social networks, creativity, and entrepreneurship. In C. E. Shalley, M. A. Hitt, & J. Zhou (Eds.), The Oxford handbook of creativity, innovation, and entrepreneurship (pp. 205–224). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199927678.013.0016

Peuker, B. (2010). Akteur-Netzwerk-Theorie (ANT). In C. Stegbauer (Ed.), *Netzwerkforschung: Vol. 1. Netzwerkanalyse und Netzwerktheorie: Ein neues Paradigma in den Sozialwissenschaften* (2nd ed., pp. 325–335). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-92575-2_29

Pevsner, N., Honour, H., & Fleming, J. (1992). *Lexikon der Weltarchitektur: Mit einer umfassenden Bibliographie und einem Ortsregister der Abbildungen* (3., aktual. und erw. Aufl., [Sonderausg.]). Prestel.

Philipps, F. Y. (2016). The circle of innovation. *Journal of Innovation Management* *4*(3, 2016), 12–31. https://doi.org/10.24840/2183-0606_004.003_0004

Phillips, N. (2015). Organizing innovation. In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (Paperback edition, pp. 482–504). Oxford University Press.

Pisano, G. P. (2019). *Creative construction: The DNA of sustained innovation* (1st ed.). PublicAffairs.

Planbox (2021, August 11). *Open Innovation Platform* [Brochure]. Planbox. Retrieved August, 11, 2021 from https://www.planbox.com/solutions/open-innovation-platform/

Planbox (2022a, January 26). *Innovation management platform: All-one-in cloud-based platform to manage all your innovation activities*. Planbox. Retrieved January 26, 2022, from https://www.planbox.com/solutions/innovation-management-platform/

Planbox (2022b, January 26). *What is the ISO 56000 Standards Series?* Planbox. Retrieved January 26, 2022, from https://www.planbox.com/what-is-iso-56000/

Planbox (2022c, January 26). *Take Charge …of the full innovation portfolio management lifecycle*. Planbox. Retreived January 26, 2022, from https://www.planbox.com/solutions/

Planbox (2022d). *Accelerate Business Outcomes* [Brochure]. Planbox. Retreived January 26, 2022, from https://www.planbox.com/resources/planbox-innovation-brochure/

Plattner, H., Meinel, C., & Leifer, L. (Eds.) (2011). *Understanding innovation. Design thinking: Understand - improve - apply*. Springer. https://doi.org/10.1007/978-3-642-13757-0

Pongratz, M. (2004). Die Rolle des Bauherrn in der Planung. In O. Schürer & G. Brandner (Eds.), *Architektur: Consulting: Kompetenzen, Synergien, Schnittstellen* (pp. 66–71). Birkhäuser.

Poole, M. S. (2004). Central issues in the study of change and innovation. In *M. S. Poole & A.H. Van de Ven (Eds.) The Oxford handbook of organizational change and innovation* (2nd ed., pp. 3–31). Oxford University Press.

Powell, W. W., & Grodal, S. (2005). Networks of innovators. In Fagerberg, J., Mowery, D. C., & Nelson, R. R. (Eds.), *The Oxford handbook of innovation* (pp. 56–85). Oxford University Press.

Prahalad, C. K., & Krishnan, M. S. (2008). *The new age of innovation: Driving cocreated value through global networks*. McGraw-Hill.

Ramage, M., & Shipp, K. (2020). Russell Ackoff. In M. Ramage & K. Shipp (Eds.), *Systems Thinkers (2nd ed.,* pp. 141–149*)*. Springer.

Rambow, R. (2000). *Experten-Laien-Kommunikation in der Architektur*. [Publishend doctoral dissertation, Goehte Universität Frankfurt am Main] *Internationale Hochschulschriften: Bd. 344*. Waxmann Verlag.

Ratti, C. (2004). Space Syntax: Some inconsistencies. *Environment and Planning B: Planning and Design*, *31*(4), 487–499.

Ratti, C. (2017). Avant-garde making. *domus,* 1011(March 2017), 5.

Rehn, A. (2019). *Innovation for the fatigued: How to build a culture of deep creativity* (1st ed.). KoganPage.

Rehn, A. (2020, June 16). *The Art and science of contrarian thinking and unconventional creativity*: [Conference Session]. Speaker Summit #1. The Recovery Summit, June 15–19, 2020.

Reichertz, J. (2013). *Die Abduktion in der qualitativen Sozialforschung*. Springer Fachmedien. https://doi.org/10.1007/978-3-531-93163-0

Reichwald, R., Möslein, K. M., & Piller, F. T. (Eds.) (2016). *Leadership for innovation: Visualizing the invisible.* PETER PRIBILLA-STIFTUNG - A Foundation of the Technical University of Munich. http://clicresearch.org/peter-pribilla-stiftung/wp-content/uploads/sites/9/2017/03/HHL_Broschur_2017-02-07_final_web1.pdf

Reiter-Palmon, R., Wigert, B., & Vreede, T. d. (2012). Team Creativity and Innovation. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 295–326). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00013-6

RIBA (2020). *RIBA Plan of work 2020: Overview* [Brochure]. RIBA - Royal Institute of British Architects. https://www.architecture.com/knowledge-and-resources/resources-landing-page/riba-plan-of-work#available-resources

Rigolizzo, M., & Amabile, T. (2015). Entrepreneurial creativity. In J. Zhou, C. E. Shalley, & M. A. Hitt (Eds.), *Oxford Library of Psychology. The Oxford Handbook of Creativity, Innovation, and Entrepreneurship* (pp. 61–78). Oxford: Oxford University Press.

Rith, C., & Dubberly, H. (2007). Why Horst W.J. Rittel matters. *Design Issues*, *23*(1), 72–91. https://doi.org/10.1162/desi.2007.23.1.72

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*(2), 155–169. https://doi.org/10.1007/BF01405730

Rittel, H. W. J., & Webber, M. M. (1984). Planning problems are wicked problems (1973). In N. Cross (Ed.), *Developments in design methodology* (pp. 135–144). Wiley.

Rizova, P. (2006). Are you networked for successful innovation? *MIT Sloan Management Review*, *47*(3), 49–55.

Robinson, J. W. (2001). Form and structure in architectural knowledge. In A. Piotrowski & J. W. Robinson (Eds.), *The discipline of architecture* (pp. 61–82). University of Minnesota Press.

Ross, A. (2010). Foreword. In P. Deamer & P. G. Bernstein (Eds.), *Building (in) the future: Recasting labor in architecture* (1st ed., pp. 9–13). Princeton Architectural Press.

Rother, M., & Shook, J. (1999). *Learning to See: Value Stream Mapping to Create Value and Eliminate Muda.* The Lean Enterprise Institute.

Rothwell, R. (1994). Towards the fifth-generation innovation process. *International Marketing Review*, 11(1), 7–31.

Rowe, P. G. (1987). *Design thinking*. MIT Press.

Rüggeberg, H., & Burmeister, K. (2008). *Innovationsprozesse in kleinen und mittleren Unternehmen* [Working Paper No. 41]. Working Papers of the Institute of Management Berlin at the Berlin School of Economics (FHW Berlin). Fachhochschule für Wirtschaft Berlin; IMB Institute of Management Berlin

Rumpfhuber, A. (2013). *Architektur immaterieller Arbeit*. Turia + Kant. https://doi.org/10.26530/OAPEN_441449

Russell, M. G., Still, K., Huhtamaki, J., & Rubens, N. (2016). Visualizations of relational capital for shared vision. *World Technopolis Review*, *5*(1), 47–60. https://doi.org/10.7165/wtr2016.5.1.47

Saam, N. J. (2009). Modellbildung. In S. Kühl, P. Strodtholz, & A. Taffertshofer (Eds.), *Handbuch Methoden der Organisationsforschung* (pp. 517–532). VS Verlag für Sozialwissenschaften.

Sailer, K. (2010). *The space-organisation relationship: On the shape of the relationship between spatial configuration and collective organisational behaviours* [Doctoral dissertation, Technische Universität Dresden). Technische Universität Dresden. https://tud.qucosa.de/landing-page/?tx_dlf[id]=https%3A%2F%2Ftud.qucosa.de%2Fapi%2Fqucosa%253A25316%2Fmets

Sailer, K. (2019). Simulieren: Experimente in der Büroraumgestaltung. Konzepte, Herausforderungen und praktische Beispiele aus Sicht der Architektur. In S. Marguin, H. Rabe, & W. Schäffner (Eds.), *Science studies. Experimentieren: Einblicke in Praktiken und Versuchsaufbauten zwischen Wissenschaft und Gestaltung* (pp. 283–296).

Sailer, K., Thomas, M., Pomeroy, R., & Pachilova, R. (2021). The Innovation Deficit: The importance of the physical office post COVID-19. *Corporate Real Estate Journal*, *11*(1), 79–92.

Salter, A. J., & Alexy, O. (2015). The nature of innovation. In In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (Paperback edition, pp. 26–49). Oxford University Press.

Samuel, F. (2018). *Why architects matter: Evidencing and communicating the value of architects*. Routledge.

Sanchez-Burks, J., Karlesky, M. J., & Lee, F. (2015). Psychological bricolage: Integrating social indetities to produce creative solutions. In J. Zhou, C. E. Shalley, & M. A. Hitt (Eds.), *Oxford library of psychology. The Oxford handbook of creativity, innovation, and entrepreneurship* (pp. 93–102). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199927678.013.0005

Sancho Pou, E. (2013). *Architekten zwischen Konzept und Strategie*. Edition DETAIL; Detail - Institut für internationale Architektur-Dokumentation.

Sancho Pou, E. (2015). *Function follows strategy: Architects' strategies from the fifties to the present*. Edition DETAIL; Detail - Institut für internationale Architektur-Dokumentation.

Sanoff, H. (1977). *Methods of architectural programming*. Dowden, Hutchinson & Ross.

Santos, C. M., Uitdewilligen, S., & Passos, A. M. (2015). Why is your team more creative than mine? The influence of shared mental models on intra-group conflict, team creativity and effectiveness. *Creativity and Innovation Management*, *24*(4), 645–658. https://doi.org/10.1111/caim.12129

Sawyer, R. K. (2008). *Group genius: The creative power of collaboration*. Basic Books.

Scheurer, F. (2009). Architectural algorithms and the renaissance of the design pattern. In A. Gleiniger & G. Vrachliotis (Eds.), *Pattern: Ornament, Structure, and Behavior* (pp. 41–56). Birkhäuser. https://doi.org/10.1515/9783034608879.41

Schnell A., & Schnell N. (2021). *New work hacks. 50 Inspirations for modern and innovative work*. Springer.

Schoeneberg, K.-P. (2014). Komplexität – Einführung in die Komplexitätsforschung und Herausforderungen für die Praxis. In K.-P. Schoeneberg (Ed.), *Komplexitätsmanagement in Unternehmen: Herausforderungen im Umgang mit Dynamik, Unsicherheit und Komplexität meistern* (pp. 13–27). Springer Gabler. https://doi.org/10.1007/978-3-658-01284-7_2

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. Basic Books.

Schramm, C. (2017). Honorarermittlung nach HOAI. In S. Scholz, K. Wellner, R. Zeitner, C. Schramm, M. Hackel, & A. Hackel (Eds.), *Architekturpraxis Bauökonomie: Grundlagenwissen für die Planungs-, Bau- und Nutzungsphase sowie Wirtschaftlichkeit im Planungsbüro* (1st ed., pp. 247–272). Springer Vieweg.

Schubert, G. J. (2021). Interaction forms for digital design. A concept and prototype for a computer-aided design platform for urban architectural design scenarios [Doctoral dissertation, Techinical University of Munich]. TUM University Press. https://doi.org/10.14459/2021md1610329

Schuh, G., & Bender, D. (2012). Grundlagen des Innovationsmanagements. In G. Schuh (Ed.), *VDI-Buch. Innovationsmanagement: Handbuch Produktion und Management 3* (2nd ed., pp. 1–16). Springer.

Schumacher, P. (2016a). Advancing social functionality via agent-based parametric semiology. *AD Architectural Design. Special Issue: Parametricism 2.0: Rethinking Architecture's Agenda for the 21st Century*, *86*(2), 108–113. https://doi.org/10.1002/ad.2031

Schumacher, P. (2016b). Design parameters to parametric design. In M. Kanaani & D. A. Kopec (Eds.), *Routledge Companions. The Routledge companion for architecture design and practice: Established and emerging trends* (pp. 3–20). Routledge Taylor & Francis Group.

Schumacher, P. (2016c). Parametricism 2.0: Gearing up to impact the global built environment. *AD Architectural Design. Special Issue: Parametricism 2.0: Rethinking Architecture's Agenda for the 21st Century*, *86*(2), 8–17.

Schumpeter, J. A. (2003). *Capitalism, socialism, and democracy* [E-library ed.]. Taylor & Francis e-Library.

Schürer, O., & Brandner, G. (Eds.) (2004). *Architektur: Consulting: Kompetenzen, Synergien, Schnittstellen*. Birkhäuser.

Scogna Wagner, R. (2018). Robert J. Marshak: Challenging Traditional thinking about organizational change. In D. B. Szabla, W. A. Pasmore, M. A. Barnes, & A. N. Gipson (Eds.), *The Palgrave handbook of organizational change thinkers* (pp. 799–826). Springer International Publishing.

Scozzi, B., Garavelli, C., & Crowston, K. (2005). Methods for modeling and supporting innovation processes in SMEs. *European Journal of Innovation Management*, *8*(1), 120–137. https://doi.org/10.1108/14601060510578619

Semin, A., & Shohina, N. (2019). *Interactive design tool for innovation processes* [Unpublished interdisciplinary project, IDP] Technical University of Munich.

Senge, P. M. (2006). *The fifth discipline: The art and practice of the learning organization* (Rev. ed.). Crown Business.

Shalley, C., Hitt, M. A., & Zhou, J. (2015). Introduction: Integrating creativity, innovation, and entrepreneurship to enhance the organization's capability to navigate in the new competitive landscape. In J. Zhou, C. E. Shalley, & M. A. Hitt (Eds.), *Oxford library of psychology. The Oxford Handbook of creativity, innovation, and entrepreneurship* (pp. 1–14). Oxford: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199927678.013.0035

Shamiyeh, M. (2007a). Foreword. In M. Shamiyeh (Ed.), *Organizing for change \ profession: Integrating architectural thinking in other fields* (pp. 9–11). Birkhäuser; Springer.

Shamiyeh, M. (Ed.) (2007b). *Organizing for change \ profession: Integrating architectural thinking in other fields*. Birkhäuser; Springer.

Shamiyeh, M. (Ed.) (2010a). *Creating desired futures: How design thinking innovates business*. Birkhäuser.

Shamiyeh, M. (2010b). Foreword. In M. Shamiyeh (Ed.), *Creating desired futures: How design thinking innovates business* (pp. 5–11). Birkhäuser.

Shamiyeh, M., & Duschlbauer, T. (2007). AMO Experience. In M. Shamiyeh (Ed.), *Organizing for change \ profession: Integrating architectural thinking in other fields* (pp. 99–113). Birkhäuser; Springer.

Shelden, D. (Guest-Ed.) (2020a). *AD Architectural Design. The Disruptors: Technology-driven architect-entrepreneurs*, *90*(2). Wiley.

Shelden, D. (2020b). Entrepreneurial Practice: New Possibilities for a Reconfiguring Profession. *AD Architectural Design. The Disruptors: Technology-driven architect-entrepreneurs*, *90*(2), 6–13.

Silverstein, M., & Jacobson, M. (1985). Restructuring the hidden program: Toward and architecture of social change. In W. F. E. Preiser (Ed.), Programming the built environment (pp. 149–164). Van Nostrand Reinold; reprint edition 2015. Routledge.

Sim, J., Saunders, B., Waterfield, J., & Kingstone, T. (2019). Can sample size in qualitative research be determined a priori? *InternatIonal Journal of SocIal ReSearch Methodology*, *21*(5), 619–634.

Simon, H. A. (1988). Creativity and motivation: A response to Csikszentmihalyi. *New Ideas in Psychology*, *6*(2), 177–181

Simon, H. A. (1992). What is an "explanation" of behavior? *Psychological Science*, *3*(3), 150–161.

Simon, H. A. (1996). *The sciences of the artificial* (3rd ed.). MIT Press.

Simon, H. A., Dantzig, G. B., Hogarth, R., Plott, C. R., Raiffa, H., Schelling, T. C., Shepsle, K. A., Thaler, R., Tversky, A., Winter, S., Goslin, D A., Hoffman, A. R. (1986). Report of the Research Briefing Panel on Decision Making and Problem Solving. In Committee on Science, Engineering, and Public Policy (Ed.), *Research Briefings 1986* (pp. 18–35). National Academies Press.

Simonse, L. (2014). Modeling business models. *Design Issues*, *30*(4), 67–82. https://doi.org/10.1162/DESI_a_00297

Simonton, D. K. (2012). Fields, domains, and individuals. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 67–86). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00004-5

Smith, E. A.T., Goessel, P., & Shulman, J. (2019). *Case Study Houses: The Complete CSH Program 1945-1966*. Taschen.

Solà-Morales, P. de (2012). Information, architecture, complexity. *Nexus Network Journal*, *14*(1), 17–24. https://doi.org/10.1007/s00004-011-0094-0

Sørensen, F., & Mattsson, J. A.N. (2016). Speeding up innovation: Building network structures for parallel innovation. *International Journal of Innovation Management*, *20*(02), 1650024-1–30. https://doi.org/10.1142/S1363919616500249

Sørensen, F. B., & Lapenta, F. (Eds.) (2017). *Research methods in service innovation*. Edward Elgar.

Soriano de Alencar, E. M.L. (2012). Creativity in organizations. In M. D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 87–111). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00005-7

Space Syntax (2021a, October 12). *Buildings & estates*. Space Syntax. Retrieved October 17, 2021, from https://spacesyntax.com/buildings-estates/

Space Syntax (2021b, October 12). *The Space Syntax approach*. Space Syntax. Retrieved October 12, 2021, from https://spacesyntax.com/the%20space%20syntax%20approach/

Space Syntax (2022, January 26). *People. Data. Performance*. Space Syntax. Retrieved January 26, 2022, from https://spacesyntax.com

Speaks, M. (2002). Theory was interesting… but now we have work. *Arq: Architectural Research Quarterly*, *6*(03). https://doi.org/10.1017/S1359135503001714

Stachowiak, H. (1973). *Allgemeine Modelltheorie*. Springer.

Star, S. L. (2010). This is not a boundary object: Reflections on the origin of a concept. *Science, Technology, & Human Values*, *35*(5), 601–617. https://doi.org/10.1177/0162243910377624

Star, S. L. (2016). The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving, In G. C. Bowker, S. Timmermans, A. E. Clarke, & E. Balka (Eds.), *Boundary objects and beyond: Working with Leigh Star* (pp. 243–259). MIT Press,

Staten, J., & Hopkins, B. (2020, March 19). *The Forrester Wave™: Innovation Management Platforms, Q1 2020: The 13 Providers That Matter Most And How They Stack Up* [Report]. Forrester.

Staun, H. (2014, September 7). Big Data & Social Physics. Wie wir gern leben sollen. *Frankfurter Allgemeine Zeitung*. https://www.faz.net/aktuell/feuilleton/big-data-social-physics-wie-wir-gern-leben-sollen-13126401.html

Steenson, M. W. (2017). *Architectural intelligence: How designers and architects created the digital landscape*. The MIT Press.

Stern, T., & Jaberg, H. (2010). *Erfolgreiches Innovationsmanagement: Erfolgsfaktoren - Grundmuster - Fallbeispiele* (4., überarbeitete Auflage). Gabler; GWV Fachverlage.

Strübing, J. (2005). *Pragmatistische Wissenschafts- und Technikforschung: Theorie und Methode* [Habilitation, Freie Universität Berlin]. Campus-Verlag

Styhre, A., & Gluch, P. (2009). Creativity and its discontents: Professional Ideology and creativity in architect work. *Creativity and Innovation Management*, *18*(3), 224–233. https://doi.org/10.1111/j.1467-8691.2009.00513.x

Szopinski, D., Schoormann, T., John, T., Knackstedt, R., & Kundisch, D. (2020). Software tools for business model innovation: current state and future challenges. *Electronic Markets*, *30*(3), 469–494. https://doi.org/10.1007/s12525-018-0326-1

Täuscher, K., & Abdelkafi, N. (2017). Visual tools for business model innovation: Recommendations from a cognitive perspective. *Creativity and Innovation Management*, *26*(2), 160–174. https://doi.org/10.1111/caim.12208

Terwiesch, C., & Ulrich, K. T. (2009). *Innovation Tournaments: Creating and Selecting Exceptional Opportunities*. Harvard Business Press.

Tidd, J. (2006). *A review of innovation models* [Discussion Paper 1]. Imperial College London; Tanaka Business School. https://doi.org/10.13140/RG.2.2.30295.57762

Tidd, J., & Bessant, J. R. (2013). *Managing innovation: Integrating technological, market and organizational change* (5th ed.). Wiley.

The Bartlett School of Architecture (2020). Space Syntax Laboratory. Retrieved from https://www.ucl.ac.uk/bartlett/architecture/research/space-syntax-laboratory

The Hyatt Foundation (2022a, January 26). *Frank Gehry – Laureate 1989*. The Pritzker Architecture Prize. https://www.pritzkerprize.com/laureates/1989

The Hyatt Foundation (2022b, January 26). Rem Koolhaas – Laureate 2000. The Pritzker Architecture Prize. https://www.pritzkerprize.com/laureates/2000

Trott, P. (2012). *Innovation management and new product development* (5th ed.). Financial Times Prentice Hall.

Trott, P. (2017). *Innovation management and new product development* (6th ed.). Pearson.

Trüby, S. (2012). Zum Verhältnis von Bauherr und Architekt. In W. Nerdinger & H. Böhm (Eds.), *Der Architekt: Geschichte und Gegenwart eines Berufsstandes [anlässlich der Ausstellung „Der Architekt - Geschichte und Gegenwart eines Berufsstandes" im Architekturmuseum der TU München in der Pinakothek der Moderne, 27. September 2012 bis 3. Februar 2013]* (pp. 500–511). Prestel.

Tufte, E. R. (1998). *Envisioning information* (6th print). Graphics Press.

Tzonis, A. (2004). Evolving spatial intelligence tools, from architectural poetics to management methods. In R. J. Boland & F. Collopy (Eds.), *Managing as designing [workshop held at the Weatherhead School of Management in June 2002 …]* (pp. 67–73). Stanford Business Books.

Uebernickel, F., Brenner, W., Pukall, B., Naef, T., & Schindlholzer, B. (2015). *Design Thinking: Das Handbuch* (Erste Auflage). Frankfurter Allgemeine Buch.

Ungers, O. M. (2011). *Die Thematisierung der Architektur*. Herausgegeben von Walter A. Noebel [Neuauflage; Erstausgabe 1983]. Niggli.

Vahs, D., & Brem, A. (2015). *Innovationsmanagement: Von der Idee zur erfolgreichen Vermarktung* (5., überarbeitete Auflage). Schäffer-Poeschel Verlag.

van Berkel, B., & Bos, C. (2010). Diagrams. In M. Garcia (Ed.), *AD reader. The diagrams of architecture* (pp. 222–227). Wiley.

Van de Ven, A. H. (2017). The innovation journey: you can't control it, but you can learn to maneuver it. *Innovation: Organization & Management*, *19*(1), 39–42. https://doi.org/10.1080/14479338.2016.1256780

Van de Ven, A. H., Polley, D. E., Garud, R., & Venkataraman, S. (1999). *The innovation journey*. Oxford University Press.

Van Delden, C. (2016). *Crowdsourced innovation: Revolutionizing open innovation with crowdsourcing* (1st ed. reprint 2016). innosabi.

Van Delden, C., & Chia, D. (2020). *Connect the dots: Agile innovation and collaborative ecosystems: insights and leading practices from innosabi* (1st ed.). innosabi.

Van den Ende, J., Frederiksen, L., & Prencipe, A. (2015). The front end of innovation: organizing search for ideas. *Journal of Product Innovation Management*, *32*(4), 482–487. https://doi.org/10.1111/jpim.12213

Van der Duin, P., & Ortt, R. (2020). *Contextual innovation management: Adapting innovation processes to different situations. Routledge studies in innovation, organizations and technology*. Routledge.

Van der Duin, P. A., Ortt, J. R., & Aarts, W. T. M. (2014). Contextual innovation management using a stage-gate platform: The case of Philips shaving and beauty. *Journal of Product Innovation Management*, *31*(3), 489–500. https://doi.org/10.1111/jpim.12109

Van der Heiden, G., Jhawar, A., & Hart, N. (2021, November 9). *Magic Quadrant for Enterprise Architecture Tools*. Gartner. Retrieved November 16, 2021 from https://www.gartner.com/doc/reprints?id=1-280IBLLX&ct=211111&st=sb

Van der Pijl, P., Lokitz, J., & Solomon, L. K. (2016). *Design a better business: New tools, skills, and mindset for strategy and innovation*. Wiley.

Van der Valk, T., & Gijsbers, G. (2010). The use of social network analysis in innovation studies: Mapping actors and technologies. *Innovation: Organization & Management: IOM*, *12*(1), 5–17.

Van Marrewijk, A. H. (2009). Corporate headquarters as physical embodiments of organisational change. *Journal of Organizational Change Management*, *22*(3), 290–306. https://doi.org/10.1108/09534810910951078

Van Prud'homme Reine, P. (2017). The culture of design thinking for innovation. *Journal of Innovation Management*, *5*(2), 56–80. https://doi.org/10.24840/2183-0606_005.002_0006

Van Schaik, L. (2008). *Spatial intelligence: New futures for architecture. Architectural design primer*. John Wiley & Sons.

VanPatter, G. K., & Pastor, E. (2016). *Innovation methods mapping: De-mystifying 80+ years of innovation process design* (First edition). Humantific Publishing.

Vassal, J.-P. & Oswalt, P. (2016). Die Aufgabenstellung gestalten. Jean-Philippe Vassal im Gespräch mit Philipp Oswalt. *Arch+ Zeitschrift für Architektur und Städtebau*, *222*(1), 140–145.

Venturi, R. (1992). *Complexity and contradiction in architecture* (2. ed., repr). *The Museum of Modern Art papers on architecture*. Museum of Modern Art.

Verganti, R. (2009). *Design-driven innovation: Changing the rules of competition by radically innovating what things mean*. Harvard Business Press.

Verganti, R. (2016). The innovative power of criticism: Judgment, not ideation, is the key to breakthroughs. Harvard Business Review, (January-February 2016). https://hbr.org/2016/01/the-innovative-power-of-criticism

Verganti, R. (2017a). Design Thinkers Think Like Managers: Two strategies linked to uncertainty resolution. *She Ji: The Journal of Design, Economics, and Innovation*, *3*(2), 100–102. https://doi.org/10.1016/j.sheji.2017.10.006

Verganti, R. (2017b). *Overcrowded: Designing Meaningful Products in a World Awash with Ideas. Design Thinking, Design Theory Series*. MIT Press.

Verganti, R., & Dell'Era, C. (2015). Design-driven innovation: Meaning as a source of innovation. In M. Dodgson, D. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (Paperback edition, pp. 139–162). Oxford University Press.

Verganti, R., & Norman, D. (2019, July 16). Why Criticism Is Good for Creativity. *Harvard Business Review*. https://hbr.org/2019/07/why-criticism-is-good-for-creativity

Verworn, B., & Herstatt, C. (2007a). Bedeutung und Charakteristika der frühen Phasen des Innovationsprozesses. In C. Herstatt & B. Verworn (Eds.), *Management der frühen Innovationsphasen: Grundlagen - Methoden - Neue Ansätze* (2nd ed., pp. 3–19). Gabler; GWV Fachverlage.

Verworn, B., & Herstatt, C. (2007b). Strukturierung und Gestaltung der frühen Phasen des Innovationsprozesses. In C. *Herstatt & B. Verworn (Eds.) Management der frühen Innovationsphasen: Grundlagen - Methoden - Neue Ansätze* (2nd ed., pp. 111–134). Gabler; GWV Fachverlage.

Verworn, B., & Herstatt, C. (2000). Modelle des Innovationsprozesses [Working paper]. Arbeitspapier Nr. 6. Technische Universität Hamburg-Harburg. https://tore.tuhh.de/bitstream/11420/104/1/Arbeitspapier_6.pdf

Vicsek, L., Király, G., & Kónya, H. (2016). Networks in the social sciences: Comparing actor-network theory and social network analysis. *Corvinus Journal of Sociology and Social Policy*, *7*(2), 77–102. https://doi.org/10.14267/CJSSP.2016.02.04

Vidler, A. (2000). Diagrams of diagrams: Architectural abstraction and modern representation. *Representations*, *72*(Autumn 2000), 1–20.

Vidler, A. (2006). What is a diagram anyway? In S. Cassarà & P. Eisenman (Eds.), *Peter Eisenman - feints [exhibition „Peter Eisenman. Contropiede", Modena, Auditorium G. Monzani, 18 June - 17 July 2005]* (1st ed., pp. 19–27). Skira.

Vogel, C. M. (2011). Notes on the evolution of design thinking: A work in progress. In T. Lockwood (Ed.), *Design thinking: Integrating innovation, customer experience and brand value* (3rd ed., pp. 3–14). Allworth Press.

Völker, R., Thome, C., & Schaaf, H. (2012). *Innovationsmanagement: Bestandteile - Theorien - Methoden*. Kohlhammer.

Vrachliotis, G. (2005). Articulating space through architectural diagrams. In *Reasoning with Mental and External Diagrams: Computational Modeling and Spatial Assistance, Papers from the 2005 AAAI Spring Symposium, Technical Report SS-05-06, Stanford, California, USA, March 21-23, 2005* (pp. 127-133). AAAI. http://www.aaai.org/Library/Symposia/Spring/2005/ss05-06-025.php

Waber, B., Magnolfi, J., & Lindsay, G. (2014, October). Workspaces that move people. *Harvard Business Review*. https://hbr.org/2014/10/workspaces-that-move-people

Wagner, I. (2000). Persuasive Artefacts in Architectural Design and Planning. In S. A. R. Scrivener, L. J. Ball, & A. Woodcock (Eds.), *Collaborative Design* (pp. 379–389). Springer. https://doi.org/10.1007/978-1-4471-0779-8_36

Wagner, I. (2004). "Open Planning": Reflection on methods and innovative work practices in architecture. In R. J. Boland & F. Collopy (Eds.), *Managing as designing: [workshop held at the Weatherhead School of Management in June 2002 …]*. Stanford Business Books.

Walker, W. E., Harremoës, P., Rotmans, J., van der Sluijs, J. P., van Asselt, M.B.A., Janssen, P., & Krayer von Krauss, M. P. (2003). Defining uncertainty: A conceptual basis for uncertainty management in model-based decision support. *Integrated Assessment*, *4*(1), 5–17.

Watt, S. (2008). Questions for: Edward de Bono: The father of 'lateral thinking' explains how it can help change the way we look at things. *Rotman - The magazine of the Rotman School of Management, Winter 2008*, 70–72.

Wecht, C. H. (2014). Innovationsmanagement. In R. Pircher (Ed.), *Wissensmanagement, Wissenstransfer, Wissensnetzwerke: Konzepte, Methoden, Erfahrungen* (pp. 252–264). Publicis.

Wegener, F. E., Guerreiro Gonçalves, M., & Dankfort, Z. (2019). Reflection-in-action when designing organizational orocesses: Prototyping workshops for collective reflection-in-action. *Proceedings of the Design Society: International Conference on Engineering Design*, *1*(1), 1255–1264. https://doi.org/10.1017/dsi.2019.131

Weisberg, R. W. (2006). *Creativity: Understanding innovation in problem solving, science, invention, and the arts*. Wiley.

West, M. A., & Sacramento, C. A. (2012). Creativity and innovation. In M. D. Mumford (Ed.), *Handbook of Organizational Creativity* (pp. 359–385). Elsevier. https://doi.org/10.1016/B978-0-12-374714-3.00015-X

Wiertz, C., Ruyter, K. de, Keen, C., & Streukens, S. (2003). *Cooperating for service excellence in multi-channel service systems: an empirical assessment*. [Working paper]. METEOR, Maastricht University School of Business. https://doi.org/10.26481/umamet.2003016

Wilhelm, E. (2012). Vom «Gebaude als System» und von kooperativen Netzwerken: Interdisziplinare Kooperation im (Auf-)Bau. In E. Wilhelm & U. Sturm (Eds.), *Gebäude als System* (pp. 33–41). Interact-Verl.; vdf-Hochschulverl.

Wineman, J., Hwang, Y., Kabo, F., Owen-Smith, J., & Davis, G. F. (2009). Spatial layout, social structure, and innovation in organizations. *Environment and Behavior*, *41*(3), 427–442. https://doi.org/10.1177/0013916508314854

Wineman, J. D., Kabo, F. W., & Davis, G. F. (2008). Spatial and social networks in organizational innovation. *Environment and Behavior*, *41*(3), 427–442. https://doi.org/10.1177/0013916508314854

Wittenstein, M. (2016). *Die Innovationsfabrik gibt der Zukunft von WITTENSTEIN eine Gestalt*. In HENN & WITTENSTEIN AG (Eds.), *Innovationsfabrik WITTENSTEIN AG. Dokumentation* (pp. 2–3). HENN / WITTENSTEIN AG.

WITTENSTEIN SE (2022a, January 26). *How to manage increasing complexity*. Wittenstein Retrieved January 26, 2022, from https://www.wittenstein.de/en-en/company/production-of-the-future/

WITTENSTEIN SE (2022b, January 26). *The Innovation Factory is shaping our future*. Wittenstein. Retrieved January 26, 2022, from https://www.wittenstein.de/en-en/company/production-of-the-future/innovation-factory/

Wöhe, G., & Döring, U. (2013). *Einführung in die Allgemeine Betriebswirtschaftslehre* (25., überarb. und aktualisierte Aufl.). Vahlen.

Woodman, R. W., Sawyer, J. E., & Griffin, R. W. (1993). Toward a theory of organizational creativity. *Academy of Management Review*, *18*(2), 293–321.

Wördenweber, B., Eggert, M., & Schmitt, M. (2012). *Verhaltensorientiertes Innovationsmanagement*. Springer.

Yang, L., Holtz, D., Jaffe, S., Suri, S., Sinha, S., Weston, J., Joyce, C., Shah, N., Sherman, K., Hecht, B., & Teevan, J. (2022). The effects of remote work on collaboration among information workers. *Nature Human Behavior*, *6*, 43–54. https://doi.org/10.1038/s41562-021-01196-4

Yi-Luen Do, E., & Gross, M. D. (2001). Thinking with diagrams in architectural design. In A. F. Blackwell (Ed.), *Thinking with Diagrams* (pp. 135–149). Springer. https://doi.org/10.1007/978-94-017-3524-7_8

Zaera-Polo, & Alejandro (2010). Between ideas and matters: Icons, indexes, diagrams, drawings and graphs. In M. Garcia (Ed.), *AD reader. The diagrams of architecture* (pp. 236–243). Wiley.

Zeithaml, V. (1981). How consumer evaluation processes differ between goods and services. In J. H. Donnelly & W. R. George (Chairs), *Special Educator's Conference.* Symposium conducted at the meeting of American Marketing Association, Orlando, Florida,

Zenk, L., & Behrend, F. D. (2014). Soziale Netzwerkanalyse in Organisationen – versteckte Risiken und Potenziale erkennen. In R. Pircher (Ed.), *Wissensmanagement, Wissenstransfer, Wissensnetzwerke: Konzepte, Methoden, Erfahrungen* (2nd ed., pp. 213–232). Publicis.

Zhou, J., & Hoever, I. J. (2014). Research on workplace creativity: A review and redirection. *Annual Review of Organizational Psychology and Organizational Behavior*, *1*(1), 333–359.

ZKM (2022). *Kugelkabinett by artist group Effekt (Dieter Hacker, Karl Reinhartz, Helge Sommerrock, Walter Zehringer)*. ZKM | center for art and media Karlsruhe. Rertreived January 26, 2022, from https://zkm.de/en/artwork/kugelkabinett

Christos Chantzaras